Environmental Impact Assessment

Yellowtail Development Project

Esso Exploration and Production Guyana Limited

Volume II

ERM

March 2022

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APPENDIX A

List of Preparers

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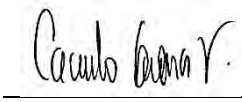
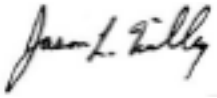
LIST OF PREPARERS

Todd Hall, ERM: Program Lead

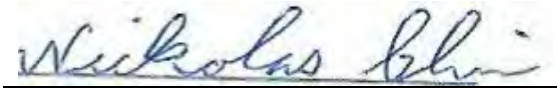
Steve Koster, ERM: Partner-in-Charge



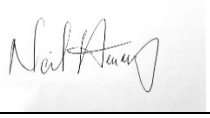
Camilo Gaona, ERM: Partner



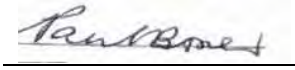
Jason Willey, ERM: Project Manager



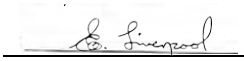
Nickolas Chin, ERM: Health and Safety Lead



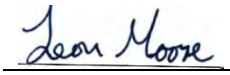
Neil Henry, ERM: Consultant Coordinator



Paul Bonar, CEMCO: Consultant Coordinator



Elford Liverpool, University of Guyana: Consultant Coordinator / Zoologist



Leon Moore, Leon Moore Nature Experience: Consultant Coordinator / Zoologist

Noam Raffel, ERM: GIS Specialist

Haimwant Persaud, CEMCO: GIS Specialist

Amberly Moon, ERM: Biodiversity Specialist

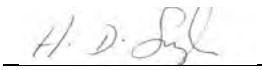
Mark Ram, University of Guyana: Biodiversity Specialist

Indranee Roopsind, Leon Moore Nature Experience: Biodiversity Specialist

Leanna Kalicharan, University of Guyana: Marine Science Specialist

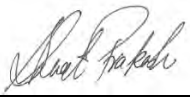
Mark Irvine, ERM: Physical Oceanographic Specialist

Catriona Munro, ERM: Marine Scientist / Biological Oceanographic Specialist



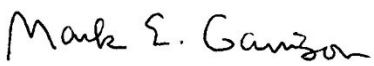
Hemwantie Singh, CEMCO: Marine Water Quality Specialist

Michael Lowe, CEMCO: Marine Water Quality Specialist

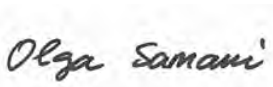


Shwet Prakash, ERM: Water Quality Specialist

Jacob Guise, ERM: Hydrodynamic Modeling Specialist



Mark Garrison, ERM: Air Quality Modeling Specialist



Olga Samani, ERM: Air Quality Modeling Specialist

Surya Ramaswamy, ERM: Air Quality Modeling Specialist

Anna Sundby, ERM: Socioeconomic Resources / Stakeholder Engagement Specialist

Candice Ramessar, ERM: Socioeconomic Resources / Stakeholder Engagement Specialist

Ashanta Osborne, CEMCO: Social Specialist

Amanda Sahai-Alli, CEMCO: Social Specialist

APPENDIX B

EIA Team Curricula Vitae

Resubmitted without changes

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Todd H. Hall, PE

Guyana Program Lead, Partner-in-Charge

Todd has over 25 years of broad experience in environmental consulting, focusing on environmental, social and health impact assessment, management plan development, multi-media permitting, site planning and licensing, remediation, and risk assessment. He has prepared environmental, social, and health impact assessments and management plans for dozens of exploration and development projects in North America, South America, Asia/Pacific, Africa, and the Middle East. Todd has worked with ExxonMobil for his entire career, from his first project involving a remedial investigation of a legacy ExxonMobil property, and he has led ERM's programs for ExxonMobil at multiple downstream facilities, legacy sites, LNG regasification facilities, and upstream exploration and development projects worldwide. He has been a part of ERM's support to EEPGL in Guyana since 2017, and has been the Program Lead for ERM's support to EEPGL since early 2018.

Experience: Over 25 years in oil and gas, petrochemical, mining, and power

Email: todd.hall@erm.com

LinkedIn: https://www.linkedin.com/in/todd-hall-5069b14/

Education

- M.E. Civil (Environmental) Engineering, Texas A&M University, College Station, TX, 1995
- B.S. Civil Engineering, Texas A&M University, College Station, TX, 1994

Professional Affiliations and Registrations

- Registered Professional Engineer, Texas
- International Association for Impact Assessment
- Society of Petroleum Engineers

Languages

- English, native speaker

Fields of Competence

- Environmental, social, and health impact assessment
- Environmental, social, and health management plan development
- International Best Practice (EP, IFC PS, etc.)
- National Environmental Policy Act (NEPA)
- Environmental planning, siting, and licensing for U.S. and international energy projects
- Multi-media environmental permitting
- Environmental engineering design
- Site investigation and remediation
- Risk assessment (human and ecological)
- Regulatory compliance assessment

Key Industry Sectors

- Oil and Gas
- Petrochemical
- Power
- Mining

Key Projects

Environmental Impact Assessments
Directed Environmental Impact Assessments (EIAs), inclusive of socioeconomic and community health resources, and associated data collection and stakeholder engagement process for the proposed Liza Phase 2 Development Project and the Payara Development Project, both offshore Guyana. Data collection included completion of onshore and marine traffic studies, onshore and offshore ambient air quality monitoring, and surveys of marine fish, marine benthos, coastal birds, seabirds, marine turtles, and ecosystem services in the Project Area of Influence.

Environmental Management Plans
Directed Environmental Management Plans for several multi-well exploration campaigns offshore Guyana.

Environmental Impact Assessment
Served as senior technical reviewer for an Environmental Impact Assessment for the Liza Phase 1 Development Project offshore Guyana.

Environmental, Social, and Health Impact Assessment
Led preparation of a bankable Environmental, Social, and Health Impact Assessment for a proposed gold mine in Colombia, working from a separate Spanish-language National EIA.

Environmental Planning, Impact Assessment and Regulatory Strategy Implementation
Directed and led the project for a proposed greenfield petroleum refinery and integrated power plant in South Dakota. Completed an environmental critical issues analysis; prepared a permitting strategy; completed an ecological reconnaissance, wetland delineation, and cultural resources intensive survey; prepared for and participated in public open houses and public zoning board hearings; prepared draft re-zoning language; completed a socioeconomic baseline study and economic impact analysis; and prepared a human health risk assessment regarding forecasted air emissions from the facility.

Regulatory Approvals Process
Supported the process for proposed LNG export terminal in western British Columbia. Prepared EA summary documentation to aid in dissemination of EA findings and proposed mitigations to internal and external stakeholders and interested parties. Provided advice related to project design alternatives with respect to air quality regulatory ramifications. Assisted with GHG management strategy including support for lifecycle analysis and development of recommendations for use in influencing and managing emerging GHG regulations applicable to the BC LNG industry.

Environmental Licensing
Directed the assessment and licensing for the Golden Pass LNG Terminal and associated Golden Pass Pipeline system in East Texas and Northwest Louisiana. Developed permitting and development strategies, prepared Environmental Resource Reports to be submitted with separate Natural Gas Act Section 3(a) and Section 7(c) applications to FERC, and prepared related federal, state, and local environmental permit applications. Coordinated ancillary studies to support the application (e.g., traffic study, bird strike monitoring). Directed field activities in support of licensing, including extensive field wetland delineation and archaeological surveys.

Socio-economic Baseline Study
Completed a socio-economic baseline study for a series of Texas counties and Louisiana parishes along the U.S. Gulf Coast. Collected an extensive socio-economic data set and created a methodology to ‘rate’ a number of socio-economic aspects of each county/parish with respect to its development needs and the degree to which each was expected to support future oil and gas development growth in the region.

Environmental Management Plan Development
Developed an environmental management plan, a waste management plan, a regulatory compliance plan, and an environmental monitoring plan for the Golden Pass LNG regasification terminal and pipeline's transition from development/construction to operations. Developed a detailed Compliance Register identifying all environmental, health and safety regulations applicable to terminal and pipeline operations, the basis for applicability, and the specific actionable requirements stemming from regulations.

Environmental Impact Assessment
Managed an Environmental Impact Assessment for the proposed Ras Tanura Refinery Expansion Project in the Kingdom of Saudi Arabia, including completion of extensive CALPUFF air dispersion modeling.

Environmental Impact Assessment
Managed an Environmental Impact Assessment for the proposed Wasit Gas Plant Project in the Kingdom of Saudi Arabia, including completion of extensive CALPUFF air dispersion modeling.

Phase I HSEIA
Directed the HSEIA under ADNOC's Code of Practices for the Integrated Gas Development – Project Habshan Platforms located in the Umm Shaif Field offshore Abu Dhabi.

Air Dispersion Modeling
Managed air dispersion modeling in support of the Saudi Kayan Petrochemical Complex development project in Jubail Industrial City, Saudi Arabia.

Environmental Assessment
Prepared the environmental component of a Public Utility Commission application to construct a transmission line from east Texas into the Houston area. Completed intensive environmental field surveys and prepared an Environmental Assessment (EA) triggered from the project crossing Federal lands.

Environmental and Socioeconomic Feasibility Study
Conducted an environmental and socioeconomic feasibility study for the development of a liquefaction facility in the Caribbean Islands. Rated and ranked several candidate sites based on environmental and social impact criteria.

Environmental, Social and Health Impact Assessment (ESHIA)
Directed the ESHIA for the proposed Congo River Crossing Canyon Project offshore Angola.

Environmental and Social Impact Assessment
Directed the assessment for a 370km segment of a proposed crude oil pipeline in Colombia, including preparing a gap analysis between local licensing requirements and the requirements that would apply under an international financing approach. Collected primary data, identified and communicated planned project details with stakeholder groups including protected communities, and completed a topographic and geotechnical survey of the pipeline segment route.

Social and Health Impact Assessment
Conducted technical review for an assessment of unconventional production operations across a >100,000 acre shale gas formation in the Eagle Ford formation.

Hazard Studies
Completed three separate studies to assess the risk associated with operation of flares on gas production platforms offshore Equatorial Guinea.

Environmental and Social Due Diligence
Completion an assessment for the proposed 'farm-in' acquisition of unconventional natural gas production operations in Eastern Louisiana. Completed a Risk Analysis transaction including interviews with the firm's management and other personnel at the firm's headquarters, and site visits to representative facilities to present summary of findings, including an

assessment of the priority of findings based on a risk categorization structured to inform decision-making.

Philosophies and Plans
Directed the development of environmental control design philosophy, oil and hazardous materials spill response philosophy, environmental management plan, environmental monitoring plan, waste management plan, and regulatory compliance plan for a component of the Barzan gas development project offshore Qatar.

Waste Management Plan
Prepared the plan for oil and gas operations in the Western Desert of Egypt.

Environmental/Regulatory Framework
Directed the assessment for the area of a proposed exploration and production effort offshore Barbados.

Technical Review
Served as Senior Technical Reviewer for a desktop environmental, regulatory, and social review and ecological resource assessment for an exploration and production area of interest in Colombia.

Environmental Impact Assessment
Directed the assessment for a proposed offshore natural gas pipeline in Angola and for three separate Supplemental EIAs for offshore oil and gas developments offshore Angola.

Environmental Impact Assessments
Directed several assessments for proposed exploratory drilling projects offshore Angola. Completed social baseline data gathering, oil spill modeling, cuttings discharge modeling, and regulatory licensing support.

Environmental Impact Assessment
Directed an assessment for proposed production platform expansions offshore Angola.

Air Quality Modeling Study
Conducted the study for a proposed floating production, storage, and offloading facilities offshore Angola. Used the Offshore Coastal Dispersion Model to predict transport of air pollutant concentrations from offshore sources to onshore receptors.

ESHIA/ESAP
Directed and led an Environmental, Social and Health Impact Assessment (ESHIA) and associated Environmental and Social Action Plan (ESAP) prepared in accordance with international best practice (EBRD and ADB) standards for the Ukhaa Khudag (UHG) Project, including a coal mine, coal-fired power generation facilities, a groundwater abstraction field, and other supporting facilities in southern Mongolia. Conducted extensive social and environmental baseline data gathering, air dispersion modeling, and noise modeling, and supported stakeholder engagement and consultation activities. Prepared Railway Construction Ecological Best Practices and Resettlement Best Practices white papers, and completed environmental and social action plan monitoring and evaluation.

Environmental and Social Impact Assessment
Prepared a preliminary ESIA for a major copper/gold mine in Alaska. Provided strategic direction relative to the ESIA approach and conducted technical reviews of project deliverables.

Environmental and Regulatory Management Plan
Developed an internal plan detailing the division of environmental and regulatory responsibilities and interfaces between exploration, geo-operations, and drilling business units within a major oil and gas company.

Environmental and Social Due Diligence
Directed the baseline characterization and conducted a due diligence exercise for a prospective farm-in of unconventional gas production operations in east Texas and northwest Louisiana. Assessed potential

environmental and social risks associated with increased production in the area.

Environmental Assessment
Directed a production well re-entry assessment to support development of oil and gas resources on property managed by the National Park Service (Big Thicket National Preserve).

Environmental Impact Review and Licensing
Directed a project to support preparation of a Department of Energy (DOE) assessment and associated state-level environmental review documentation for a major solar energy development in the Northeast U.S. Completed a viewshed analysis to assess visual impacts from construction of the project.

Socioeconomic Baseline/Impact Assessment
Directed the assessment supporting a gold mining project in Kazakhstan.

Due Diligence Assessment
Led the assessment for a major petroleum refinery in the U.S. Virgin Islands. Conducted a review of investigation, remediation, and permitting requirements, and status of associated refinery activities.

Hazard Assessment Project
Completed assessment for two proposed natural gas storage caverns in the Southwestern U.S. Developed worst-case failure scenarios and analyzed the expected consequences of the failure.

Environmental Impact Analyses
Acquired drilling licenses and completed the analyses associated with a proposed production well drilling and testing project in northern Brazil.

Air Quality Modeling Study
Conducted the study for proposed floating production, storage, and offloading (FPSO) facilities for a natural gas formation offshore Angola. Used the Offshore Coastal Dispersion Model to predict transport of air pollutant concentrations from offshore sources to onshore receptors.

Sustainability Reporting
Directed the project for a major wind energy development in accordance with Global Reporting Initiative (GRI G3) guidelines. Collected necessary reporting information, prepared an internal reporting handbook, and developed documentation demonstrating methodology used for reporting.

Environmental Licensing
Directed a permitting and impact assessment project in New York for a proposed wind power project. Acquired licensing through the New York State Public Service Commission and prepared an EIS pursuant to the State Environmental Quality Review process. Completed wetland delineation, cultural resource surveys, noise surveys, and visual impact simulations.

Site Screening Studies
Directed over 160 studies for proposed wind power projects in the U.S., each including mapping to identify key resources and land uses at the site, characterization of biological and aquatic resources potentially affected by the development, identification of recorded cultural resources within the site area, evaluation of potential land use related issues (e.g., zoning, visual restrictions, height limitations, designated conservation lands, floodplains, etc.), identification of potential tribal interests, and identification of potential communication, radar, and aviation related issues. Created a permit matrix that identified the federal, state, and local regulatory requirements that would apply to the development, the contact information for the agency responsible for the permit/approval, the requirements of the permit/approval application process, and the anticipated timeline.

Steven J. Koster, P.E.

Partner-in-Charge

Steve Koster has more than 30 years of experience in environmental impact assessment, permitting, and impact mitigation and remediation. Mr. Koster has served as Partner-In-Charge or Project Manager for numerous impact assessment and permitting projects for the oil and gas, energy, mining, transportation, and government sectors within a range of governmental jurisdictions. He has managed multi-disciplinary teams to complete siting studies, environmental baseline studies, impact assessments, permitting, due diligence assessments, and risk assessments.

Experience: 30 years' experience in Oil and Gas, Energy, Mining, Transportation, and Government Sectors.

Email: steve.koster@erm.com

LinkedIn: https://www.linkedin.com/in/steve-koster-04b10424/

Education

- M.S., Environmental Engineering, The University of Michigan, 1985
- B.S., Civil Engineering, The University of Michigan, 1984
- B.S., Letters and Engineering, Calvin College, 1984

Professional Affiliations and Registrations

- Registered Professional Engineer, State of Michigan
- American Society of Civil Engineers

Languages

- English, native speaker

Fields of Competence

- Federal, state, and local permitting for major capital projects
- Environmental impact assessment/NEPA
- Environmental baseline studies
- Stakeholder and tribal engagement
- Litigation support

Key Industry Sectors

- Oil and Gas
- Energy
- Mining

Certification and Training

- Environmental Site Assessment, ASTM
- 40-Hour OSHA Health and Safety Training for Hazardous Material Operations and Emergency Response
- Risk-Based Corrective Action

Key Projects

Keystone XL Pipeline Supplemental EIS. Partner-In-Charge and Project Manager for preparation of the Supplemental Environmental Impact Statement for the proposed Keystone XL Pipeline, an 875-mile long crude oil pipeline that would cross Montana, South Dakota, and Nebraska. Working under the direction of the US Department of State as the Third Party Contractor, ERM prepared a comprehensive analysis of the proposed project and alternatives consistent with the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and National Historic Preservation Act. Services performed have included reviewing and researching technical data and reports, conducting analyses of environmental and social resources impacts, identifying project alternatives and mitigation measures, and preparing a Draft and Final Supplemental EIS. In addition, approximately 5 million public comments were reviewed, catalogued, and responded to. ERM also assisted the State Department in consultation with various tribes as well as the US Fish and Wildlife Service.

Wolverine Pipeline System Permitting. Partner-In-Charge/Project Manager for obtaining various permits for pipeline repair and maintenance projects in three Midwest states. Completed assessments of wetlands, streams, soils, and biodiversity. Project included permit coordination and negotiation with multiple federal, state, and local regulatory agencies. Managed environmental field staff for permitting compliance monitoring during project construction.

Mariner West Pipeline Permitting Support. Partner-in-Charge for environmental studies and permitting support for the Mariner West ethane pipeline from the Marcellus Shale region in western Pennsylvania through Ohio and Michigan to Sarnia, Ontario. Project involved wetland delineations, wetland mitigation planning support, and cultural resource assessments of planned disturbance areas along the pipeline route.

Marcellus Union Pipeline Fatal Flaw Analysis. Project Manager for Fatal Flaw Analysis of a planned 400-mile NGL pipeline from the Marcellus region in western Pennsylvania through Ohio and Michigan.

Spartan Pipeline EIA and Permitting, 1999-2004. Partner-In-Charge/Project Manager for Environmental Impact Assessment of 63-mile long pipeline in Michigan, including working with MDOT and FHWA for pipeline segments using interstate highway right-of-way. Performed siting studies for alternate routes and completed assessments and evaluated potential impacts on natural and historic cultural resources. Developed mitigation measures to reduce impacts on wetlands, streams, soils, groundwater supplies, air quality, noise, and socioeconomic aspects. Project included permit coordination and negotiation with multiple federal, state, and local regulatory agencies. Provided community and media relations support and expert testimony in multiple contested case hearings and litigation support for Michigan Supreme Court appeal. Managed team of environmental field staff for permitting compliance monitoring during project construction.

Natural Gas Pipeline EIAs and Permitting, various. Partner-In-Charge for Environmental Impact Assessments of multiple natural gas pipelines for landfill gas recovery and natural gas supply to power generating plants, focusing on wetland, stream, soil erosion, and historical resource impacts. Projects included preparation and submittal of permit applications to state and local agencies.

FirstNet Nationwide Broadband System
Programmatic EIS for the Non-Contiguous US. Partner-In-Charge for the first party preparation of the National Telecommunications and Information Administration (NTIA), First Responder Network Authority's (FirstNet) Programmatic EIS for a proposed nationwide, interoperable, public safety broadband network in the non-contiguous region of the US, including Alaska, Hawaii, and five US territories in the Pacific and Caribbean. Responsible for leading the project team conducting the environmental and cultural review and analysis

requirements of NEPA, NHPA, and ESA, consultation with cooperating agencies, and tribal consultation.

USTDA Honeywell Flowergate Preliminary EIA. Project liason and support for preparation of a Preliminary Environmental Impact Assessment for the Sagamu Independent Power Plant Project in Ogun State, Nigeria. In accordance with USTDA requirements, ERM prepared a PEIA in support of a Feasibility Study that identified statutory requirements and global standards on environmental management and sustainability, assessed positive and negative environmental and social effects and made associated recommendations, and presented a roadmap for environment and social impact management for all phases and life cycle of the IPP project.

Organization of American States Baseline Study for Dominica Cruise Ship Port. Project Manager for completion of an environmental baseline study in support of an Environmental Impact Assessment on the Island of Dominica under contract with the Organization of American States in support of a proposed cruise ship port. Project assessed baseline conditions including land and marine resources, cultural resources, and impacts of solid waste and wastewater disposal.

River Reach Boulevard EA. Partner-In-Charge for a NEPA Environmental Assessment for a new FHWA-funded road, working under the direction of the Michigan DOT. Field surveys were completed and impact assessments and mitigation measures were developed for noise, wetlands, and contaminated sites for the transportation corridor that traversed an industrial brownfield area.

Transmission Line EISs. Partner-In-Charge for third-party support and preparation of numerous EISs under a third party contract with the State of Minnesota in coordination with multiple federal and state agencies, including a NEPA EIS for the 68-mile Bemidji-Grand Rapids transmission line through the U.S. Forest Service Chippewa National Forest, a state-level MEPA EIS for the Pleasant Valley-Bryon transmission line, and a MEPA EIS for the Hiawatha transmission line in Minneapolis.

White Pines Wind Energy Facility EIS. Partner-In-Charge for NEPA EIS and permitting for a new 70 MW wind energy facility and transmission line in the U.S. Forest Service Huron-Manistee National Forest. ERM was responsible for supporting the FS throughout the NEPA process, including scoping, resource studies, impacts analysis, alternatives and mitigation evaluation, EIS preparation, and public comment management. ERM developed a stakeholder engagement program and permitting strategy and provided assistance to a local township for wind ordinance development. ERM is responsible for local, state, and federal permitting, including wetlands, streams, stormwater, SHPO, SPCC, special use/zoning, road, and FAA approvals.

Rail Corridor Alternatives Study. Partner-In-Charge and Project Manager of a multi-part confidential rail siting study for a major power utility in the Midwest. The project identified preferred alternatives for delivering coal to six existing and new baseload power plant sites by rail and Great Lakes vessels. Rail corridors were identified, evaluated, and prioritized using technical, environmental, and socioeconomic criteria. Preferred rail transportation corridors were identitied using both new and existing rail lines.

NorthMet Mine (MN) EIS. Senior Technical Lead for Third-Party NEPA EIS for the first proposed sulfide mine, pipeline, and access road in Minnesota. This is a joint federal (USACE, USFS) and state (Minnesota DNR) project that also included the U.S. EPA and multiple tribes as Coordinating Agencies. This project required evaluation of impacts, cumulative effects, and alternatives for development of EIS documents, with a particular focus on issues surrounding potential acid rock drainage and approximately 800 acres of wetlands impacts. Lead for biological and social impact analysis.

Back Forty Mine Baseline Studies, EIA, and Permittiing Support. Partner-In-Charge for completion of an environmental baseline assessment, environmental impact assessment, and support for permitting of a proposed metallic minerals mine, road, and transmission line in the Upper Peninsula of Michigan. Project included assessments of wetlands, threatened and endangered species, cultural resources, hydrology and surface waters, ground water resources and hydrogeology, water quality, and land use. Project involves public presentations to engage and educate community and regulatory stakeholders in aspects and potential impacts of the proposed mine.

Buckeye Wind Energy Facility EIS. Partner-In-Charge for NEPA EIS for Habitat Conservation Plan and Incidental Take Permit for Indiana bat for a proposed wind farm in Ohio. Working under the direction of the USFWS and in cooperation with the wind developer, ERM prepared the EIS under a precedent-setting permitting process pursuant to the federal Endangered Species Act. Project included scoping evaluation, HCP review, alternatives evaluation, and impacts and mitigation analysis for draft and final EIS preparation.

Municipal Power Plant Stakeholder Engagement. Partner-In-Charge for a stakeholder engagement program for proposed expansion of a municipal coal-fired power plant in Michigan. Internal and external stakeholders for this controversial project were identified, mapped, and interviewed to educate stakeholders and identify interests. The mapping results were used as input to the project decision-making process and a comprehensive communications program was developed.

Camilo Gaona

Partner

Camilo is a Partner in ERM and is the Lead for the operation of ERM Guyana since 2018. Between 2016 and 2018 was the Team Lead for Environmental Impact Assessments in ERM Korea and was responsible for undertaking International ESIAs, Environmental monitoring and audit (EM&A) as well as Environmental and Social Due Diligence in alignment with International Standards, either for commercial banks or ECAs. He is focused on Environmental and Social Impact Assessment Projects in a number of sectors including Oil & Gas and Power sector. He has been working on projects in several locations and countries as South Korea, Myanmar, Philippines, South Africa, Botswana, Mongolia, Turkmenistan, Colombia, Nicaragua, Dominican Republic and recently Guyana, developing International ESIA according to IFS-Ps and OECD Guidelines and following local regulations for each one of the countries, giving him a wider experience in environmental and social permitting processes.. He has conducted several ESDD in different in different countries in Asia, Africa, Middle East and Latin America in alignment with Equator Principles (EP), OECD, among others.

Experience: 12 years' experience in oil & gas, and power sectors

Email: camilo.gaona@erm.com

LinkedIn: www.linkedin.com/in/camilo-gaona-6745866b

Education

- Environmental Engineer, La Salle university, Colombia, 2008
- IFC Performance Standards, Managing Environmental and Social Performance course, 2014

Professional Affiliations and Registrations

- Engineering Association of Colombia -COPNIA

Languages

- Spanish, native speaker
- English, fluent
- Korean, working knowledge

Fields of Competence

- Environmental and Social Impact Assessment, local and international standards (IFC-PS, OECD, EP)
- Environmental and Social Due Diligence (ESDD), ESAP and monitoring for lenders.
- Environmental and social permitting

Key Industry Sectors

- Oil and gas
- Power
- Infrastructure

Key Projects

Mr .Gaona is familiar with requirements of lenders such as the IFC- PS. He has conducted several ESDD in different in different countries in Asia, Africa, Middle East and Latin America in alignment with Equator Principles (EP), OECD , among others.

Environmental and Social Studies for Kanukuku Block Offshore Guyana . Repsol Guyana. Oil & Gas Sector. 2018- Ongoing, Project Manager
ERM was engaged by Repsol Guyana to conduct and EAMP and ESHIA for the Multiwell Drilling Campaign in Kanuku Block Offshore Guyana. Scope of work also includes the update of the Stakeholders Engagement Plan.

Environmental and Social Impact Studies for Guyana Program . ExxonMobil. Oil & Gas Sector. 2018- Ongoing, Program Master Planner
Planning for different Projects belong to ExxonMobil Guyana Program as Liza Phase 2 and Payara oil fields

Environmental, Social and Technical analysis for a route selection for Gas Pipeline of 150Km length in Dominican Republic. SK E&S. Oil & Gas Sector. 2018- Ongoing, Project Manager
ERM was engaged by SK E&S to and Environmental, Social and Technical analysis to select the most viable route for a gas pipeline of ~150Km length. Scope of work also includes Identification of special crossings as well as diagnosis of roads to be use at construction stage.

Environmental and Social Screening for a Coal Power Plant in Phillipines. SK E&C. Power Sector. 2017, Project Manager
ERM was engaged by SK E&C to conduct an Environmental and Social Screening and a specific mangrove surveys for Coal Power Plant Project in Philippines. 2017

Environmental and Social Assessment and Environmental Legal Review for CCGT Power Plant in Dominican Republic. SK E&S Power Sector. 2017- Ongoing, Project Manager
ERM was engaged by SK E&S to conduct an ESA and Environmental review for a Combined Cycle Gas Turbine Power Plant in Dominican Republic. Scope of work also was a topographic survey and water quality sampling.

International Environmental and Social Impact Assessment for a De-Waxing unit in Turkmenbashi, Turkmenistan in alignment with IFC-PS and OECD Guidelines. O&G. 2017 – On Going, Project Manager
ERM is in charge to conduct an International Environmental and Social Impact Assessment in alignment with IFS-PS and OECD Guidelines for a De-Waxing Unit in Turkmenbashi, Turkmenistan. Project sponsor is a korean company and main finance came from a Korean ECA.

Environmental and social Due Diligence for Coal Power Plant in Botswana, Africa, in alignment with IFC-PS and OECD Guidelines, Power. 2016 – Ongoing. Confidential client, Project Manager
ERM was selected to act as Lender's independent consultant to conduct the ESDD, ESAP and Monitoring for Coal Power Plant (CFPP) in Botswana for a Korean ECA in alignment with IFC-PS and OECD Guidelines.

Environmental and social Due Diligence for Coal Power Plant in South Africa, Africa, in alignment with IFC-PS and OECD Guidelines, Power. 2016 – Ongoing, Project Manager
ERM was selected to act as Lender's independent consultant to conduct the ESDD, ESAP and Monitoring for Coal Power Plant (CFPP) in South Africa for a Korean ECA in alignment with IFC-PS and OECD Guidelines.

Environmental Impact and Social Study for Production Stage in Shwe Offshore Field in Bay of Bengal in Myanmar. POSCO-DAEWOO Corporation. Oil&Gas Sector. 2016-ongoing, Project Manager
ERM is in charge to undertake an Environmental and Social Impact Study for Production Stage in Shew Offshore Field an Offshore block in the as part of the Shwe Development Project in Myanmar.

Environmental and Social Monitoring for a Cracker and PE/PP Plant with IFC Performance Standards, Turkmenistan, Oil & Gas. 2016-ongoing, Project Manager
ERM was commissioned to monitoring the obligations of the EPC consortium for environmental and social aspects as part of an international credit which demands meet the IFC Performance Standards. ERM is the independent consultant for lenders.

Environmental Management Plan for Mining Exploration Activities in Shangalon Project. Myanmar, Mining Sector. 2016, Project Manager
ERM is in charge to undertake the Environmental Management Plan for a Gold-Copper Mining Exploration Activities in Shangalon region in Myanmar.

ESIA for Gran Canal Project in Nicaragua according with international standards. Nicaragua. Infrastructure Sector, 2013- 2015, Project Manager in Country
Preparation of a baseline as part of the elaboration of the ESIA for a Canal project of 270Km length in Nicaragua. Responsible for communications with the government and stakeholders. The project had about 400 people in the field and participation of different offices of ERM.

Environmental Alternatives Study and Environmental Impact Study for a gas pipeline, Colombia, Oil&Gas. 2015-2016, Project Manager
ERM was commissioned to evaluate the alternatives for the construction of a gas pipeline, document to be submitted to the environmental authority. ERM also was commissioned to do the Environmental Impact Study of the gas pipeline.

Environmental Impact and Social Study for an Offshore block, Colombia, Anadarko. Oil&Gas. 2015-2016, Project Manager
ERM was commissioned to undertake an Environmental Impact Study for an Offshore block in the Caribbean of Colombia.

Environmental Management Plan for a Pumping Station of Caño Limon Coveñas Pipeline. Oil & Gas Sector. 2012-2014, Project Manager
Preparation of a decision support document required for Environmental Licensing of a Pumping Station for the main pipeline in Colombia according with Colombian regulation.

Environmental, Social and Sustainable Risk Assessment for a Container Terminal in Cartagena, Colombia. Infrastructure Sector, 2015, Project Manager
Environmental and Social Risk Assessment for Terminal in Cartagena as part of A Due Diligence process, including International Standards (IFC) as one of the matters to assess.

Develop of H&S Management System for an Exploration petroleum Company in Colombia. O&G sector. 2013, Project Manager
HSE Management System was done based in Colombian and international standards for an exploration petroleum company in Colombia.2013- 2014.

Technical Concept to Develop Unconventional Resources in Colombia. Colombia. Oil & Gas Sector. 2013, Project Manager
Working with more than 6 ERM offices spanning 3 regions, ERM developed the Technical Concept for Sustainable Exploration and Production of Unconventional Resources in Colombia.

HSE Compliance Audit, Colombia, Confidential Client, Oil & Gas Sector, 2013, Auditor
We performed the audit of seven petroleum and gas blocks in Magdalena department and Putumayo, preparation of the report according to the scope (internal policies and national regulatory).

Jason Willey

Project Manager

Jason has 20 years of experience in environmental consulting. He focuses on environmental and social impact assessment, due diligence, and permitting. He has extensive experience in northern South America and the Guianas. Jason has been the Program Manager for ERM's support to EEPGL since late 2014. He spent 2007-2008 working in Australia and having led the aquatic resources component of ESIAs and due diligence assessments on every continent except Antarctica, often in remote or frontier regions. He has worked on numerous upstream and midstream oil and gas projects throughout his career, including LNG regasification facilities, pipelines, and upstream exploration and development projects worldwide. Prior to his involvement with EEPGL's activities in Guyana. Jason worked for several years for oil and gas and mining clients in neighboring Suriname.

Experience: 20 years' experience in transportation, mining, oil & gas, power and government sectors

Email: jason.willey@erm.com

LinkedIn: https://www.linkedin.com/in/jason-willey-14948530/

Education

- M.S. Environmental Science and Policy, Johns Hopkins University, 2007
- B.S., Biology, University of Richmond, Richmond, VA, 1997

Languages

- English, native speaker

Fields of Competence

- Environmental and Social Impact Assessment, to NEPA (USA) and international standards
- Aquatic and estuarine ecology, including quantitative and qualitative fish community survey methods (US EPA rapid bio assessment protocol)
- Essential Fish Habitat evaluation, aquatic macroinvertebrate ecology, water quality sampling, and in-stream macrohabitat assessment
- Fish and benthic macroinvertebrate taxonomy
- Aerial photograph, landscape feature, and habitat interpretation
- Wetland delineation and functional assessment
- Stakeholder engagement particularly related to traditional fishing practices
- Recreational studies

Key Industry Sectors

- Transportation
- Mining
- Oil & Gas
- Power
- Government

Key Projects

Energy Client
Senior aquatic ecologist supporting the completion of a Supplementary Environmental and Social Impact Assessment (ESIA) and associated Management Plans to bring a 900 MW hydropower project planned for the Upper Karnali River in Nepal into compliance with IFC Performance Standards. Working on behalf of the Project Sponsor in coordination with the IFC. Key issues include determining riparian flows required to sustain IUCN listed fishes.

Financial Client
Developed a standard Terms of Reference for hydropower baselines for IFC's Infraventures program. Compiled global best practices for baseline study design, aquatic biodiversity and habitat surveys, and ecosystem services assessment. Presented good practices for fish surveys as part of the Sustainable Hydropower Series of workshops co-sponsored by the IFC and USAID in Nepal.

Government Client
Currently conducting an environmental and social due diligence on the Government of Liberia's rehabilitation of the Mount Coffee Hydroelectric Project, an 80 MW hydropower project Monterserrado County Liberia. Conducting the due diligence on behalf of MCC, which is a major donor to the project. Project involves re-constructing a dam, powerhouse, and reservoir that were destroyed during Liberia's civil war. Major issues include ecoflow and fisheries, resettlement, and community access. Providing strategic advice to MCC and the Liberian Electric Corporation to maximize compliance with the World Bank Environmental Safeguards.

Energy Client
Led a supplemental study of aquatic biological impacts of NSHE's 500 MW run-of-river hydroelectric project proposed on the Batang Toru River in North Sumatra, Indonesia to support lender financing of the project. ERM was engaged to undertake supplemental biodiversity studies, social studies (land acquisition audit, development of a stakeholder engagement plan and gathering of socio-economic baseline data), and an environmental flow study to address identified gaps between the Project's Indonesian Regulatory Approval (AMDAL) and the expectations of the 2012 IFC Performance Standards.

Transportation Client
Led the fisheries and aquatic resource component of the biodiversity field studies for the ESIA for the Nicaragua Grand Canal project, which included a hydropower project on the Agua Zarca River in central Nicaragua. Supervised the daily activities of two groups of fisheries scientists, malacologists, and macro-invertebrate specialists as they surveyed aquatic biodiversity across the Pacific and Atlantic slopes of Nicaragua and Lake Nicaragua. Authored the aquatic biological portion of the ESIA for the project.

Financial Client
Conducted an environmental due diligence on the ESIA for the proposed 48 MW San Bartolo hydropower project proposed on the Rio Negro in Copal Santiago, Ecuador. ERM identified critical gaps in the ESIA analysis and identified seven specific corrective actions that would enhance the ESIA and bring it into compliance with international standards. ERM's EDD report separated these actions into categories according to their priority for implementation, likely effect on construction or operation of the project, and cost to implement.

Power Client
Prepared aquatic resources section of the Preliminary Application Document submitted to FERC for a small (<10 MW) municipal hydropower project on the Grasse River in Massena, MY. Scoped initial aquatic ecological and fisheries studies required for the environmental impact analysis. Supervised riparian habitat mapping surveys and a wetland delineation along approximately 8 miles of the Grasse River. Developed conceptual designs for fish passage facilities designed to pass lake sturgeon (Acipenser fulvescens) and American eel (Anguilla rostrata). Assessed the potential impacts to local traditional fisheries practiced by the Mohawk tribe.

Federal Energy Regulatory Commission (US)
Assessed the effects of the proposed relicensing of Portland General Electric's 173 MW Clackamas River Hydroelectric Project on the Clackamas River in Oregon. Evaluated effects of the hydroelectric facility on fish and aquatic species, including several species of threatened or endangered salmonids. Described PGE's proposed action and incorporated agencies' comments into a comprehensive agency alternative. Authored the Threatened and Endangered Species section of the EIS for the project, which compared the effects of the proposed action and agency alternative on listed salmonids, native fish species, and benthic macroinvertebrates.

Federal Energy Regulatory Commission (US)
Co-authored the fisheries and aquatics resources section of the EIS for relicensing NYPA's 912 MW St. Lawrence-FDR Power Project on the St. Lawrence River in northern New York (US). Assessed of relicensing the hydroelectric project on fish and aquatic species, including several species of threatened or endangered fish, macroinvertebrates, and plankton. Considered effects on rare warm-water habitats created by the project and their role in enhancing fish reproduction in the river. Considered fish passage design and protective measures to avoid loss of fish passing downstream via the spillway and/or the turbines. FERC issued NYPA a 50 year license to operate the project in October 2003.

Mining Client
Preparing an EIA for an aluminum-smelting project in southwest Greenland to include a smelter, marine port, two hydroelectric developments, and electric transmission lines. Issues of concern related to construction of the marine port include potential impacts to near shore marine habitats, marine fisheries, marine mammals, and contamination of the marine environment. Issues of concern related to construction of the hydropower developments include potential ecological impacts of freshwater discharges to near shore marine habitats. Issues of concern related to the transmission lines include potential restriction of access to inshore fishing areas and interference with seabird flight patterns.

Energy Project
Prepared the fisheries and aquatics resources impact assessment as part of the ESHIA for the proposed 60 MW Nam Sane 3 Hydroelectric Project in Ban Phouviang, Xieng Khouang Province, Lao PDR. Conducted field assessments of aquatic habitat, fisheries and aquaculture practices, and general aquatic ecology. Overcame potential safety hazards from unexploded ordinance that prevented in-water surveys by interviewing local and indigenous people concerning fish distributions, migrations, and habitat use, as well as extrapolating from existing fisheries data from elsewhere in the Mekong River Basin. Collated information from various local, governmental, and NGO sources into the environmental baseline, and assessed impacts according to the Department of Energy's guidelines.

Energy Client
Provided general environmental impact assessment and planning services for several petroleum exploration and production facilities around Australia. Prepared EPBC Act (Australia) referrals and environmental management plans for offshore exploration projects. Coordinated oil spill contingency planning and sediment transport modeling to support EIA process for another offshore project in a potentially sensitive marine environment. Managed numerous concurrent modeling tasks to support the EIA process for the project and an ongoing a joint experiment by Woodside and the Australian Institute of Marine Science to determine the effects of accelerated episodic sedimentation on shallow Indo-Pacific reef building corals.

Oil & Gas Client
Managed an EIA for a marine seismic survey in the Great South Basin off the coast of New Zealand's South Island. Key issues include potential impacts on endangered marine mammals, marine fisheries, and seabirds, as well as ecosystem-level effects on sensitive habitats including the Sub-Antarctic island archipelago. Project required collating results of

recent and ongoing scientific research on the effects of vessel noise, seismic noise sources, and near-to mid-field interactions with vessels on rare, threatened, and endangered marine mammals. Impact assessment process included consultation with several key government stakeholders, and resulted in finding of no significant impacts and favorable feedback from NZ regulators.

Hydroelectric Project
Performed the aquatic resources and fisheries impact assessment for the Bui Hydroelectric Project in western Ghana. Key aquatic issues included conversion of riverine habitat to lacustrine habitat, loss of riparian productivity, and migration barriers.

Mining Client, Suriname
Lead aquatic ecologist on a feasibility assessment for a bauxite mine at a greenfield site in central Suriname. Historical investigations documented several species of armored catfish at the site, including at least one species that was potentially endemic to the local watershed immediately surrounding the proposed development site. Subsequently captured two suspected endemic armored catfish species at the site. Other potential ecological receptors of concern included amphibians, terrestrial mammals and birds, and riverine fisheries downstream of the development site. ERM has preliminarily concluded that considerable mitigation was likely to be necessary in order to render the environmental impacts of the proposed project acceptable under international and Suriname standards. Currently planning a detailed aquatic baseline survey at the site to establish the range of the suspected endemic fish at the site.

Power Client
Provided on-call environmental support to project engineers during the design phase of a natural gas pipeline project on Barrow Island off Western Australia. Provided design engineers with strategies intended to streamline the environmental permitting process. Project is a critical downstream component of the Gorgon natural gas development, a $50 billion development project near Karratha.

Hydro Power Project
Authored the aquatic resources and fisheries section of the EIA for the planned 100 MW Kalivac Hydro Power Plant on the Vjose River in Southern Albania. Determined that the project had the potential to fragment populations of resident and migratory fish species, including the several IUCN-listed minnows, two salmonids, and two species of sturgeon. Concluded that the project had the potential to enhance fisheries upstream of the dam due to increased productivity in the impounded reach. Recommended monitoring for indications of barotrauma and/or congregations of migratory fish downstream of the dam, and mitigation of these impacts if required.

International Joint Commission (US and Canada)
Managed a project to evaluate the potential effects of peaking ponding by hydropower interests on the ecology of the St. Mary's River. Consulted with the federal, state, and provincial agency personnel with regulatory responsibility on the river to evaluate the agency's concerns relative to peaking and ponding. Prepared an assessment for the IJC of peaking and ponding's effects on biological resources of concern, including migratory fish, the threatened lake sturgeon (Acipenser brevirostrum), and nuisance species, including the catadromous sea lamprey (Petromyzon marinus).

Virginia Department of Game and Inland Fisheries
Sampled fish communities in several major drainages throughout Virginia (US). Collected historical data and developed a database of historical fish collections throughout the state organized by watershed. Compiled data and prepared reports on watershed health based on recent and historical qualitative and quantitative fish data. Standardized stream data collection procedures in preparation for the eventual development of a statewide fish Index of Biotic Integrity in Virginia.

Recreational Boating Management Plan
Managed an update to the Recreational Boating Management Plan for Deep Creek Lake, an 18-MW

hydropower facility in western Maryland. Projected future use and developed recommendations for managing future recreational use and growth. Characterized use of the lake, involving a stratified random survey of commercial marinas, recreational users, and lakefront residents, and surveys of commercial rental operators, lakefront residents, and recreational boaters. Tracked commercial use in the lake's buffer strip. Determined that commercial use had experienced moderate growth over recent years, and that development could detract from the quality of the recreational resource. Made several recommendations to the DNR and the PRB for managing increased use of the lake.

Confidential Client
Lead biologist on the marine ecology and fisheries component of an Environmental and Social Impact Assessment (ESIA) for a resort planned on New Providence Island, The Bahamas. Verified preliminary marine habitat maps and data provided by the client in the field, and assessed the potential for the proposed project to impact marine resources. Resources of concern included listed marine reptiles, corals, seagrasses, and commercially and recreationally important fish and invertebrates. Conducted high-level consultations with select government agencies to ensure support for the ESIA.

Fisheries and Aquatic Resource
Co-authored the fisheries and aquatics resources section of the EIS for relicensing NYPA's 912 MW St. Lawrence-FDR Power Project on the St. Lawrence River between northern New York (US) and Ontario (Canada). Assessed the potential effects of relicensing the hydroelectric project on fish and aquatic species, including several species of threatened or endangered fish, macroinvertebrates, and plankton. Considered potential effects on rare warm-water habitats created by the project and their role in enhancing fish reproduction in the river. Considered fish passage design and protective measures to avoid loss of fish passing downstream via the spillway and/or the turbines. Reviewed input from Canadian communities affected by the project, including Native American tribes. FERC issued NYPA a 50 year license to operate the project in October 2003.

Nickolas Chin

Health and Safety Lead

Nickolas has 5 years of broad experience in environmental consulting, focusing on environmental, social and health impact assessment, management plan development, environmental compliance, site auditing and risk assessment. With a background in environmental science, his primary focus was on the extractive sector, but has since transitioned into health & safety and environmental services for the energy sector. Experienced in myriad aspects of the local mining and forestry operations, he rapidly developed in health & safety and now focused on the newly burgeoning oil & gas sector. He has prepared environmental, social, and health impact assessments and management plans for multiple local companies, created emergency response plans, health and safety plans and journey management plans to ensure safety is always held paramount. Nickolas is a born and raised Guyanese and has worked and been involved in the local environmental field all his life. He has been a part of ERM's support to EEPGL in Guyana since 2019, and has been the Program H&S Lead for ERM's support to EEPGL since mid 2020.

Experience: 5 Years' experience in the Environmental Field, specifically Extractive Sectors.

Email: nickolas.chin@erm.com

Education

- B.Sc. Environmental Science, University of Guyana, Guyana, 2016

Languages

- English, native speaker

Fields of Competence

- Environmental compliance & operational analysis
- Health & safety best practices
- Activities & logistics coordination

Key Industry Sectors

- Mining
- Forestry
- Health & Safety
- Oil & Gas

Key Projects

EAMP and EIA for a Multi-well Exploration Campaign for O&G Operator in Offshore Guyana (Ongoing)
HSE Lead for the project and works to review the current local situation and update the client whilst in the permitting and planning phase.

ERM COVID 19 Return To Workplace (RTW) (Ongoing)
Created the ERM Guyana Office COVID 19 RTW protocol. Subject Matter Expert on COVID 19 and regular monitoring of the local situation to safeguard company and client interests.

ERM Diversity, Equality & Inclusion (Ongoing)
ERM Global Advisory Group for DE&I global member with regular recommendations and input for improving and promoting the company's DE&I agenda.

Key Projects Prior to Joining ERM

Onshore Technical Services Coordination (2019)
Served as the Technical Services Coordinator for Tiger Rentals Guyana and serviced Esso Exploration and Production Guyana Limited (EEPGL) Marine Logistics Division.

Health, Safety & Environmental Supervision (2018)
Served as the Senior HSE Officer for Environmental Management Consultants (EMC), which is now the local partner to ERM in Guyana.

Occupational Health & Safety Management (2017)
Served as the Occupational Health & Safety Officer for Giftland Group of Companies.

Neil Earle Henry

Consultant Coordinator

Neil is an experienced environmental professional with more than 20 years of experience in the environmental monitoring field both private and public. He previously worked at the Guyana´s EPA and has a good understanding of environmental management issues in Guyana. He has a breadth of experience working across several companies in environmental projects in Guyana. His primary focus was on the mining, forestry and tourism sectors, with experience in infrastructural monitoring. He has assisted in the preparation and review of environmental and social impact assessments and management plans for development projects in Guyana and Suriname. For the last three years Neil has been working with ERM in the Oil and Gas Industry in Guyana exclusively on EEPGL´s projects assisting with the preparation of their ESIAs.

Experience: 20 years' experience in environmental field

Email: Neil.Henry@erm.com

Education

- Graduate Diploma: Climate Change Adaptation, University of the Sunshine Coast, (Australia), August 2008 to March 2009
- Postgraduate Diploma: Integrated Watershed Modeling and Management, International Institute For Geo-Information Science and Earth Observation (ITC), University of Twente (The Netherlands), September 2007 to June 2008.
- B. Sc Environmental Studies, University of Guyana, 2000
- Guyana Mining School

Languages

- English, fluent

Fields of Competence

- Surface and Ground water Monitoring
- Assessing environmental impacts
- Recommending environmental remediation measures
- Prepare and conduct surface and ground water monitoring programs
- Reclamation projects - Gold Mines Limited (Essequibo), Gross Rosbel Gold Mines (Suriname), and Omai Bauxite Mining Inc. (Linden)

Key Projects

Guyana Industrial Minerals Inc. Subsidiary of First Bauxite Corporation - Senior Environmental and Community Relations Advisor (December 2015 to 2017)
Responsibilities include managing all environmental matters relating to the Company's success in achieving financial closure, creating an Environmental Management System using Local and International Standards. Both office and field work.

Troy Resources - Environmental Manager (2014-2015)
Responsibilities include managing all environmental matters relating to the Company's success in its startup of operations, creating an Environmental Management System using Local and International Standards. Both office and field work.

Guyana Industrial Minerals Inc. Subsidiary of First Bauxite Corporation. Environmental and Community Relations Officer (January 2012 to 2014)
Responsibilities include managing all environmental matters relating to the Company's success in achieving financial closure, implementing the Equator Principle Financial Institutions by applying the International Financial Corporation/World Bank Standards. Both office and field work.

Environmental Management Consultants, 60 Area H Ogle, ECD Environmental Inspector (April 2010 to December 2012)
As a team member of the consultant group working on environmental projects; (a) environmental monitoring of the Amaila Falls Hydro Access Road, (b) environmental management plans, (c) environmental monitoring of the Ministry of Public Works and Communications Bridges Rehabilitation Program-Phase 11 Rehabilitation of Lot II – Lot A1 and Lot A2 Structures.

Director on the Guyana Geology and Mines Commission's Board (2006- 2007)
Guyana Environmental Protection Agency, Environmental Officer II (April 2006-2007)
Responsible for all environmental issues that fall under the Mining, Forestry and Tourism sectors. Ensuring that all developers adhere to the Environmental Protection Act No. 11 of 1996 and all Regulations made under the Act.

Omai Gold Mines Ltd, Environmental Officer September (January 2000 to July 2005)
Responsible for coordinating all activities relative to the effective management of environmental activities at Omai Gold Mines Limited. Technical duties include, implementing surface and ground water monitoring programme, implementing the ISO14001 Standards, providing environmental training for Omai's employees. Management duties include supervising subcontractors and consultants working at Omai, representing Omai's interests at meeting with the government regulators as well as professional and industrial association.

Linden Mining Enterprise Ltd, Summer Job (1997,1998,1999)
- Special Projects – Conduct Site Inspections- Progressive Reclamation through the use of native plants in Linden- Water Quality and Erosion Control in Mined-out Areas

Ministry of Agriculture, Livestock Division. (1993-1996)
To provide extension services to the Linden community.

Special Assignments
- Hydro-meteorological Analysis of Lake Naivasha, Kenya and Lake Buurse, The Netherlands
- A Strategic Approach to Solid Waste Disposal in McKenzie, Linden.
- Environmental Inspections of the McKenzie Bauxite Plant and the East Montgomery operations Area
- Stack Dust: Health effects on Lindeners.
- Water Quality in the Northeast Kara Kara Mined-out area.

- The use of indigenous plants as a method of erosion control in mined affected areas.

Reclamation Activities

- Supervise re-vegetation of mine-out areas (approximately 188 hectares).
- Liaise with personnel during sloping, grading, and back filling of mined- out areas.
- Participate in an aquatic monitoring programme at Omai Gold Mines Limited (Aug. 2003).
- Assist and monitor University of Guyana students conducting special projects at Omai Gold Mines Limited.

Environmental Impact Assessment

- Assisted with the accumulation of baseline data for Gross Rosbel's EIA
- Assisted with the accumulation of baseline data for Linmine's EIA
- Trained in ambient dust sampling using the MiniVol dust sampling equipment;
- Trained in ambient noise sampling using the Quest noise level meter

Environmental Audits

- (External Audits) Consultants-Lakefield Research- November, 2000- February, 2003
- SGS ISO 14001 audits
  - Registration Audit- January 2001
  - Maintenance Audit- February 2002
  - Maintenance Audit- March 2003
  - Re-certification Audit- March 2004
  - (Internal Audits)
  - Consultants-G. Amyot- October 2001
  - D. Therrien- January 2003
  - G. Amyot- January 2004

FORM TECH-6

CURRICULUM VITAE (CV)

Name of Expert:	Paul Andrew Bonar, Consultant Coordinator
Date of Birth:	06/11/1946
Country of Citizenship/Residence	Guyana, South America

Education:

Educational Institution	Dates Attended	Degree/Diploma Gained.
University of Guyana	1970-1972	Higher Technical Diploma in Civil Engineering (equiv. to HND (UK).
University of Guyana	1980	Bachelor of Engineering (Civil)
Government Technical Institute	1967-1969	City & Guilds of London Technician's Diploma in Mechanical and Electrical Engineering.

- FIDIC Accredited Certificate in Management of Claims and Resolution of Disputes under MDBs' Harmonised Construction Contract 2010 Edition (2014).
- Fellow of the Guyana Association of Professional Engineers.

Employment record relevant to the assignment:

Period	Employing Organisation and your Title/Position. Contact Information for references	Country	Summary of activities performed relevant to the assignment.
2005 to present	Caribbean Engineering and Management Consultants Inc. (CEMCO); Chief Engineer. Contact: CEMCO (592 226 2758;	Guyana	**Construction Supervision of 3No. large Drainage Pump Stations, Ministry of Agriculture (Feb. 2005 to 2018)**: CEMCO was contracted to supervise and manage three Works contracts (US$5million) using IADB's standard form of contract. The Expert performed the role of Team Leader, supervised team of engineers and technicians and directed the interpretation of the conditions of contract and related contract documentation.
			Marriot International Hotel and Entertainment Center (2015-2017): Following contractual disputes from April 2015, Atlantic Hotel Inc. engaged CEMCO to guide the hotel firm to completing remaining work, remedy a substantial number of defects and to represent the hotel firm in managing

			all disputes, using the in-place FIDIC Design-Build form of Contract. The Expert was the lead representative for CEMCO, made all assessments and issued recommendations.
			BNTF Programmes (Various; 2005 to 2018): Under its Basic Needs Trust Fund Programme, the Caribbean Development Bank engaged CEMCO under several infrastructure projects (water, education, health, municipal markets, etc.) Basic Needs Trust Fund Programme to provide design and supervision services. As Chief Engineer, the Expert supervised development of design and the procurement and supervision of Contractors using CDB's procurement procedures and the FIDIC Multilateral Development Bank Harmonised Edition of Conditions of Contract for Construction for Building and Engineering Works designed by the Employer.
			GPL IDP (US$42M; 2010 to 2014): The national power utility, Guyana Power & Light Inc. engaged CEMCO to supervise a design-build contract for the engineering, procurement and construction of approx.100km of 69kV transmission lines, 10No. 69kV/13.8kV Substations with a SCADA Automation System, valued at US$40 million. The Expert represented the Engineer under FIDIC Design-Built contract format and in the role of Resident Engineer, managed the procurement of the installations, resolved contract issues and valued the work as it progressed.
			IADB T1090 - GWI Guyana Water Supply & Sanitation Infrastructure Project (US$28M; 2014): Development of Design Criteria and Preparation of Tender Documents for procurement of Contractors for a) Design-Build of 3 Water Treatment Plants (WTPs), Upgrade of 3 WTPs and approx. 50km of new reticulation as well as b) Employer's (Consultant) full-scale design for the Upgrade of existing 18km of reticulation in the city of Georgetown, Guyana (Est. US$30M). The Expert performed the function of Procurement Specialist, reviewed technical scope of works, performed desktop research on various applicable forms of contract to suit specific scope including design build for

			water treatment works and employer-designed for reticulation work. Recommended and finalised forms of bidding structures for two types of contracts. Prepared bidding documents to complement technical designs and specifications. Finally modified to suit Client's specific choices. Worked separately and with Consultancy team.
			GoG Amaila Falls Hydropower Project – 49KM Road Contract (US$8.5M; 2013): CEMCO was engaged by the National Industrial and Commercial Investment Limited (NICIL) on behalf of the Ministry of Public Works and Transport, Government of Guyana to develop a Contract for design, procurement and construction of 49km of new access road, being the final section of the hinterland route to the proposed Amaila Falls Hydropower Project. The Expert in the role of Contract Specialist: a) Utilised the FIDIC Silver Book (Design Build) Form of Contract, developed Special Conditions of Contract and related Contract Addenda including Payment Schedule, Form of Agreement, Performance Security, Advance Payment Bonds, etc. b) Reviewed Employer's Requirements to ensure compatibility with Contract Forms; advised adjustments. c) Assisted the Client with contract negotiation and finalisation of Contract with selected firm, China Railway First Group (Guyana) Inc.
			GoG Georgetown Marriott International Hotel and Entertainment Complex (US$52M; 2011): CEMCO was engaged by the National Industrial and Commercial Investment Limited (NICIL) on behalf of Atlantic Hotels Inc. to develop a Contract for design, procurement and construction of a 197 room international hotel and entertainment complex in Georgetown, Guyana. The Expert in the role of Contract Specialist: a) Utilised the FIDIC Design Build Form of Contract, developed Special Conditions of Contract and related Contract Addenda

			including Payment Schedule, Form of Agreement, Performance Security, Advance Payment Bonds, etc. b) Used the FIDIC Design Build Form of Contract, developed Special Conditions of Contract and related Contract Addenda including Payment Schedule, Form of Agreement, Performance Security, Advance Payment Bonds, etc. c) Following selection of the preferred bidder, assisted the Client with contract negotiation and finalisation of Contract.
			GoG Berbice River Bridge Project (US$40M; 2005-2009): CEMCO was engaged by the National Industrial and Commercial Investment Limited (NICIL) on behalf of emerging Berbice Bridge Co. to conclude Contract negotiations and to supervise the Contractor for the design and construction of a 1.6km long pontoon floating bridge at the estuary of the Berbice River, Guyana, with a 70m wide retractable span; using suction embedded anchor systems to restrain the 39 pontoons, pre-fabricated galvanised steel sections, riding surface of calcined bauxite embedded in polymer and approaches at both landing ends. The Expert performed the roles Contract Specialist/Resident Engineer/Deputy Project Manager: a) As Contract Specialist, assisted in the negotiation of the final form of FIDIC design build contract including special conditions of contract, bonds and payment schedule. b) As Resident Engineer and Deputy Project Manager, used the contract particulars to aid the control of the contract processes and the delivery of the bridge.
1996 to 2004	Guyana Water Authority (GWI); Project Manager Engineer. Contact: o - GWI, Guyana - Jailal (592 225 0471).	Guyana	**Water Supply Technical Assistance and Rehabilitation Project (Est. US$60M; 1996 2004)**: The Government of Guyana, through the Guyana Water Authority, the national water utility, undertook the procurement of Works for the improvement of water supply systems along the coastal region of Guyana where 90% of the population resides. Funded

			by several multilateral Agencies including World Bank, European Union, DFID, European Investment Bank, Caribbean Development Bank, Japanese Govt., and Govt. of Guyana. Includes rehabilitation of approx. 100 well pump stations and 5 water treatment plants, construction of 4 new water treatment plants; improvement and extension of pipe reticulation in all project areas. Procurement of laboratory facilities, etc. The Expert was engaged by the World Bank to manage the entire project; with the assistance of international specialist, develop procurement documentation including forms of contract for all aspects of the project, management of the tender processes, and management of both construction firms and engineering supervision services to ensure project deliverables are achieved wrt time, quality and cost. Perusal of all forms of contract and editing to suit local requirements.

Membership in Professional Associations and Publications:

Fellow of the Guyana Association of Professional Engineers.

Language Skills (indicate only languages in which you can work):

Language	Speaking	Reading	Writing
English (native)	Excellent	Excellent	Excellent
German	Fair	Fair	Fair
Spanish	Limited	Limited	Limited
Guyanese Dialect	Excellent	Excellent	Rudimentary

Adequacy for the Assignment:

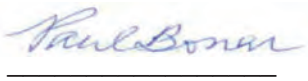
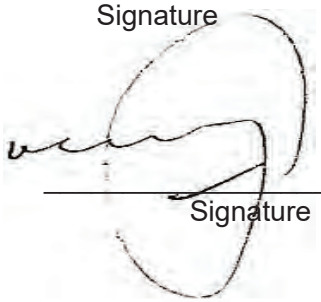
Task No.	Ref. to ToR	Detailed Task assigned to the Procurement Specialist	Reference to Prior Work/Assignments that Best illustrate Capability to handle the Assigned Tasks.
1.	All aspects,	a) Review Terms of Reference and	All work references in

	including 1.03 (assistance to GoG in managing the procurement of Contractors)	finalise with Consultant's Team Leader any issues relating to the CDB's procurement procedures and the specific suitability of the FIDIC Multilateral Development Bank Harmonised Edition of Conditions of Contract for Construction for Building and Engineering Works designed by the Employer. b) Agree on the approximate construction time lines each of the eight interventions and the packaging of these interventions into eight or less individual contracts. c) Review and discuss the general content of the document for prequalification of Contractors.	including the Expert's extensive general experience in the planning and timely execution of works.
2.	3.06 (e)	a) Prepare document for pre-qualification of Contracting Firms using the CDB i) User's Guide for Prequalification Document for Procurement of Works and ii) Prequalification Document for Procurement of Works. b) Finalise document after review with Team and Client.	Tasks undertaken for BNTF during 2005 to present.
3.	3.06 (b)	Following finalisation of Task 1 and tentative agreement on Task 2, prepare the bidding documents for each bidding package, Part I - Bidding Procedures and Part 3 – Conditions of Contract and Forms. Part 2 would await inputs from the design engineers and other specialists. The form of Contract would be in keeping with CDB procedures, namely FIDIC Multilateral Development Bank Harmonised Edition of Conditions of Contract for Construction for Building and Engineering Works designed by the Employer.	Tasks undertaken in all of the aforementioned bid and contract preparations.
4.	3.06 (b)	Finalise all documents and publish as required after approval by the Team Leader and concurrence by the Client. If may be required to issue pre-qualification document before the end of Phase II – Detailed Design.	All work references in including the Expert's extensive general experience in the planning and timely execution of works.

Expert's contact information: (pbonar@cemcoguyana.com, phone: 226 2758)

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience, and I am available to undertake the assignment in case of an award. I understand that any misstatement or misrepresentation described herein may lead to my disqualification or dismissal by the Client, and/or sanctions by the Bank.

Paul A. Bonar		12/12/2018
Name of Expert	Signature	Date
Raymond. B. Latchmansingh		12/12/2018
Name of authorized Representative of the Consultant	Signature	Date

Curriculum Vitae

Elford Alwin Liverpool
University of Guyana: Consultant Coordinator/Zoologist

584 West Ruimveldt H/S, Georgetown, Guyana, South America
Tele: 592-223-3257, 626-4109, 6256558
E-mail: elfordliverpool@yahoo.com, elfordliverpool@gmail.com

Personal Information

Nationality -	Guyanese
Date of Birth -	August 30th 1984
Marital Status -	single

Education

DOCTOR OF PHILOSOPHY (Ph.D) BIODIVERSITY CONSERVATION –STUDENT
Thesis topic: Mining impacts, mercury and food web ecology in fishes of the Middle Mazaruni River Drainage, Guyana
UNIVERSITY OF GUYANA AND (COL: SAM HOUSTON STATE UNIVERSITY, U.S.A.
SEPT 2015-PRESENT

MASTERS OF SCIENCE (MSC) IN FOREST BIOLOGY)
SEPT2010- NOV 2013
UNIVERSITY OF GUYANA AND (COL: ROM AND UOFT, CANADA) GEORGETOWN, GUYANA

TURKEYEN CAMPUS
Thesis: **Impacts of environmental degradation on fish assemblage structure in the Upper Mazaruni River Basin, with description of their community structure and habitat requirement, Guyana, South America**
Advisors; Dr. Hernan Lopez, University of Toronto and Royal Ontario Museum, Canada and Dr. A. Ansari, Mr. P. Da Silva; Faculty of Natural Sciences, University of Guyana

INT'L DIPLOMA PROJECT MANAGEMENT **APRIL–AUGUST 2010**
EDEX U.K. AND UNITED KINGDOM
ROYAL ACADEMY GEORGETOWN, GUYANA

INTERNATIONAL CERTIFICATE IN MUSEUM STUDIES **2008**
COMMONWEALTH ASSOCIATION OF MUSEUM (CAM) CANADA

TRAINED IN TAXIDERMY AND MUSEUM CONSERVATION **DEC 2008 - 2009**
GUYANA NATIONAL MUSEUM GEORGETOWN, GUYANA
INSTITUTE OF ECOLOGY AND SYSTEMATICS (CUBA) & MINISTRY OF CULTURE, GUYANA)
HAVANA, CUBA
Advisor; Mr. Marco Olcha, Institute of Ecology and Systematics, Cuba

BACHELOR OF SCIENCE DEGREE (BSC BIOLOGY) **2001 - 2005**
UNIVERSITY OF GUYANA GEORGETOWN, GUYANA
Major: Biology *Minor:*Chemistry
Activities: Member of UG football club (Natural sciences).
Major Research: **The effects of *momordica charantia* (karela) and *apium graveolens***

(celery) on high blood pressure and blood glucose levels in laboratory rats.
Supervised by; Dr. Emanuel Cummings, Faculty of Health sciences

Certificate in Laboratory Techniques **May- Sept. 2005**
GOVERNMENT ANALYST FOOD AND DRUGS DEPARTMENT KINGSTON GEORGETOWN
MINISTRY OF HEALTH BRICKDAM, GEPRGETOWN

Guyana Zoo Education Volunteer Certificate April- **Aug 2004**
GUYANA NATIOINAL ZOO GEORGETOWN, GUYANA

Certificate in Ornithological (bird) field and taxidermy Techniques **Aug 2004**
Smithsonian Institute WASHINGTON DC, U.S.A.
Centre for the Studies of Biological Diversity UNIVERSITY OF GUYANA.

EIGTH (8) CARIBBEAN EXAMINATION COUNCIL (CXC) - GENERAL PROFICIENCY LEVEL
1996 – 2001.
ST. JOHN'S COLLEGE. GEORGETOWN, GUYANA
ENG/A-111, MATHS-111, SOC.STUDIES-111, HISTORY-11, BIO-11, AGRI-SCI-11, INTE-SCI-11 AND ENG/B 1V
Awards: Second best graduating student for the year **2001.**
Best graduating student in **Biology, Agriculture Science** and **History** for the year **2001**

Research Projects/ Papers/Publications

Shark identification using DNA barcoding from fin clips in Guyana (in Darft) Oct, 2016

Scoping study for sharks and rays from artisanal fisheries in Guyana (Funded by WWF-Guianas) 2015-2016

Impacts of environmental degradation on fish assemblage structure in the Upper Mazaruni River Basin, with description of their community structure and habitat requirement, Guyana, South America. E. Liverpool (in Draft and review) 2016

Mind the (information) gap: the importance of exploration and discovery for assessing conservation priorities for freshwater fish.
Alofs, Liverpool, Lopez, Bernard & Taphorn **(**Pub) Aug 2013

New species of *Cichlid* (Teleostei: Cichlidae) *Krobia aff. potaroensis* from the upper Mazaruni River drainage, Guyana. Steele, Liverpool and Lopez (Pub) Jul 2013

New species of *Lebiasina* (Ostariophysi: Characiformes: Lebiasinidae) from the upper Mazaruni River drainage, Guyana. reira, Taphorn, Liverpool *etal* 2012 (pub) Jan 2013

Phylogenetic diagnosis and expanded description of the genus *Mazarunia* Kullander, 1990 (Teleostei: Cichlidae) from the upper Mazaruni River, Guyana, with description of two new species
Lopez, Taphorn and Liverpool Pub 2012

Taxidermy and Museum conservation Manuals composed, developed and edited with Cuban Museum Specialist: Mr. Marco Olcha and Elford Liverpool **December 2008-2009**

Formula for Taxidermy Works, Guide to taxidermy classes, Procedure manual for crustacean taxidermy (crab), Procedure manual for crustacean taxidermy (lobster), Procedure Manual for Liquids Collections, Procedure Manual for Preparation of Chelonian (turtles), Procedure Manual for Preparation of Fishes with scale, Procedure Manual for the Preparation of Bats, Procedure manual for preparation of bird for study skins, Procedure manual for reptiles, Procedure manual for Snakes, Procedure manual for taxidermy of amphibians, Procedure Manual for the preparation of Skeletons, Procedure manual for preparation of small mammals, Procedure manual for taxidermy of mammal heads for trophy, Recommendations for the capturing and mounting insects and butterfly,

Recommendations for the conservation of the zoological collections and Recommendations for the Preparation of Shells and Snails, A proposal on the general recommendations for the Guyana National Museum developed by Mr. Marco Olcha and Elford Liverpool.

The effects of *momordica charantia* (karela) and *apium graveolens* (celery) on high blood pressure and blood glucose levels in laboratory rats; this research was done in the aim of suitable alternatives to treat High blood pressure and Diabetes in Guyana using natural plant
extracts that are found locally in Guyana**.** **Elford Liverpool Sept. 2005** (unpublished)

Completion of a **tour guide booklet** for the Guyana National Museum.
It is based on Guyana's Natural history (faunal biodiversity and the taxidermy specimen) and social history collections displayed at the National Museum. (MCYS printed)

Employment/Research Experience

Head, Department of Biology
Management of Biology Department on day to Day basis, Budgeting, Development and Implementation of Programmes, Human Resource management, policy decisions, Examinations.

July 2017-
July2019

Lead Researcher/Consultant NAPPI Reservoir Fisheries Project CI-Guyana
Biodiversity and Fisheries survey for NAPPI Reservoir project, Nappi Village, Region 9, 2019. Fisheries and other biodiversity assessment of reservoir including water quality data collection, Checklist/inventory of species, characterization of habitats. Conservation International Funded Project.
February- April 2019

Museum conservation Workshops
Chief Instructor and Trainer for two workshop programs for Ministry of Culture, Government of Guyana on Museum conservation and preservation techniques for natural history collections (flora and fauna) and ethnographic artifacts (basketry, craft etc) from Amerindians in Guyana. Twenty (20) persons were trained in theoretical and practical work in Care for Museum
collections**.** **Novermber-December, 2017**

Co-Lead Researcher: Length Frequency Data Guyana-Suriname-WWF Guianas
Development of protocols for length frequency and size at maturity data for commercially important fish species in Guyana and Suriname. Coordination of data collection for Guyana in collaboration with Tomas Williams in Suriname.
August 2017-2018

Museum conservation Workshops
Chief Instructor and Trainer for two workshop programs for Ministry of Culture, Government of Guyana on Museum conservation and preservation techniques for natural history collections (flora and fauna) and ethnographic artifacts (basketry, craft etc) from Amerindians in Guyana. Twenty (20) persons were trained in theoretical and practical work in Care for Museum
collections**.** **Novermber-December, 2016**

Public Presentation: Sharks and Rays
Scoping study for sharks and rays from artisanal fisheries in Guyana at Muray House Georgetwon, (Funded by WWF-Guianas)
November, 2016

Executive Board Member Wildlife Scientific Authority (CITES) Board
Aid in policy decision making for wildlife studies and related issues in Guyana. Monitoring of permits and wildlife related activities in Guyana. **January 2016-present**

Lead Researcher: Dry season Field Survey and data collection on mining impacts on fishes and food web ecology in mid and lower Mazaruni River, region 7 Guyana.
Project in collaboration with IDB-UGSTSP, ROM Canada, Auburn University USA, WWF-

Guyana, GGMC and EPA Guyana. **July- August, 2016**

Temp. Marine Officer: WWF-Guiana
Temporary staff with responsibility for the marine programs in Guyana. Assist with completion for two sets of proposals (SRJS & EU MPA/MSP) and WWF country programs and budgets. Interacted with stakeholder's including Department of Fisheries, Protected Areas Commission, CI-Guyana, FAO and other NGOs for successful participation and implementation of projects related to the Marine Sector.

May-July, 2016

Lead Researcher: Wet season Field Survey and data collection on mining impacts on fishes and food web ecology in mid and lower Mazaruni River, region 7 Guyana.
Project in collaboration with IDB-UGSTSP, ROM Canada, Auburn University USA, WWF-Guyana, GGMC and EPA Guyana. **March- April 6, 2016**

Identification and survey of Sting Rays on the Coast of Guyana
Survey of Sting Ray diversity on the Coast of Guyana using various gear types (with Mohini Sooklall. **Sept-2015-May, 2016**

Estuarine Fish Diversity project
Seasonal variations in diversity of Fishes in the estuarine of the Demerara and atlantic coast Guyana. (with Ajuba Clarke) **Sept-2015-May, 2016**

WWF-Guyana: Survey of Sharks and Rays landed at fisheries sites on the coast of Guyana
General survey including questionnaire instrument, shark and ray identification, collection of socio-economic data and morphometric data and DNA samples from sites in Region 2, 3, 4, 5 and 6.

June-July, 2015

Awardee: IDB-University of Guyana Science and Technology Support grant (33,000 USD)
Impacts of Mining on Fish Community Structure and trophic levels (diet) using stable isotopes in the Lower Mazaruni River basin, Guyana. Donald Taphorn, Royal Ontario Museum Canada, Hernan Lopez-Fernandez, Royal Onatrio Museum Canada and University of Toronto; Jon Armbruster, Auburn University USA, Abdullah Ansari, University of Guyana; World Wildlife Funds (WWF)-Guyana, EPA-Guyana, GGMC-Guyana. **June 2015- Present**

Lead Researcher-Guyana Gold Fields
Assessment of Stream Health and mercury analysis of macro-invertebrates and fishes of the Cuyuni River, Guyana. Guyana Gold Fields **June-July 2015**

Co-Lead Researcher-Estuarine and Marine fisheries Survey
Survey of Freshwater, Estuarine, and Marine fishes of Demerara and coast of Guyana; In collaboration with CSBD, ROM and University of Toronto, Canada. **March-April, 2015**

Researcher: WWF-Guyana and Global Wildlife Conservaion

Assessment of stream health and fishes of the Konawaruk and Mazaruni rivers and Exploration of Upper Berbice river. Sampling of fishes and marco-invertebrates using various methods and techniques and recording water quality data. Collection of tissue samples for Mercury analysis from fishes in all locals. Assessment of habitat and technical report writing and submissions.

Sept 1-30, 2014

Amaila Falls Consultancy: Assistant Research Consultant: WWF and IDB

Lead by Prof. Donald Taphorn, this exercise embarked on collection of specimens for newly described *Characiduim amaila* fish species from the Amaila falls and ecological habitat data to better understand their population genetic structure and habitat requirement needs, to assess other potential habitats that will reduce any impacts of dam construction on species population of this fish species, and to provide strong recommendations to mitigate any threats from such projects. This is to assist with the implementation and construction of the Amaila hydroelectric dam on the Kuribrong river, Guyan**.** **March to April 2014**

Scientific Officer/Lecturer

University of Guyana, Faculty of Natural Sciences, Department of Biology; teaching Taxonomy, ecology, biostatistics, biodiversity surveying techniques to Biology Undergraduate students. Aslo works on verification of specimens for export from field researches in Guyana at the CSBD with collaborations with the EPA and CITES Deparments. Supervision of Undergrad final year projects.

September 2013-present

Amaila Falls Consultancy SITHE Global: Assitant Research Consultant

This excercise embarked on collection of specimens for newly described *Characiduim* and *Lebiasina* fish species from the Amaila falls and ecological habitat data to better understand their population genetic structure and habitat requirement needs. This is to assist with the implementation of the next phase for the construction of the Amaila hydroelectric dam on the Kuribrong river**.**

April-May 2013

Teaching assistant (TAs) for **Ornithology** and **Herpetology** studies at **Camp Seywao, Linden Highway** to University biology students. This involved trapping using various methods, collecting, Taxonomy: identifying species and environmental impact such as food resources, human impact etc. and methods in preservation of specimen. **March 2013**

Project Manager and Coordinator:

The preparation and launching of a Museum Mobile and School Loan Programme for the

Guyana National Museum and schools around Guyana; The programme involved taking Museum exhibits to schools and uses them as teaching aids in classrooms with work sheets. It also aims to promote museum awareness and preserve our cultural heritage in Guyana.

February 2013

Government Chief Museum Rep.
Cross-Border Network of Amazonian Museums Conference and meeting win Suriname, French Guiana and Brazil to assess the situation of Museums across the region and to establish bi-lateral and concrete agreements with these neighbouring countries. Presentation was done on Museums and our cultural programmes in Guyana to the audience. **December 2012**

Teaching assistant (TA): for **Mammology** and **Ichthyology** studies at **Chikabaru- Region 10** to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of museum specimens (fishes and small mammals). **November 2012**

Chief Instructor and coordinator for The Children's Taxidermy Camp 2012: at the Guyana National Museum. It involved lessons and practical work on wildlife biodiversity, environmental problems and taxidermy preparation of simple specimens along with roles of Museums. Organizations involved are Iwokrama, University of Guyana, Centre for the Study of Biodiversity, and the Environmental Protection Agency. **July- August, 2012**

Project Planner: Annual Immigration exhibition at the Guyana National Museum
The objectives of the exhibition are: to highlight the Cultural Impacts of Indentured Immigrants since their arrival to Guyana, to develop a program of activities that would promote Cultural Diversity in Guyana using the Indentureship Experience and to commemorate the arrivals of the Chinese, Portuguese, East Indian and African Immigrants to Guyana. **May 2012**

Training in Data and Statistical Analysis:
During the period April to June 2012, worked on data analysis for ecological data collected over the past four years for Habitat requirement for Fish fauna of the Upper Mazaruni river basin Guyana. Training involved preparation of data for CANOCO (Canonical Correspondence Analysis), ANOSIM (Analysis of Similarity) and DFA (Discriminant Function Analysis); to test the effects of environmental variables on fish community structure as a result of mining activities in the Mazaruni Region. **ROM Canada** **April to June 2012**

Coordinator/facilitator: preparation and launching of Ministry of Culture Mash Exhibition at the Guyana National Museum as part of our public programmes for educational development. It was the sixth successful exhibition held as part of our annual programme of activities. **February 2012**

Chief Researcher
Research and Ecological survey of fishes in the upper Mazaruni basin and its tributaries

The research focused on the sampling of all fishes in various reaches of the Upper Mazaruni river basin with ecological data between and including Kukui, kako, waruma, piakwa and kamarang rivers and Assessing species richness and abundance of the fish fauna of the upper Mazaruni river basin, Museum specimen collections etc. This was collaborated with the CSBD University of Guyana, the Guyana National Museum, and Royal Ontario Museum, Canada

November 2011

Country Supervisor:
Supervisor for Commonwealth Association of Museum Internship Exchange Programme between Guyana and Canada; Intern Ms. Renee Homiak from Canada for six months internship in Guyana at several Government Museums. The focus was on developing public programming and conservation for Museums. Oct 2010 to April 2011

MSc research and Ecological survey of fishes in the upper Mazaruni basin and its tributaries
The research focused on the sampling of all fishes in various reaches of the Upper Mazaruni river basin with ecological data between and including Kukui, kako, waruma, piakwa and kamarang rivers and Assessing species richness and abundance of the fish fauna of the upper Mazaruni river basin; Museum specimen collection. This was collaborated with the CSBD University of Guyana, the Guyana National Museum, and Royal Ontario Museum, Canada

March 2011

Coordinator/facilitator: preparation and launching of Ministry of Culture Mash Exhibition at the Guyana National Museum as part of our public programmes for educational development. Feb, 2011

Coordinator/facilitator: preparation and launching of Curio shop at the Guyana National Museum: The shop served to provide additional services for visitors to the Museum as part of a visiting experience. **December 2010**

Coordinator and Organizer: Mexican Exhibition for the Mexican Embassy and the Ministry of Culture, Youth and Sport and National Museum. November, 2010

Coordinator and Organizer: Annual Chinese Exhibition for the Embassy of the People Republic of China and the Ministry of Culture, Youth and Sport.
September 2008 to 2010

Coordinator: Children's Taxidermy Camp 2010: at the Guyana National Museum. It involved lessons and practical work on wildlife biodiversity, environmental problems and taxidermy preparation of simple specimens along with teaching students about roles of Museums. Organizations involved are Iwokrama, University of Guyana, Centre for the Study of

Biodiversity, National Trust and the Environmental Protection Agency.

July-August, 2010

Coordinator Museum Policy Committee:
The objective is to develop and implement a National Museums of Guyana Policy and a Museum Act for all Museums in Guyana. June, 2010- present

Project Manager /Coordinator: Cartographic Museum/map room project, Guyana National Museum, Ministry of Culture, Youth and Sport. The aim was to establish a Map/Cartographic Museum to display Guyana's cartographic heritage, boundary disputes etc from the 1500s to current. Sept 2009 to May, 2010

Coordinator and Organizer: Russian Exhibition for the Embassy of Russia and the Ministry of Culture, Youth and Sport Titled: ''*the Great Patriotic War*" at the Guyana National Museum May 2010

Coordinator/facilitator: Annual Immigration exhibition at the Guyana National Museum. The objectives of the exhibition are: to highlight the Cultural Impacts of Indentured Immigrants since their arrival to Guyana, to develop a program of activities that would promote Cultural Diversity in Guyana using the Indentureship Experience and to commemorate the arrivals of the Chinese, Portuguese, East Indian and African Immigrants to Guyana. **May 2010**

Commonwealth Association of Museum executive Board Member and Youth Representative: Assistance in technical advice and planning programmes, conferences etc, Guyana representative **Feb, 2010-present**

Coordinator for the Preparation of the Megatherium: at the Guyana National Museum. All technical planning, monitoring and evaluation and Implementation of Mega-T specimen within the National Museum **Jan-April, 2010**

Technical Assistant/Assistant Lecturer and Co-Researcher to University of Guyana third and final year Biology students. Pibiri forestry concession, Mabura trail, **Ornithology** and **Herpetology** studies; involved teaching trapping using various methods, collecting, identifying/Taxonomy of species and environmental impact such as food resources, human impact etc. and preservation of specimen for Museum collection. **January 2010**

Field Expedition for excavation of Giant Ground Sloth bones: collaboration with: Berkley University, U.S.A, Walter Roth Museum and CSBD University of Guyana.

Oct. 2009

Chief Instructor and coordinator for The Children's Taxidermy Camp 2009: at the Guyana National Museum. It involved lessons and practical work on wildlife biodiversity, environmental problems and taxidermy preparation of simple specimens along with roles of Museums. Organizations involved are Iwokrama, University of Guyana, Centre for the Study of Biodiversity, and the Environmental Protection Agency. **July 07- August 07, 2009**

Coordinator- Annual Indentureship exhibition, mounted at the Guyana National Museum, highlighting Guyana's Cultural heritage. This exhibition focused on the arrival of Indentured Immigrants to Guyana after the abolition of Slavery. Objectives were to highlight the Cultural Impacts of Indentured Immigrants since their arrival to Guyana, to develop a program of activities that would promote Cultural Diversity in Guyana using the Indentureship Experience, to increase the public`s awareness on the in-depth history of Indentured servants, to assess the impacts of European influences on Guyana. **May 2009**

Commonwealth Association of Museums (CAM) student; the Program is a distance learning program with CAM, involves Museum management, conservation, preservation and restoration and managing visitors to the museum. **April 2009**

Project Manager and coordinator Giant Sloth/Megatherium Project and Recon Field Expedition: responsible for laying out and setting up giant sloth exhibit at the Guyana National Museum and to develop further research in the paleontology and paleobiology areas.

March 2009

Administrator, Taxidermist and Curator (Guyana National Museum): involves managing the National Museum on a day to day basis, financial transactions and budget preparation for National budget for the Museum, planning and executing programme of activities etc

October, 2008-present

Technical Assistant to University of Guyana third and final year Biology students. Chikabaru forestry concession, Ituni trail, region 10, **Ornithology** and **Herpetology** studies; involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen for Museum collection.

February 2009

Global Information system (GIS), Global Positioning System (GPS), MapInfo software program training; involves reading of Maps, using of spatial data in map Software, creating maps, and taking coordinates for input.
Guyana Geology and Mines (GGMC) **Jan 2009.**

Taxidermist/Conservator; Completion of a one year training on museum conservation, preservation, restoration and taxidermy and taxonomy; Tr ainer and facilitator: Cuban Museum Specialist and Taxidermist- Mr. Marco Anthonio Olcha; from the Institute of Ecology and Systematics, Cuba. **Dec 2007- Dec 2008.**

External Supervisor/Assessor/Examiner- Faculty of Natural sciences, University of Guyana, Final year Biology Students Research presentations at **Conservation International conference room.** This involved analysis research data presented by research students and grading them according to preparation, content, knowledge and skills, response to questions asked etc. The following researches were examined: A survey of the Avifauna diversity at OMAI Gold Mines Ltd, A survey of the Herpetofauna diversity at OMAI Gold Mines Ltd, To investigate the fecundity rates in *Poceila sp* during capitivity, A study of Oma ponds as a

traditional Natural Resource Management Approach in the North Rupununi, Guyana, Survey of mammals in gallery forest of the Upper Rupununi River, Guyana, Optimizing in-vitro growth for cellulytic bacteria from the cattle rumen, Pilot investigation of the possible anticarcinogenic effects of local fruits on Leukemia, Study of the aquatic Macro-invertebrate community at the Yararibo lake system, Mc Kenzie, Linden, Guyana, A investigative study on primates in the Iwokranma forest conservation. **July 30-September 11, 2008.**

Co-researcher/Assistant supervisor- field survey on 'hassar' Loricariidae catfishes in the Mahaicony conservancy area using drag seining techniques and collecting museum specimens to enhance the national collection. This study is to assess the economic importance of the hassar in Guyana. **August 22, 2008.**

Co-researcher/assistant supervisor- ecological and species diversity survey of fishes at Lake Mainstay Essequibo, Guyana. This research involved the surveying of fishes in the lake using methods of drag seining, gill netting and hand netting. Water parameter tests were conducted on PH, temperature, depth and range finder, along with GPS coordinates. Diurnal and nocturnal surveys were done over a three days period. **Aug 15-17, 2008.**

External Assessor/Examiner- Faculty of Natural sciences, University of Guyana, Final year Biology Research presentations at Conservation International conference room. This involved analysis research data presented by research students and grading them according to preparation, content, knowledge and skills, response to questions asked etc. **July 30, 2008.**

Assistant supervisor/Co-Reasercher: biodiversity survey on avifauna and herpetofauna studies for reclamation project OGML, Omai Gold Mines Limited and environmental effects. Assisting University of Guyana Final year biology students in field techniques and writing criterias for their final year research projects, in addition preparation of ornithological museum study skins and museum wet collections of herpetofauna. **June18-25, 2008**

Cheif/ Head Researcher: Faunal diversity survey and Impact Assessment**,** The Amaila Falls Transmission line Hydropower Alignment project. Assessing and analysing faunal data and reporting on such in relation to environmental impact and checklist on fauna etc.
Potaro region, Guyana, South America **May 2008**

Co-Researcher/Assistant Researcher: Ichthyofaunal survey of the Upper Mazaruni River, **Guyana, South America.** The research focused on the sampling of all fishes in various reaches of the Upper Mazaruni river basin between and including Kukui, kako, waruma, piakwa and kamarang rivers and Assessing species richness and abundance of the fish fauna of the upper Mazaruni river basin; Museum specimen collection. This was collaborated with the CSBD University of Guyana, the Guyana National Museum and Royal Ontario Museum, Canada
14- 25 April, 2008.

Teaching assistant (TA): for **Mammology** and **Ichthyology** studies at **Pibrie- Mabura area** to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of museum specimens (fishes and small mammals). **4-7, April 2008.**

Assistant supervisor/Co-Reasercher: biodiversity survey on avifauna and herpetofauna studies for reclamation project OGML, Omai Gold Mines Limited and environmental effects. Assisting and teaching University of Guyana Final year biology students field techniques and writing criterias for their final year research projects**.** **Feb 27- March 5, 2008.**

Anthropological (Scientific) Officer and Taxidermist at the **Guyana National Museum**, chief functions and protocols involves head of taxidermy department with a supervisory roles and responsibility for anthropological assistants and duties thereof to the department. Responsibility for planning and coordinating field works for specimen collections, analysing the data for biological and other natural history specimens in the museum laboratory and providing updated information on Natural history (biodiversity) aspects, preparation of scientific study skins and mounting of taxidermy specimens. Cleaning, conservation, preservation and restoration of natural history collections a.g. Deputy to Administrator with duties of management at the National Museum among many other assigned duties which includes lectures and tour guides to various organisations, schools and the general public. **June 2007 – October 2008**

Assistant and external supervisor;
Supervisory role to students at the University of Guyana with respect their final year research projects. Involves identification and classification of biological specimens along with relevant information and approaches in analysis of data. **2005 –present**

Teaching Assistant (TA)
Mammology and **Ornithology** studies TA at **CEIBA** for University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen for Museum collection. **Nov 16- 19 2007**

Assistant supervisor/ researcher on final year research project to University of Guyana student: studies based on the use of entomology or insects in forensic studies. Done by; C. Horatio. **July - Oct. 2007.**

Chief Instructor and deputy coordinator for The Children's Taxidermy Camp 2007 at the Guyana National Museum. It involved lessons and practical work on wildlife biodiversity, environmental problems and taxidermy preparation of simple specimens along with roles of Museums. Organizations involved are Iwokrama, University of Guyana, Centre for the Study of Biodiversity, and the Environmental Protection Agency.

July 07- August 07, 2007.

Teaching assistant (TAs) for **Mammology** and **Ichthyology** studies at **CEIBA** to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen for Museum collection. **April 2007.**

Research field assistant on **Ornithology** studies and **bird museum** (wet and dry) collections at Paurima and Holitipu, Upper Mazaruni region #7. This included preparation of specimens, trapping of birds, identification of birds. **Feb-March 2007**

Teaching assistant (TAs) for **Ornithology** and **Herpetology** studies at **CEIBA** to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen. **Nov 2006**

Head faunal researcher/Assistant researcher for **Environmental Impact Assessment** (EIA) on floral and faunal studies at Guyana gold fields, Aurora, Upper Cuyuni River**.** **Oct. 2006.**

Research field assistant on **floristic studies** and sample collections at Kaieteur National Park, Amatuk, Madahia, Eagle Mountain and Micobe. This was done in Collaboration with Smithsonian Institute and Centre for the Study of Biodiversity. **August- sept. 2006.**

Head faunal researcher/Assistant researc her for **Environmental Impact Assessment** (EIA) on floral and faunal studies at Guyana gold fields, Aurora, Upper Cuyuni River**.** **July 2006.**

Assistant researcher for **Environmental Impact Assessment** (EIA) on baseline study of aquatic environment at Yararibo old mines Omai bauxite mining inc. (OBMI) Mc Kenzie, Linden. **June 2006.**

Teaching assistant (TAs) for **Ichthyology** studies at CEIBA to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen. **April 2006.**

Centre for the Studies of Biological Diversity Volunteer/ researcher; involves local field research, expeditions, techniques in trapping, DNA and Tissue sampling, Study of Biodiversity and ecological studies, Museum techniques and preparation of Museum Specimens, training of Biology students, research with Smithsonian Institute and Royal Ontario Museum, Auburn University, and Texas A&M university. **Jan. 2006-present.**

Research field assistant on **ichthyology** studies/survey and sample collections at Iwokrama, Annai, Piarra, Takutu river, Ireng river, Kurupukari and upper Essequbo River. This involved trapping using various methods, collecting, identifying species and preservation of specimen. **Nov-Dec. 2005.**

Teaching assistant (TAs) for **Mammology** and **Ichthyology** studies at CEIBA to University biology students. This involved trapping using various methods, collecting, identifying species

and environmental impact such as food resources, human impact etc. and preservation of specimen. **Nov 2005.**

Ministry of health: Government Analyst Food and Drugs Department. Work study attachment, functioning as **Laboratory technician** in the department of food chemistry, water chemistry, microbiology. **Jul-Sept. 2005.**

Teaching assistant (TAs) for **Ornithology** and **Herpetology** studies at CEIBA to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen for Museum collection. **Apr. 2005.**

Faunal researcher/Assistant researcher for **Environmental Impact Assessment** (EIA) on floral and faunal studies at Guyana gold fields, Aurora, Upper Cuyuni River**.**

Jan. 2005.

Teaching assistant (TAs) for **Ornithology** and **Herpetology** studies at CEIBA to University biology students. This involved trapping using various methods, collecting, identifying species and environmental impact such as food resources, human impact etc. and preservation of specimen for Museum collection. **Nov 2004.**

Ornothological field and taxidermy training: this involved the field techniques in trapping, taxonomic identification of birds, taxidermy-skinning, preservation of skins and stuffing, Preparation of bird reference collections for museums. **Aug. 2004.**

Guyana Zoo education volunteer: include giving informal cage side talks, guided zoo tours, and policing the zoo and giving factual information on animals in the zoo

Jun 2004-present.

Contributing Researcher to the development of the Bird checklist of Guyana, Herpetofauna and Mammalian fauna Checklist of Guyana. Jan 2004 to Present

Ministry of health: Work study attachment at the **Georgetown Public Hospital** in **Orthopaedic clinic**, duties include setting and casting of broken bones and removal of casts.

Jul-Aug. 2001.

Current/Pass Project Supervision: BSc students

Adele Elcock, The effects of various nutrient types on the rate of eutrophication ex situ.

Ajuba Clarke, Survey, seasonal diversity and diet of Estuarine and Marine fishes from the Demerara and its immediate coast.

Mohini Sooklall, Survey of Sting Ray diversity on the Coast of Guyana using various gear types.

Mohinder Deven Itwaru; To investigate the effects of applying different sources of animal manure on the yield and growth rate of tomatoes (Solanum lycopersicum) plants grown Geoponically.

Bhagmadai Sooku; Bio-survey on water quality and fishes in central Georgetown, with assessment of morphology, diet and heavy metal content in tissues of selected species.

Ferial Pestano; An investigation on entamo-pathogenic fungus found on insects at the University of Guyana campus. (Main Supervisor: Prof. A. Ansari)

Jenelley Lewis; The effects of brewery wastewater on tilapia sp at Banks DIH ltd.

Nichloas Ali; Investigating the efficiency and effectiveness of the wastewater treatment at the Banks DIH wastewater treatment plant.

Mark Bastian; Variations of microbiota found in the alimentary canals and on the external bodies of Rhinella marina toads within rural and surban areas. (Main Supervisor: Prof. A. Ansari)

Devya Hemraj; The effects of Neme and pronto on tadpoles and paddy bugs in rice fields of Guyana. (Main Supervisor: Ms. Jewel Liddel)

Kellisha Edwards, Topic: Quantitative Analysis of Heavy Metals in Sugar Cane (*Saccharum officinarium*) in Administrative regions (three, four and six) of Guyana. **Lab analysis**: testing sugar cane samples (stem, roots and leaves) for the presence of **heavy metals** which includes **Cadmium (Cd), Copper (Cu), Lead (Pb), Nickel (Ni), Iron (Fe)** and **Cobalt (Co).**

Lokaya Wrights, Topic: Phytoremediation and Adsorption of contaminated water using Duckweed (*Lemna minor*) and Coconut (*Cocos nucifera*) shell Biochar. **Lab analysis**: test for **Iron, Lead** and **Manganese** in Coconut Biochar and Duckweed samples.

Sueellen Ewing-Chow, Topic: Gastrointestinal and external Parasites found among Monkeys in captivity at the Guyana National Zoological Park

Radha Permaul, Topic: Oil content in selected species of algae in Guyana. **Lab analysis**: measuring the rate of growth and biomass (density) of algal species samples and testing for the amount of oil generated from the various algae species grown under different conditions.

Curtly Critchlow, Topic: The prevalence of Helminths found in cattle and pigs that are slaughtered at the Georgetown Abattoir**.**

Vishaul Bhryo, Topic: An ecological study of the Rufous Crab Hawk (Buteogallus aequinoctialis) and the effects of anthropogenic activities on their habitats along the Coast in Regions 3 and 4, Guyana.

Pryia Singh, Topic: To investigate microbiological organisms that is common among selected fruits and vegetables in local markets.

Tameka King; A survey of the Avifaunal diversity at OMAI Gold Mines Ltd (Main Supervisor: Mr. C. Bernard) 2008

Rydel Moore; A survey of the Herpetofauna diversity at OMAI Gold Mines Ltd (Main Supervisor: Mr. C. Bernard) 2008

Odile Broomes; Mammalian Diversity in mined and non-mined sites at at Yararibo old mines Omai bauxite mining inc. (OBMI) Mc Kenzie, Linden. (Main Supervisor: Mr. C. Bernard) 2008

Romeo Singh; Survey on 'hassar' Loricariidae catfishes in the Mahaicony conservancy area (Main Supervisor: Mr. C. Bernard) 2008

Roschelle Grant; Ecological and species diversity survey of fishes at Lake Mainstay Essequibo, Guyana (Main Supervisor: Mr. C. Bernard) 2008

Candace Horatio; The use of entomology or insects in forensic studies (Main Supervisor: Mr. C. Bernard) 2007

Conferences/Seminars/Training Courses/Workshops

Public proposal Presentation

Impacts of environmental degradation on fish assemblage structure in the Upper Mazaruni River Basin, with description of their community structure and habitat requirement, Guyana, South America by Elford Liverpool **March 2013**

Attended Training programs in Supervisory Management at Public Service Ministry
June, 2010

Glimpses of Amazonia: A display and celebration of Amerindian heritage Month 2009. Walter Roth Museum of Anthropology.
Sept 15, 2009

Introduction to the taxonomy of amphibians of Kaieteur National Park, Guyana, By Philippe Kok and Michelle Kalamandeen,
Sept 2009

Three part lecture series, Walter Roth Museum of Anthropology**, Umana Yana**
August, 2009

The Launching of Kaieteur National Park Management Planning Process, Dr. Graham Watkins
A celebration of Kaieteur by: Mr. Bobby Fernandes. **June 25, 2009**

Conference: Theme; Communities and Ecological Sustainable Development;

- **The Guiana Shield Initiative project- Lesson of Iwokrama;** Dr. Raquel Thomas
- **Galapagos-Both sides of the coin;** Dr. Graham Watkins

April 22, 2009.

GIS, GPS and MapInfo training; Guyana Geology and Mines Commission
Jan 2009.

Taxidermy, Museum conservation, preservation and restoration training at the Guyana National Museum
Training executed by Mr. Marco Olcha, Cuban Museum specialist.
Dec 2007-Dec 2008.

A survey of the Avifaunal diversity at OMAI Gold Mines Ltd: by Ms. Tameka King**.**
September 11, 2008.

A survey of the Herpetofauna diversity at OMAI Gold Mines Ltd: By Mr. Rydel Moore.
September 11, 2008.

To investigate the fecundity rates in Poceila sp during capitivity. By; Ruth Rampersaud.
September 11, 2008.

A study of Oma ponds as a traditional Natural Resource Management Approach in the North Rupununi, Guyana. By; Diana Seecharan.

July 30, 2008.

Survey of mammals in gallery forest of the Upper Rupununi River, Guyana. By Ms. Diana Singh. **July 30, 2008.**

Optimizing in-vitro growth for cellulytic bacteria from the cattle rumen. By; Padmini Ragnaugth. **July 30, 2008.**

Pilot investigation of the possible anticarcinogenic effects of local fruits on Leukemia. By; Seleyna Headley. **July 30, 2008.**

Study of the aquatic Macro-invertebrate community at the Yararibo lake system, Mc Kenzie, Linden, Guyana. By; Crissaundra Mohabir.

July 30, 2008.

An investigative study on primates in the Iwokranma forest conservation: CI conference room. June 2008.

Museum development workshop at the Guyana National Museum, Lecture room. Aspects on history, management and maintenance of the museum were scoped, along with staff development, approach to the visiting public, museum conservation and policies, it also entaled museum education and preservation principles.
PREPARED AND PRESENTED BY: MS. T. BOATSWAIN

Dec. 11- 14, 2007.

INTERNATIONAL CONFERENCE ON THE STATUS OF BIOLOGICAL SCIENCES IN THE CARIBBEAN AND LATIN AMERICAN SOCIETIES: HOSTED BY THE DEPARTMENT OF BIOLOGY, FACULTY OF NATURAL SCIENCES, UNIVERSITY OF GUYANA AT BUDDY'S INTERNATIONAL HOTEL, PROVIDENCE.

September 24- 25, 2007

ASSISTANT AT THE CHILDREN'S ZOO CAMP: FACILITATED BY THE GUYANA NATIONAL ZOO AND WORLD'S WILDLIFE FUNDS (WWF): HOSTED BY **DR. FELIX (WWF**), TOPICS INCLUDED MARINE TURTLES, THEIR STATUS, AND CONSERVATION POLICES AND STRATEGIES. **September 22- 23, 2007**

Presentation on the floristic studies in selected regions of Guyana. By Dr. K. Redden Jan, 2007.
.

Guyana Zoo education volunteer training: Jun-Aug 2004.

Centre for the studies of Biological Diversity Volunteer training.

Jan. 2006-Present.

Training on basic laboratory techniques: Government Analyst Food and Drugs Department. **Jul-Sept. 2005.**

Ornothological field and taxidermy training: CSBD and Smithsonian Institute Aug. 2004.

Laboratory work on sample/specimen collections from field expeditions/works and other researches done in Guyana 2004- Present.

Skills

Basic Electronics, Carpentry, Masonry, Computer (Excel, Word, PowerPoint, Publisher and more), Moulding and casting, tanning etc.

Hobbies

Football, cricket, swimming, running, meeting and interacting with people, music, studying, life guarding etc.

Reference

PHILIP DA SILVA - Senior Lecturer, University of Guyana, Tain Campus, Berbice.

DR.HERNANLOPEZ FERNANDEZ- Assistant Professor, Department of Ecology and Evolutionary Biology, University of Toronto, Canada and Curator, Royal Ontario Museum, Toronto Canada.

DR. NATHAN LUJAN- NSF International Fellow, Royal Ontario Museum, Toronto Canada

DR. JAMES G. ROSE - Director of Culture, Department of Culture, Ministry of Culture, Youth and Sport

PROF. ABDULAH ANSARI- Professor, Department of Biology, Faculty of Natural Sciences, University of Guyana.

Leon Moore

Leon Moore Nature Experience: Consultant Coordinator/Zoologist

Mr. Moore specializes in the field of ornithology and is actively concerned about Guyana's ecosystem and the preservation of its wildlife. He enjoys working with people, is experienced in the photography of birds and mammals, and is a knowledgeable nature guide.

Experience: 10 years' experience in bird observations and the evaluation of ecosystems in Guyana and other countries such as Suriname and Brazil.

Email: leon.moore@erm.com

Education

- High School Diploma, Linden Foundation Secondary School, Guyana, 2002.

Languages

- English

Fields of Competence

- Hospitality THAG Certificate
- Tour Guide Training
- Water Quality Testing Training
- Emergency First Responders Training
- Conservation and development
- Preservation of wildlife
- Ornithology
- Photography

Key Industry Sectors

- Tourism

Honors and Awards

- Tour Guide of the Year (Guyana Tourism Authority)

Publications

- Developed the Rock View Lodge Bird List

Key Projects

Coastal Mapping Sensitivity and Bird Survey
Nov 17 to 24, 2019. Conducted for Environmental Resources Management (ERM)

Coastal Mapping Sensitivity and Bird Survey
Apr 16 to 24, 2018. For Environmental Resources Management (ERM)

Key Projects Prior to Joining ERM

Guyana Defense Force
2002–2006

Auto Mechanics
2007–2008

Guest Service Officer, General Tour Guide
June 2008–June 2009 - Developed Bird List.

Bird Censor as Field Officer
August 2008. Baganara Island Resort - GATBS /Wetland International in the Essequibo River.

Bird Guide Tours and Surveys
Jan 2008–2017. Bird Guide Tours and surveys in Regions 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 Guyana.

Rock View Lodge
Sep 2009–2012. Tour Guiding, Appointed Team Leader, Assistant Tourism Manager, and General Assistant Manager.

Tour Guide
Jan 2012–Feb 28, 2014. Atta Rainforest Lodge & Iwokrama Canopy Walkway

BBC Guyana Documentary
Oct 2013. Worked with BBC team conducting a documentary in Guyana.

www.ebirds.org (Guyana) volunteer
Apr 6, 2014. Started volunteering as regional reviewer.

Assistant Instructor Bird and Tour Guide
Oct 2014. Training at Iwokrama International Research Center for rainforest conservation and development.

Conducted Bird Guide Training
Nov 2014. At Iwokrama International Research Center for rainforest conservation and development.

Bird Survey
Aug 20 to Sep 21, 2016, at Guyana Goldfields Inc.

Bird Survey
Feb 6 to Feb 24, 2017. At Guyana Goldfields Inc.

Bird Survey
June 4 to June 13, 2017. At Environmental Services & Support (ESS) in Suriname.

Bird Survey
Feb 26 to Mar 6, 2018. At Guyana Goldfields Inc.

Shorebirds Survey
Along the coast of Guyana for (United States Shorebirds Consecration Plan). Currently in progress.

Noam Raffel

GIS/Geospatial Data

Noam has 8 years of experience in the field of GIS. With a technical geospatial background, Noam focusses in the energy sector, including gas facilities, power generation and remission, and renewable energies. He has prepared environmental, social, and cultural impact assessment plans for numerous exploration and development projects in North America, South America, Africa, and the Middle East. Noam has worked with ExxonMobil for multiple projects while at ERM, including a project using 3D Lidar modeling of sites in Texas; developing an online dashboard for geospatial environmental data for ExxonMobil Qatar; and various projects for EEPGL in Guyana. He has been a part of ERM's support to EEPGL in Guyana since 2017, focusing on mangrove health monitoring, coastal sensitivity modeling, overseeing the ecosystem services, coastal bird, offshore bird, and mangroves.

Experience: 8 years of experience in GIS and remote sensing

Email: noam.raffel@erm.com

Education

- Master of Arts in Geographic Information Systems, Clark University, Worcester, MA, 2014
- Bachelor of the Arts in Geography, Clark University, Worcester, MA, 2013

Languages

- English, native speaker
- Hebrew, fluent

Fields of Competence

- GIS Modeling/Remote Sensing/WebGIS
- Social, Health and Environmental Impact Assessment
- Field Survey and Reconnaissance Techniques
- ArcGIS Desktop, ArcGIS Collector, ArcGIS Online, Survey123, IDRISI TerrSet, ESA SNAP, QGIS, IDRISI, GRASS, ENVI, SPSS, Adobe, Path Finder, Excel, Python, MS Access

Key Industry Sectors

- US Government
- Oil & Gas
- Mining
- Linear Infrastructure
- Climate Change
- Health & Communicable Disease Modeling

Key Projects

Social and Environmental Geothermal Site Selection, Mexico
Noam led the GIS team in creating a site selection tool for geothermal projects across 29 sites in Mexico. This project included collecting, developing and managing geospatial data for block areas across the country, as well as landcover modeling for all areas. He created biodiversity, environmental, social and cultural heritage sensitivity models for all sites. Noam developed a user-friendly online tool using these sensitivity models to rank and identify areas for geothermal site selection.

Transportation Project Oversight, Benin and Ivory Coast
Noam develops an online tool to manage large-scale transportations projects in two countries.
This work includes managing massive imagery databases and uploading them to the cloud. Additionally, Noam oversees survey management and creation, and project progress and management.

Offshore Development – Guyana
Noam assists the geospatial team for a large offshore development project. He leads the geospatial approaches to biodiversity and ecosystem services data collection and modeling, along with environmental and technical siting of potential on-shore infrastructure. He participates in the shoreline and mangrove field surveys. Noam uses a variety of software platforms for this work, including mobile digital data collection and secure web-hosted GIS.

Climate Change Shoreline Analysis, Tobago
Noam led the GIS team in a climate change analysis project for an international financial institution, using satellite imagery over multiple dates to measure coastline changes. He developed landcover models to analyze how and why the landscape changed over time. Additionally, he mapped local coral reefs and created a “bathtub” model to measure how rising sea levels are expected to change the local shoreline.

Modeling for Major Energy Company
Noam modeled all forest and agricultural plots in a five-mile buffer of the 600-mile pipeline using Sentinel 2 10 meter resolution imagery. He also assisted with the culture heritage team to create viewshed and 3D models of potential disturbances created by the project.

Impact Assessment, Mozambique
ERM conducted an ESIA report for the potential impacts of a GTL plant on the Afungi Peninsula in Mozambique. Noam led the geospatial team to assist with the biodiversity, social, and marine teams. This included creating a landcover module from Worldview 2 and 3 imagery, creating social and biodiversity sensitivity and constraint models as well as identifying near shore coral reefs.

Climate Change and Urban Development Plan, Emerging and Sustainable Cities Imitative
Noam was tasked with classifying and analyzing landcover change over a 30-year period using Landsat Satellite Imagery. He used the Landsat results to predict urban growth over the next 50 years. For this project, he also used high-resolution Worldview 2 satellite imagery and field verification to develop a land use map of the entire city. Noam also, developed a tool to model the factors that determine future development demand.

E&S Screening (Transmission-Line) and GAP Analysis (Hydro)
Noam classified the landcover of three different transmission routes using Sentinel 2 satellite imagery. He used the classification results as well as other variables to determine the most optimal route for the transmission line.

Impact Assessment, Nicaragua
Assisted in assessing the impact of a potential canal through Nicaragua. Noam was responsible for managing the archeology and built heritage database that may be potentially affected by the canal. He assisted in the development of a sensitivity model to

assess high risk location of archeology. Noam modeled and mapped the cumulative impact assessment of the project.

Cultural Heritage, Guinea
Assisted in finding potential cultural heritage sites in the location of a potential mine in Guinea. Noam created a sensitivity model from LIDAR imagery to assess where potential sites are located. The model was tested against known sites and proved to be highly accurate.

Cultural Heritage for Manufacturing Plant
Noam was responsible for reviewing LIDAR data and satellite imagery to inspect for potential cultural heritage finds. He collects data in the field to assist with both archeology and built heritage for a plan on building a manufacturing plant in rural West Virginia.

Development of Decision Support Protocols and Procedures to Strengthen Health Sector Response to Severe Weather Risks and Climate Change, Mozambique
Noam was a GIS specialist on this project, which included countrywide modelling of risks to human health from climate change and severe weather events. Activities performed include:

- Generating country-wide landcover & land use model (including remote detection of agricultural areas from imagery analysis)
- Collecting GIS data on human health issues
- Generating precipitation and temperature prediction models
- Running a geographically weighted regression analysis to link certain types of weather events and climate change to downturns in human health
- Using current patterns project which areas in Mozambique are at highest risk for human health issues in the future.

Windfarm Cumulative Impact Assessment, Pakistan
Provided a cumulative impact assessment of over 20 windfarms in Sindh Pakistan. Noam was in charge of providing all the figures and modeling. This includes a visual impact assessment, a land cover model, and auditory modeling.

ERM Foundation and Foundation for Africa, West Africa
Noam built a method to test forest fragmentation and its relation to past and present Ebola outbreaks using advanced statistics and remote sensing.

Screening Assessment, Ethiopia & Djibouti
Noam was a GIS specialist for an aligned screening assessment of a proposed pipeline running from the port of Djibouti to Awash in Ethiopia. He was responsible for generating landcover/land use models that included the classification of agricultural land and generating resource constraint models that were used to site the pipeline using a least cost routing analysis in order to avoid major impacts to the society and the environment.

Haimwant Persaud
GIS Specialist

195 Schoonord
West Bank Demerara

592-677-1458
hv.persaud@gmail.com

PROFILE

- Well-qualified GIS and Remote Sensing specialist with extensive experience in Project Management.
- More than 10 Years' experience as a GIS and Remote Sensing User, Educator, and Developer.
- United Nations Vetted Geospatial Data Specialist with Expertise in Biodiversity Conservation, Natural Resource Management, and Sustainable Development.
- Trained in all Proprietary and Open Source GIS and Remote Sensing applications.
- Excellent verbal communicator; readily adapt communication style to the technical level of the audience to facilitate understanding.
- Personal qualities: Analytical – precise – thorough – curious – patient – independent.

EDUCATION

*Doctor of Philosophy (Ph. D.), Forestry Science (**Ph.D. Candidate**)*
University of Pinar del Rio, Cuba
Pinar Del Rio, Cuba
In progress, expected 2020

Master of Science Degree (MSc), Geographic Information Systems
University of Redlands
Redlands, California
2013

Master of Business Administration (MBA), Project Management
Royal Academy of Career Development
Georgetown, Guyana
2011

Executive Project Manager (Executive *Master of Business Administration)*
Edexcel International
United Kingdom (UK)
2011

Bachelor of Science Degree (BSc), Forest Engineering
University of Pinar Del Rio
Pinar Del Rio, Cuba
2009

CERTIFICATION

Certified GIS Professional (GISP)
GIS Certification Institute
Des Plaines, Illinois, USA
2015

EXPERIENCE

Year	Employing organization	Country	Summary of activities performed relevant to the Assignment
2020	Deen + Partners/ Ministry of Education Guyana	Guyana	**GIS Specialist** • Spatial Data collection for the development of a Natural Hazard Risk Profile for the Education Sector. • Create a Geospatial Database for the Natural Hazard Risk Profile for the Education Sector. • Conduct Spatial Analysis for Risk and Vulnerability Assessment. • Conduct Training on Spatial Data capture for Natural Hazard Risk Profile for the Education Sector.
2020	Landell Mills International Ltd	Guyana	**GIS Specialist** • Develop pertinent data contained in shapefiles for hydrology, vegetative cover that includes Mangal ecosystem vegetation. • Develop the boundaries of the SPA that protects the Mangal vegetation along the tributaries and rivers. • Legally defined Amerindian territories, existing concessions, settlements, and the Shell Beach Protected Area • Calculate the total area of the SPA and the mangals within it, as well as rivers and their commonly used names.
2019	Cheri Sugal Consulting/FCPF	Guyana / USA	**GIS/Land Tenure Specialist** • Analyze the Land Tenure situation in Guyana • Analyze the total non-forest by Land Tenure Class • Analyze the rate of deforestation by Land Tenure Class for the past three decades. • Analyze the total standing forest by Land Tenure Class as of January 1, 2019.

			• Develop scenarios for the allocation of Carbon Benefits from REDD+ activities by Land Tenure Class in Guyana. • Make projections on Emission Reduction for Guyana to achieve its NDC.
2018-2019	Vivid Economics/ Inter-American Development Bank (Climate Resilience Support for the Adequate Housing and Urban Accessibility Program in Georgetown)	Guyana	**GIS and Remote Sensing Consultant** • Identify and aid in the sourcing of spatial data required. • Development of historical urban footprint of Georgetown. • Development of a land-use inventory within Georgetown. • Application of urban growth model of Georgetown.
2018	Caribbean ecosystems limited	Jamaica/ Guyana	**GIS and Remote Sensing Consultant** • Develop a flood risk model for Guyana Coastal plain.
2018	Caribbean Aqua-Terrestrial Solutions/GIZ GmbH	Guyana/ CARICOM	**GIS and Remote Sensing Consultant** • Establish an inventory of archived SAR satellite data available for Iwokrama with a focus on coverage for the historical period (pre-2000). • Map and Assess of Change in Forest Area for 2000, 2014, and 2017. • Develop a capacity-building framework, for the processing, interpretation of data, and quality insurance of remote sensed SAR data.
2018	United Nations Environment	Guyana	**National Consultant – Urban Environmental Assessment** • Establish a methodology for environmental assessment. a) Detailed municipal solid waste profile of the Centre and an estimate of industrial waste from mining b) Geophysical profile of the city and its boundaries c) The topography of the town d) Fragile ecosystems

			e) Geological structure and soil type f) Water resources and water consumption distribution g) Climate data (rainfall, atmospheric temperature) h) Energy and transport profile i) Socio-economic profile • Develop a report consolidating the baseline data collected in the implementation of the methodology and providing recommendations for further work as well as mechanisms to continue data gathering. • Develop communications materials that present the current situation and future scenario.
2017-2018	Engineering and Management Consultancy Group	Guyana	**GIS Consultant** • Spatial Modeling of Kwakwani to determine the locations most vulnerable to flooding • Identify using spatial models the reason/s for the occurrences of flood • Develop relevant Spatial datasets • Develop Spatial Database • Geocode locations
2017-2018	GeoIdeas/Crime mapper application	Guyana	**GIS Consultant** • Develop spatial Database for crime mapping application crimemapper.gy • Conduct system design and database models • Aid in the Development of a Geo-coder for crime mapping in Guyana.
2014-2020	Ministry of Natural Resources	Guyana	**GIS Manager** • Responsible for the overall management and the day to day activities of the Geographic Information Systems (GIS) Unit, within the Ministry of Natural Resources and the Environment. • Assist in the provision of information to the Ministry for proactive action in monitoring, regulation, and compliance by the Ministry and its agencies.

- Responsible for the general management, integration, documentation, and dissemination of spatial data to the Ministry and its agencies.
- Conduct spatial analysis on data collected, including the interpretation of any available up-to-date Remote Sensed Imagery.
- Conduct accuracy and consistency checks on data received from the different natural resources agencies.
- Contribute to the collection and inventory of available reports, maps, aerial photographs, satellite images, digital data, and scientific articles related to land use and natural resources management.
- Prepare and provide reports and digital maps (at appropriate scales) and accompanying quantitative analyses.
- Design and developing spatial databases for the storage, retrieval, manipulation, and analysis of data.
- Research and explore opportunities for the acquisition of imagery that is readily available to achieve the unit's objectives.
- Assist in the development of Standard Operating Procedures (SOP's) necessary for the functioning of the unit.
- Develop web mapping applications and services that support decision making.
- Ensure that the Geoportal site is up and running acceptably, and perform any additional functionality as is required.
- Develop metadata for key datasets in coordination with the respective data owners.
- Develop maps, reports, and splashboard type charts as required by the Ministry and GIS Committee
- Develop manuals and Standard Operational Procedures as it relates to key operations of the platform.
- Establish and maintain professional cooperation, linkages, and partnership with government and other institutions whose intentions and programs of work are related to the above.

2017-2018	Development, Policy, and Management Consultants.	Guyana	**GIS Specialist** • Building survey instrument into an electronic platform • Facilitating training exercises for enumerators and supervisors on the use of the questionnaire in electronic format • Maintaining an online data collection system during the conduct of the survey
2017	Ministry of Public Infrastructure	Guyana	**GIS Consultant** • Creation of a Spatial Decision Support System for the National Task Force Commission. • Acquiring the Required GIS Data from Sources • Creation of Conceptual Database Models • Creation of Logical Database Models • System Design • Database Creation • Data Scrubbing and Loading • Data Presentation in GIS Environment
2016	Hamburg Port Consulting, The Consultancy Group, and IDB,	Guyana	**GIS Specialist** • Investigate and Map the origin and destination of cargo to and from Manaus and Roraima (Boa Vista in particular) to determine the current international volumes traded with North America, the Caribbean, and Europe. • Collect and map commodity flow data originating from and destined for Amazonia and Roraima including internal Brazilian trade. • Analyze Yearly cargo flow data should be collected for the period from 2000 to the latest available year to reveal the main trends. • Geocoded by commodity type and mapped for the earliest and most recent years for which most complete data are available for the major commodities only.

			• Analyze the origin and destination of time-sensitive and/or refrigerated cargo. • Identify the characteristics of the land and maritime shipping networks involved in the cargo flows of the same major commodities. • Identify, describe, and Map transport modes along with a combination of modes serving the different trade routes. • Analyze maritime transport data including the number of vessels by ports relevant for each trade route in terms of international and internal trade, vessel size (net registered tonnage), vessel types (deep sea, short sea), and countries of the registry. • Identify and map vessel movement patterns in the transshipment ports should be identified. A sample of actual vessel monthly movements should be collected from geo-coded data sources such as Lloyds List Intelligence. • Identify and map the main trade corridors to understand the size and intensity of trade flows and/or several commodities relevant for both internal and international trade corridors to understand their degree of spatial concentration. • Identify and analyze spatially the supply chains for the main export commodities in the identified maritime trade corridors. • Identify and map exporters-importers, shippers, producers, and those engaged in international transit movements in the Roraima, Manaus, Paramaribo, and Cayenne. • Develop a geodatabase (GIS database) to accommodate the spatial data developed for this project and is required for the second deliverable.
2016	Development Policy and	Guyana	**GIS Consultant** • Create maps and graphs as required by the

	Management Consultants		Client, using GIS software and related equipment, • Meet with data providers as necessary, to define data needs, project requirements, and required outputs, • Identify, locate and obtain existing databases that may be useful for the study, • Gather, analyze, and integrate spatial data from the Client and determine how best the information can be displayed using GIS techniques, • Compile geographic data from a variety of sources including censuses, field observation, satellite imagery, aerial photographs, and existing maps to produce a gradation of hotspots in the six (6) mining districts of Guyana, • Analyze geographic relationships among varying types of data as provided by the Client.
2012-2013	Health Assessment Research Center	Coachella Valley, USA	**GIS Intern** • Develop an interactive Web GIS application for the visualizing of health indicators, behaviors, and disparities in the Coachella Valley • Geo-code data about the health indicators, behaviors, and disparities by cities. • Create a Spatial database to house the datasets
2012-2013	Amazon Cooperation Treaty Organization (ACTO), GIS Consultant,	Brazil	**GIS Consultant** • Support the development of planning and technical-operational execution of the project at the national level; • Participate in planning meetings for the installation of the Observation´s Rooms; • Support the development of routine mapping and cartographic quality control in the mapping and spatial analysis of the characteristics and dynamics of the landscape (physical and biotic environment, land use, deforestation, and logging, among

others) using the System TERRA AMAZON INPE;
- Support the analysis and interpretation of satellite images to generate or update databases of geographic information;
- Use geoprocessing tools for mapping and spatial analysis and Spatio-temporal;
- Participate in updating and/or structuring of a database of geographic information;
- Participate in the preparation of reports and/or publications that are based on information generated by the monitoring system of deforestation;
- Actively participate in project training courses;
- Advise national experts working in the area of geo-technologies for monitoring deforestation;
- Make the necessary communications with the INPE Amazon to support the processes of implementation of systems and methodologies for monitoring deforestation;
- Prepare at the technical and logistical level, missions or field trip as part of the monitoring process of the project and participate in them;
- Develop other related duties assigned to him/her by the National Technical Coordinator.

2010-2012 Guyana Mangrove Restoration Project — Guyana

GIS Consultant

- Interpret satellite imagery/aerial photos of Guyana's coast to create baseline mangrove forests.
- Develop relevant datasets to aid in the management and monitoring of mangrove forests.
- Data collection and geocoding for map creation and analysis.
- Design and develop an appropriate GIS database to capture, store, analyze, manage, and generate GIS data and reports.

2009-2014	Guyana Forestry Commission	Guyana	**Assistant Commissioner of Forest/GIS Manager** • Assisting with the preparation of work plans and budgets for the division • Overseeing and supporting the implementation of all GIS/RS work of the FRIU • Supporting efforts aimed at consolidation, archiving and preprocessing of all GIS data necessary for the MRVS • Providing technical support to the development of the main areas of the MRVS forest areas assessment and change monitoring activities including the development of the benchmark forest map, assessment of historic forest are a change • Supporting independent accuracy assessment work on forest area mapping and change detection • Liaising closely with relevant natural resources agencies in Guyana to support MRVS process • Supervising GIS activities, evaluating resource information, and preparing reports. • Providing information and mapping service to the GFC and Forestry sector. • Researching and advising GFC on forest resources information and GIS practices quarterly. • Promoting and understanding of the use of resource information by the forest sector and stakeholders quarterly. • Assisting with the preparation of forest resource information. • Facilitating Interagency collaboration amongst relevant government agencies involved in GIS activities. • Providing recommendations for training in GIS and related skills development. • Participating in REDD activities, including procuring, compiling, processing of satellite images for change detection purposes as outlined in methodology development for the GFC by Poyry.

- Developing standards for conducting GIS/RS work at the GFC.
- Assisting in updating GFC guidelines on Sustainable forest management.
- Providing training to FRM field staff on relevant GFC/FRMD guidelines.

PROFESSIONAL SKILLS and POSTGRADUATE STUDIES

- ***Remote Sensing***

- LiDAR
- Digital Imagery Analysis and Processing Land Use Classification
- Spectral Analysis
- Feature Analysis
- ENVI
- RADAR Remote Sensing
- TerraAmazon
- Feature Extraction
- Orfeo Toolbox
- SAGA GIS
- Forest Remote Sensing and Carbon Models
- IDRISI
- GRASS

- ***Geographic Information System***

- ArcGIS for Server
- ArcGIS Desktop
- ArcHydro
- Network Analysis
- Spatial Analysis
- Spatial Relational Database Management Systems
- GIS Web Application Development
- Business Analysis
- GIS for Marketing
- Geocode
- REST Services
- GIS for Local government
- GIS Modeling
- Electric Distribution
- GIS for Crime
- Editing
- Quantum GIS
- GIS for Land Management
- GIS database Creation

Programming

- Python JavaScript HTML Adobe Flex

MEMBERSHIP IN PROFESSIONAL ASSOCIATIONS

- Certified GIS Professional – GIS Certification Institute
- Member Urban and Regional Information Systems Association (URISA)
- Board Member of Guyana Marine Conservation Society (GMCS)
- United Nations Vetted Expert: Geospatial Data Specialist with Expertise in Biodiversity Conservation, Natural Resource Management and Sustainable Development.

PUBLICATIONS

• Geographical Information System for Community Health Monitoring	**Paperback:** 96 pages **Publisher:** LAP LAMBERT Academic Publishing (November 10, 2014) **Language:** English **ISBN-10:** 9783659632679 **ISBN-13:** 978-3659632679 **ASIN:** 3659632678
• Feature Level Fusion of Multi-Temporal ALOS PALSAR and Landsat Data for Mapping and Monitoring of Tropical Deforestation and Forest Degradation.	**Published in:** IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (Volume: 6 , Issue: 5 , Oct. 2013) **Page(s):** 2159 – 2173 **Print ISSN:** 1939-1404 **Electronic ISSN:** 2151-1535
• Estudio De La Dinámica De Vegetación En Parte De La Ciudad De Pinar Del Río	Revista Forestal Baracoa vol. 33, Número Especial 2014 ISSN: 2078-7235 Artículo científico, pp. 317-327

RECENT WORK

- Climate-resilient urban growth for adequate housing and urban accessibility in Georgetown, Guyana.
- Object-based image analysis approach to determine the fallow periods for shifting cultivation in indigenous communities in Guyana.
- Project Manager: Development of the Ministry of Natural Resources, Natural Resources Information System (NRIS). http://nris.gim.gov.gy/.
- An Assessment of the Loss of Mangrove Stands in Mahaica – Berbice, Guyana.
- Feature level fusion of multi-temporal ALOS PALSAR and Landsat data for mapping and monitoring deforestation and forest degradation in Guyana.
- Web-Based GIS Application for Monitoring Community Health.

- Spatial Analysis and Modeling to determine the causes of flooding in Coomacka Region #10
- Assessment of Forest using RADAR technology in the Berbice area.
- Standard Operating Procedures for Guyana's MRVS Interim Measures.
- Dynamic Study of Vegetation within the City of Pinar del Rio.
- Guyana Forest Carbon Stratification and Sampling Design.
- Near-real-time analysis of forest change in Guyana.
- Temporal analysis and quantification of Mining deforestation.
- Prioritization of Hot Spots for Monitoring and enforcement of Gold Mining Activities in Guyana.
- Guyana – Brazil Land Transport Link and Deep Water Port Market Study.
- Development of Guyana Geoportal, web and mobile applications. http://data.gim.gov.gy/.
- Development of desktop-based GIS applications for Natural Resources Management.
- Development of mobile data collection application for Natural Resources Management. http://collect.gim.gov.gy/.
- SPATIAL DATA: A common infrastructure can lead to development in Guyana.
- Rainfall Distribution Using Kriging Interpolation in Rice Producing areas of Guyana.
- Mapping and Inventory of the Coastal Zone Forest in Guyana.
- Vegetation Map of urban and suburban of a sector of the city of Pinar del Río. Cuba.
- Applied Geographical Information Technology in the designing of forest roads Sector; Outlet of the River Cuyaguateje. Cuba.
- Study of vegetation around water bodies in urban and suburban zones within the city of Pinar del Río. Cuba
- Creation of a spatial database of the protected areas in Punta del Este Isla de la Juventud. Cuba.
- Biophysical characterization of the Mangrove ecosystem in the protected area Punta del Este Isla de la Juventud. Cuba.
- Determination of the current state of the strips hydro-regulators in the half section of the basin of the Guamá River Pinar del Río. Cuba.
- System of measures for the recovery of stagnant and degraded Mangrove Forest of the Cuyaguateje River. Cuba.
- Proposed management for the Arboretum of Taironas. Pinar del Río. Cuba
- The application of Linear Programming in Forest Engineering.
- Contamination of Mangrove by Hydrocarbons and restoration strategies. Pinar del Río. Cuba
- Proposal for the ordination of the trees found outside of the forest in the northeast section of the Guamá River Pinar del Río. Cuba.

Amberly R. Moon

Biodiversity Specialist

Amberly has over 12 years of professional experience that includes project management, assessing biological impacts, conducting baseline studies and habitat assessments, surveys for threatened and endangered species, and environmental permitting. As an environmental consultant, her primary focus has been on the oil and gas and mining sectors, with additional experience in the power and transmission sector. She has assisted in preparation and review of environmental, social, and health impact assessments in North and South America. Amberly has supported projects for EEPGL since late 2018. She has managed EA&MPs for proposed exploratory drilling campaigns in offshore Guyana, and assisted in preparing EMPs, EIAs, and supplemental EIAs.

Experience: 12 years' experience including mining, oil and gas, power, and government.

Email: amberly.moon@erm.com

LinkedIn: www.linkedin.com/in/amberly-moon-482bb618

Education

- M.S. Biology, Virginia Commonwealth University, Richmond, VA, 2011
- B.S. Biology, (Chemistry Minor), Virginia Commonwealth University, Richmond, VA, 2008
- CPR & First Aid certified
- ERM Field Safety Officer Certified
- MSHA Certified
- U.S. Government Driver Safety Awareness Training
- Managing Our People Training
- Project Manager Fundamentals Training
- Project Manager Excellence Training

Languages

- English, native speaker

Fields of Competence

- Project management
- Biological impact assessment
- Baseline biological surveys
- Raptor species specialist
- Invasive species management
- Vegetation analysis
- Habitat restoration
- Technical writing and review
- Environmental review
- ArcGIS
- Migratory Bird Treaty Act (MBTA) and Bald and Golden Eagle Protection Act (BGEPA)
- Endangered Species Act (ESA)

Key Industry Sectors

- Mining and Metals
- Oil and Gas
- Power & Transmission
- Government

Publications

- Moon, A.R, J.D. Kleopfer, L.P. Bullock, and J.Ware. "Winter Ecology of the Eastern box turtle (*Terrapene carolina carolina*) including temperature tolerance and microhabitat selection."

Key Projects

EIA for Off-shore Drilling and Production, Guyana 2019
Authored the introduction, administrative framework, and cumulative impacts for an offshore oil and gas EIA. Developed a traffic impact analysis data sheet and potential traffic routes for vehicles related to the project. Assisted in managing client comments and implementing changes including embedded controls, mitigation measures, and monitoring measures for the physical, biological, and social resource sections. Created presentations for the Guyana EPA and posters for the public describing the project.

EA&MP for Off-shore Exploration Drilling, Guyana 2020
Managed the production of an Environmental Assessment and Management Plan for an offshore exploration drilling project including existing conditions and impact assessment for physical, biological, and social resources, and cumulative impact analysis.

EA&MP for Off-shore Exploration Drilling, Guyana 2019
Managed the production of an Environmental Assessment and Management Plan for an offshore exploration drilling project including existing conditions and impact assessment for physical, biological, and social resources, and cumulative impact analysis.

Supplemental EIAs for Two Off-shore Drilling FPSOs, Guyana 2019
Managed the production of two addendum EIAs for two FPSOs based on input from the Department of Energy. The supplemental EIAs included updates to the Development Plan, definitions of magnitude and sensitivity, descriptions of Best Available Technologies, alternatives for treatment and disposal of produced water, analyzing impacts from greenhouse gas emissions, and updates to the Environmental and Socioeconomic Management Plan, Waste Management Plan, Decommissioning Plan, and Oil Spill Response Plan.

EMP for Off-shore Exploration Drilling, Guyana 2019
Assisted in managing team in writing an Environmental Management Plan for an offshore exploration drilling project. Authored the existing conditions and impact assessment sections for special status species and protected areas.

Technical Review for ESIA, Columbia
Managed a large team to provide a technical review of an ESIA for a mining site in Columbia. The review included revisions to proper English from its original Spanish translation.

Permitting and Environmental Surveys for a Pipeline, Wyoming & Colorado
Assisted in regulatory permitting with U.S. Army Corps of Engineers, Wyoming state permitting, and Colorado local county permitting. T&E species lead and coordinator for MOCs in Wyoming and Colorado. Authored species memos for burrowing owls and raptors, and coordinated with state agencies to discuss recommendations for state T&E species. Conducted surveys for burrowing owls.

SEIS for Transmission Line Project for a Large Pipeline, Montana, South Dakota, and Nebraska
Wrote the water resources section in a draft SEIS for a large crude oil pipeline crossing three states. The SEIS project is for the transmission and distribution lines and substations connecting to the pipeline.

Exploration Drilling EA, Arizona
Completed a preliminary data adequacy review of the client's survey data to determine data gaps or needs for the Section 7 consultation process. Served as project coordinator by maintaining the administrative record, authoring meeting notes, RFAIs, monitoring the project schedule, and scheduling meetings with USFS. Developed an administrative record index, RFAI tracking spreadsheet, and QC of the author

templates. Project management activities include cost monitoring, budgeting, invoicing, and preparing monthly progress reports.

Annual Greater Sage-grouse Lek Survey, Nevada
Managed the project from 2018 through 2020 including staff, schedule and survey logistics, protocols, cost monitoring, budgeting, invoicing, and quality control of collected data in Survey123. Conducted Greater sage-grouse lek surveys and habitat reconnaissance using the Nevada Department of Wildlife (NDOW) protocol, Survey123, and ArcGIS Collector. Analyzed the collected data and completed a final technical review of all survey reports. Built a strong working relationship with NDOW that has aided in opening the doors of communication and allowed flexibility in protocols to ensure better data collection at lek sites.

Greater Sage-grouse Lek Survey, Nevada
Managed a new sage-grouse survey program for a mine in the Battle Mountain range of Nevada, including development of the program, coordination with NDOW, survey logistics, cost monitoring, and cloud-based data collection in Survey123.

Biological Baseline Studies for a Legacy Uranium Mine, New Mexico
Managed and authored the Phase I Environmental Report associated with a legacy uranium mine site to support future compliance with NEPA. Conducted migratory and breeding bird surveys along transects at 300 m intervals as part of the Phase II Environmental studies. Completed a desktop assessment of habitats to digitize transects for the surveys and develop the survey protocol and forms using ArcGIS Collector and Survey123. Analyzed the collected data to author the final Phase II report. Created maps for the report using ArcGIS. Completed project management duties including field scheduling, Level 3 HASP compliance, cost monitoring, budgeting, and oversight of subcontractors.

Biological Baseline Studies for a Mining Site, Nevada
Managed the project including staff, schedule, survey logistics, subcontractor, protocols, budgeting, and invoicing. Performed a desktop assessment prior to field work to establish survey transects in locations of suitable habitat. Conducted surveys for migratory and breeding birds, burrowing owls, and pygmy rabbits following BLM protocols. Determined appropriate sites for deployment of a bat acoustic monitor. Processed all collected data for analysis and authoring the final Biological Baseline Report.

Sage-grouse Mitigation Program, Nevada
Managed and authored the first agency Annual Report containing implementation data for activities performed to restore habitat for greater sage-grouse as part of a Bank Enabling Agreement (BEA) between the client and Bureau of Land Management (BLM). Analyzed annual monitoring data to create implementation data sheets to present to BLM. Project management activities include budgeting and invoicing.

Kangaroo Mouse Survey at a Mining Site, Nevada
Performed a desktop assessment prior to field work to determine areas of suitable habitat in a leach pad expansion area for the dark and pale kangaroo mouse. Managed the field staff who conducted the survey, analyzed data collected in the field, and authored the final survey report.

Biological Baseline Report for a Mining Site, Nevada
Provided technical authoring and editing for the 2017 Biological Baseline Report containing 5 years of collected data to support future NEPA compliance. Compiled data from the survey years to create final report tables and appendices. Implemented BLM comments and prepared responses. Performed quality control of presented data and figures, and assumed project management duties including invoicing, budgeting, and cost monitoring.

Wildlife Impact Assessment for a Mining Site, South Carolina
Authored a wildlife impact assessment including using existing data from previous baseline surveys. Project management duties included budget and schedule oversight, and review of authored reports and data.

Cyanide Audit for a Mining Site, South Carolina
Project manager for cyanide code audit to ensure client is ready for an audit. Provided project oversight to ensure gaps were being addressed on-site, all ERM and client H&S measures are being followed, and management of the budget and schedule.

Burrowing Owl Surveys for a Pipeline, Wyoming
Conducted burrowing owl surveys as a lone-worker along a pipeline ROW to confirm presence/absence of species in accordance with state requirements. Validated the Environmentally Sensitive Areas (ESA) established to protect the burrowing owls.

Emergency Permitting for Wildfire Rapid Response EP, Environmental Coordinator, and Business Unit Staff Coordinator, California
Wrote biological permits for an emergency response project along an existing transmission line in Northern California. Permits were written to agencies including USFS and BLM. Managed biological monitors on daily surveys and data collection. Coordinated and vetted staff from the Mountain West Business Unit for long-term deployment to the project site.

Bald Eagle Survey for Pipeline ROW, West Virginia
Performed aerial bald eagle nest surveys via helicopter in Monongahela National Forest for existing pipeline constructions. Compiled the collected data and edited the final survey report.

CURRICULUM VITAE

Mark Ram
University of Guyana: Biodiversity Specialist

Education	PG Dip (2019) Higher Education, University of Guyana, Guyana MSc (2018) Forest Biology, University Guyana, Guyana. BSc (2016) Biology, University of Guyana, Guyana.
Current Position	Lecturer, Department of Biology, University of Guyana.
Office Address	D5 Department of Biology, University of Guyana.
Contact Information	
– **telephone:**	+1 592-611-9927
– **email:**	mark.ram92@yahoo.com mark.ram@oug.edu.gy
– **website:**	http://fns.uog.edu.gy/staff/mr-mark-ram

Research Interests	Marine Ecology, Marine Conservation Science, Coastal ecosystems, Oceanography, Forestry, Climate Change, Habitat Degradation and Restoration.

Professional Experience	April 2019– Present: **University of Guyana** **Student Internship Coordinator** Main duties: Responsible for the selection, placement and supervision of interns in the Department of Biology. April 2017– Present: **University of Guyana** **Scientific Officer/Assistant Lecturer** Main duties: Aid in the delivery of course content to undergraduate students, co-supervise undergraduate research projects, involved in the day to day management of a museum and herbarium, verification of biodiversity specimens and samples for export and individual research. September 2016 – June 2017 **University of Guyana** **Laboratory Demonstrator (part-time)** Main duties: Supervision of laboratory exercise, graded and recorded marks for lab assessment and aid in designing practical field exercise.
Publication In-preparation	(1) Fish community composition after mangrove restoration along the Northern Atlantic Coast of Guyana. (2) Regeneration of *Chlorocardium rodiei* (greenheart) in logged and unlogged forest in Guyana
Professional Courses & Training	• Forest Landscape Restoration • Quantitative Analysis of Ecological Data • Qualitative Research Methods • Forest Research Methods • Ocean Governance-University of Sao Paulo • Tropical Coastal Ecosystems • Wildlife Survey Techniques • Disasters Environment Risk Reduction • Life on Earth: Biomes, Climates, Ecology and Evolution • Scientific Writing • Principles of Biochemistry • Ecological Monitoring • Species Conservation • Field Guide Preparation

CURRICULUM VITAE

Teaching Experience

University of Guyana-Department of Biology

Instructor (Undergraduate Courses)

- Marine & Coastal Ecology
- Biology of Marine Organisms
- Coastal Zone Management
- Ecology and Environmental Biology
- Biometry & Biostatistics
- Introduction to the Biology and Ecology of Living Organisms
- Conservation & Management of Forest Ecosystems
- Laboratory Instructor (2016-2017) for the following courses: Introductory Biology, Ecology, Biochemistry, Parasitology, Animal Physiology, Biotechnology, Microbiology, Plant Ecology, Taxonomy& Systematics, Vertebrate Zoology, Biology of Animals and Biology of Plants.

Instructor (workshops)

- Data Analysis in R (2018) Centre for the Study of Biodiversity, University of Guyana.

Research and Fieldwork

- Impacts of mangrove habitat degradation on fish community structure along Guyana's coastal regions (2018) MSc. Thesis.
- Socio-Economic Survey and Length-Based Stock Assessment Guyana and Suriname (2017-2018) for WWF Guianas.
- Regeneration of *Chlorocardium rodiei* (greenheart) in logged and unlogged forest in Guyana
- Survey of ecotourism resources and aquatic and terrestrial ecosystems of Orinduik falls and the upper Ireng river drainage, Region 8, Guyana (2016) led by Dr. Nathan Lujan
- Assessment Sharks & Rays Diversity of the North Atlantic Ocean, Guyana (2016) led Elford Liverpool
- Stream quality assessment and mercury content analysis using fishes and macroinvertebrates at Cuyuini Guyana (2015) led by Mr. Elford Liverpool.
- Comparison of avian and fish diversity in disturbed and undisturbed mangrove ecosystem (2015) led by Kavita Dookram.
- Effect of changing climatic variables on butterflies at CEIBA Biological Centre (2016). BSc. Thesis.

Talks

- Wetlands in Guyana (2019) Biology Club at the University of Guyana

Awards & Grants

- World Wildlife Fund- Education for Nature Professional Development Grant (2019)
- Conservation Leadership Progamme. Population dynamics of *Chlorocardium rodiei* (Greenheart) in Guyana, South America (2019).
- UG-UF (NORAD/WWF-Guianas). Achieving a Green State: Building human capacity for natural resource management in Guyana (2018)
- National Agriculture Research and Extension Institute, Guyana Mangrove Restoration Project small Grant (2017)

Posters and presentations

- Distribution, abundance & types of plastics debris along selected beaches in Guyana. Gulf & Caribbean Fisheries Institute 72nd Conference (2019) Punta Cana, Dominica Republic.
- Impacts of mangrove habitat degradation on fish community structure along Guyana's coastal regions. National Agriculture Research & Extension Institute Research Conference (2018), Guyana.

- Impacts of mangrove habitat degradation on fish community structure along Guyana's coastal regions. Latin America Caribbean Conference for Conservation Biology (2018) University of West Indies, Trinidad.
- Impacts of climate change on farmers and their adaptive strategies along the Essequibo Coast, Guyana. Latin America Caribbean Conference for Conservation Biology (2018) University of West Indies, Trinidad.
- Impacts of mangrove habitat degradation on fish community structure along Guyana's coastal regions. Sao Paulo School of Advanced Science on Ocean Interdisciplinary Research and Governance. (2018) University of Sao Paulo, Brazil.
- Regeneration of *Chlorocardium rodiei* (greenheart) in logged and unlogged forest in Guyana. The University of Guyana and The University of Florida in collaboration with WWF launch NORAD Funded Partnership, Guyana.

Consultancies

- Barima-Mora Passage Mangrove Special Protected Area (2019) Landel Mills International
- Coastal Sensitivity Mapping for Oil Spill Response in Guyana (2019) for Pragmatics Inc.
- Fishes of the Nappi Water Catchment Area, Nappi Village, Rupununi, Region 9 (2019). Conservation International Guyana.
- Identification of Marine Deepwater Specimens (Macro-Invertebrates and Fishes) (2018) Environmental Resource Management.
- Survey of mangrove fishes at Hope, Guyana. (2018). The Conservation Leadership in the Caribbean.

Associations

- Society for Conservation Biology
- Global Youth Biodiversity Network
- University of Guyana Biology Club
- Caribbean Youth Environment Network Guyana

Supervision of undergraduate Research Projects

- Brea Aaron (2019). Assessment of Crustaceans abundance and diversity in different mangrove ecosystems in Demerara-Mahaica (Region 4), Guyana.
- Waynace Forde (2019). The distribution, abundance, and characteristics of Marine debris along beaches in Demerara-Mahaica (Region 4), Guyana.
- Daniella Decosta (2019). Distribution, Composition and Abundance of fishes from the Moruca river (Region 1), Guyana.
- Jaishri Jethu (2019). A partial baseline study of the Butterfly Diversity within the Biodiversity Gardens of the Botanical Gardens, Georgetown, Guyana.
- Joanna Porte (2018) Impacts of water quality on fish diversity, richness and abundance in mining-impacted and non-mining impacted sites at Kaieteur National Park.
- Rovindra Lakenarine (2018) Impacts of climate change on farmers and their adaptive strategies along the Essequibo Coast, Guyana.

References

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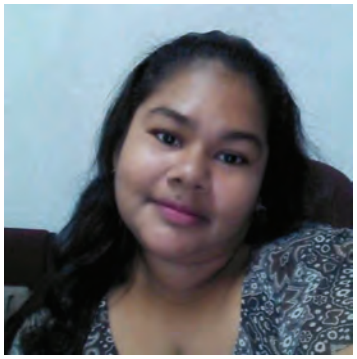
Indranee Roopsind

Leon Moore Nature Experience: Biodiversity Specialist

Indranee is a Guyanese field biologist who has conducted field expeditions all over Guyana studying large and small mammals with special focus on riverine and semi-aquatic specie, reptiles and amphibians, birds, and fishes. She has worked on developing and implementing monitoring systems for wildlife management, and wetland systems within the Iwokrama Forest and the North Rupununi Wetlands. She has a keen interest in understanding the population and behavioral ecology of the Giant River Otter Pteronura brasiliensis in Guyana. Over the years, she has also worked extensively with indigenous peoples on strategies that link the science of traditional knowledge with strategies for natural resources management. In the last year, she worked as part of a team with ERM Guyana for the EEPGL Guyana to develop and implement surveys for riverine mammals in the Demerara River.



Experience: 20 years of experience in environmental education, biodiversity assessments and working with indigenous communities on natural resource management planning

Email: Indranee.Roopsind@erm.com

Education

- Bachelors of Science, Biology Major, Chemistry Minor, 2002, University of Guyana
- Master of Science, Forest Biology, UG (Ongoing)

Professional Affiliations and Registrations

- IUCN SSC Otter Specialist Group (Giant Otter Species Group)
- Women in Nature Network (WiNN)Guyana

Languages

- English

Fields of Competence

- Field biology (Mammalogy, Herpetology and Ichthyology)
- Community engagement
- Environmental education

Key Industry Sectors

- Biodiversity
- Wetland ecology
- Ecosystem services and sustainable development

Honors and Awards

- Cleveland Metro Parks Zoo Scotts Neotropical Fund.
- Tom Dolan IV Conservation Fellowship. 2003. Philadelphia Zoo, USA
- UNDP Volunteer Award.
- Grant from the Smithsonian National Zoo. 2001
- Grant from the Jacksonville Zoo. 2001

Key Projects

Demerara River Mammal Survey (2019-2020) ERM Guyana
Main Duties: Assist in the development of survey methodology, implementation of survey and compilation of final report**.**

Community Engagement Specialist/Field Manager (2016 – 2018) WWF Guianas
Main Duties: Facilitate training and development sessions for indigenous villages in Region 9 on the development of 10 year village improvement plans, and coordinate field activities in the Rupununi.

Research Assistant (April 2015 – 2016) PANTHERA
Assessing sustainable hunting yields and hunter awareness as a foundation for managing wildlife populations in Guyana.

Rapid Assessment Programme Researcher (June 2014 – September 2014) Conservation International
Responsible for the documentation of the levels of ecosystem services use by communities and potential impacts on the savanna/forest/wetland systems for the baseline assessment for the expansion of the pre-investment Georgetown-Lethem Road.

Biodiversity specialist (August 2012 – October 2012)
Responsibilities included the design, implementation and compilation of an assessment of the biodiversity along the Cove and John Mangrove Reserve for applications to the Guyana Mangrove Restoration Project.

Researcher/Lecturer (August 2009 – October 2011)
IUCN funded project working with indigenous communities in southern Guyana (Rupununi) on capacity enhancement and natural resources management planning associated with wetland resources, including community fisheries management, and natural sites management. Work included facilitating courses to youths from Amerindian communities in the Rupununi, aimed at wildlife and natural resources management.

Research Assistant/Wetlands Researcher (January 2004 – December 2008)
Darwin Initiative sponsored project; Sustainable Management of the Rupununi Wetlands – Linking People, Environment and Biodiversity; Phase 1 and Phase 2.

Research Assistant
Development and implementation of distribution and habitat use studies of P. brasiliensis in the Iwokrama Forest and North Rupununi Wetlands. Additional responsibilities included extensive faunal field surveys, river patrols, data entry, and community outreach.

Environmental Educator
Responsibilities include the preparation of a bi-annual newsletter, instructing classes at the Guyana Zoo to primary level.

Leanna Kalicharan
University of Guyana: Marine Science Specialist

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EDUCATION

Master of Arts: Education (Leadership). In progress **2019 – 2021**
University of Bedfordshire (UB), United Kingdom

Post Graduate Diploma in Education: Higher Education. Pass with Distinction **2017 – 2018**
University of Guyana (UG), Turkeyen Campus, Georgetown, Guyana

Master of Science: Nat. Resource & Environ. Mgmt.: Coastal & Marine Resource Management **2015 – 2017**
University of the West Indies (UWI), Cave Hill Campus, Saint Michael, Barbados

Bachelor of Science: Biology. Pass with Distinction **2009 – 2013**
University of Guyana (UG), Turkeyen Campus, Georgetown, Guyana

EXPERIENCES

Consultant. CARIBBEAN REGIONAL FISHERIES MECHANSIM (CRFM), GY/SVG **3 – 4/2021**
Independently reviewed Guyana's fisheries laws, policies and plans, and consulted with the Officers of the Guyana Fisheries Division and artisanal fisherfolk to develop a detailed report and Communication Strategy Action Plan to improve effective communication of key fisheries laws, policies and plans between the Fisheries Division and fisherfolk in Guyana.

Consultant. OMAI GOLD MINES, Cuyuni-Mazaruni, GY **1 – 3/2021**
Conducted an Environmental Baseline Study (EBS) to develop a detailed report that described vegetation and wildlife biodiversity (terrestrial and aquatic), surface water and sediment quality that can be potentially affected by mining exploration.

Consultant. PRAGMATIS INC., GY **7 – 8/2019**
Conducted an Environmental Sensitivity Mapping (ESM) of Guyana's Coastal Zone to develop a detailed report, which characterized sensitive coastal and marine environmental and socioeconomic resources that can be potentially exposed and affected by the oil and gas industry.

Consultant. Guyana Society for Biodiversity and Ecosystems (GSBE), GY **7 – 8/2017**
Independently reviewed literature and conducted interviews with key stakeholder agencies involved in the water sector to prepare a detailed report and subsequently presented at a public forum on the status of Guyana's Freshwater Ecosystems.

Lecture I. University of Guyana, Faculty of Natural Sciences, Department of Biology **10/2016 to present**
Core Subject Areas: Introductory Biology, Introductory Microbiology, Biochemistry, Ecology, Environmental Biology, and Natural Resources & Environmental Management.

Assistant Lecturer. University of Guyana, Faculty of Natural Sciences, Department of Biology **3 – 7/2015**
Independently delivered 3 third year courses to undergraduate Biology majors in one semester by planning and organizing each course lectures, laboratory exercises, assignments, and examinations.

Field Research Assistant. Guyana Gold Fields Inc., Cuyuni-Mazaruni, GY **6/2015**
Collected and catalogued freshwater fish species, macro-invertebrates, sediment, and water samples for assessment of mercury content, culminating to an analytical report with recommendations for the improved management of mercury usage on site.

Tutor. University of Guyana, Faculty of Natural Sciences, Department of Biology **9/2012 – 12/2014**
Supervised at least 10 hours of laboratory sessions weekly over 6 semesters by introducing and demonstrating lab exercises to up to 60+ undergraduate students, while ensuring each activity was conducted in an orderly and safe manner.

Field Research Assistant. World Wildlife Funds Guianas/Global Wildlife Conservation, GY **9 – 10/2014**
Collected and documented freshwater fish species from the South Central region of Guyana with 3 other team members. Assisted with the scientific tagging of the collected specimens, and technical collection & storage of fish tissue for DNA, mercury and isotope analyses. Contributed to data analyses and subsequent preparation of the preliminary survey report.

Field Research Assistant. Arapaima Research Project, Shedd Aquarium/Rewa, GY **3/2014**
Assisted the principal researcher with the capturing of arapaima for surgical implantation of radio transmitters and tracking of arapaima in the Rewa River to map their migration patterns.

Field Research Assistant. Black Caiman Research Project, Yale University/Yupukari, GY **2/2014**
Captured and processed large (10+ feet) caimans to assess their morphological features and kept the Caiman Capture Database updated and organised. Assisted with stomach pumping of caimans to determine their feeding habits by identifying prey items collected from stomach contents. Collected caimans blood samples and prepared them for stable isotope analysis.

Field Research Assistant. World Wildlife Funds Guianas/Global Wildlife Conservation, GY **10 – 11/2013**
Collected and documented freshwater fish species from the South Rupununi region of Guyana. Assisted with the scientific tagging of the specimens, and technical collection and storage of fish tissue for DNA analyses.

EXPERIENCES

Summer Intern. Environmental Protection Agency Guyana (EPA), Georgetown, GY **6 – 9/2013**

Interned full-time as an Assistant to National Biodiversity Strategy Action Plan (NBSAP) Project Manager and conducted field surveys with the Environmental Management Division to produce detailed reports from one-on-one interviews done with the citizens on environmental compliance.

Enumerator. Guyana Bureau of Statistics, Georgetown, GY **9 – 11/2012**

Conducted at least 800+ structured interviews with civil servants to obtain census data through verbal communication, and prepared weekly progress reports on the status of work.

Field Research Assistant. Neotropical white-sand forest Research, Mabura, GY **8/2012**

Assisted the principal researcher to collect and identify local plants species, and prepared specimens for DNA analysis.

Field Research Assistant. **Aquatic Biodiversity & Water Quality Surveys, Shedd Aquarium/Karanambu, GY** **3/2012**

Collected and documented fish species to assess their health by preparing blood smears for evaluation and assessed water quality.

ACTIVITIES

N**etwork Coordinator** (Caribbean). United Nations Sustainable Development Solutions Network (SDSN) – Youth 12/2016 to 02/2021

Regional Coordinator (Caribbean & the Americas). Commonwealth Youth Climate Change Network (CYCN) 7/2016 – 7/2018

Recipient. Dean's Honour Roll Award for outstanding scholastic performance in PGDip Programme. 12/2018

Special Envoy. Caribbean Youth Environment Network (CYEN) 7/2016 – 7/2018

Recipient. National Youth Awards. Award of Service in recognition for championing Environmental Awareness and Biodiversity both as a Volunteer and Lecturer at the University of Guyana. 11/2017

Awardee. Best Graduating Student of Class 2013 – Department of Biology, University of Guyana 10/2013

Recipient. The Harry Persaud Memorial Prize for highest grade in taxonomy course – University of Guyana 9/2013

Mentee. Commonwealth Women's Mentorship Scheme 7 – 12/2017

Participant. University of Guyana (CSBD) – *Statistical Methods for Data Analysis in R (Workshop)* 10/2018

Country Participant. UNESCO, Port of Spain, Trinidad and Tobago – *Sandwatch: Citizen Science Workshop* 10/2017

Participant. Guyana National Youth Council, Georgetown, Guyana – *Effective Conflict Management, (Workshop)* 2/2015

Participant. Guyana National Youth Council, Georgetown, Guyana – *Grant Writing & Fundraising, (Workshop)* 1/2015

Participant. Global Shapers Community Hub, Georgetown, Guyana – *Communications Workshop, (Certificate)* 11/2014

Participant. Panthera/University of Guyana – *Tools for Conservation: Monitoring with camera traps, (Certificate)* 2/2014

Country Participant. Green Heritage Funds Suriname, Paramaribo, Suriname – *Diversity, Conservation and Research of Xenarthra*, (*Certificate)* 2/2013

PUBLICATIONS

Kalicharan, L. and Oxenford, H. A. (2020) 'Short-term Estimate of Finfish Bycatch Discards in the Inshore Artisanal Shrimp Fishery of Guyana', *Gulf and Caribbean Research*, 31(1), pp. GCFI1–GCFI9. doi: 10.18785/gcr.3101.01.

Kalicharan, L and Oxenford, H.A. (2019). 'Examining finfish bycatch discards in the artisanal Chinese seine fishery in the Demerara estuary, Guyana', *Centre for Resource Management and Environmental Studies, The University of the West Indies*, *Cave Hill campus, Barbados*, CERMES Technical Report No. 95. Retrieved from: https://www.cavehill.uwi.edu/cermes/docs/technical_reports/kalicharan_oxenford_2019_by_catch_guyana_chinese_s.aspx

Kalicharan, L., and Seecharran, D. (2018) 'Impacts of Coastal Agricultural activities on freshwater fish diversity in Guyana', *International Journal of Scientific and Research Publications*, 8(10), pp. 93 –95. doi: http://dx.doi.org/10.29322/IJSRP.8.10.2018.p8214

Rosenblatt, A.E., Li, F., Holland, A., Taylor, P., and Kalicharan, L. (2015). *Melanosuchus niger* (Black Caiman) Diet. *Herpetological Review*, 46(3), 430.

Mark Irvine

Physical Oceanographic Specialist

Mark Irvine is a Technical Director in ERM's Impact Assessment and Planning team and is based in Edinburgh. Mark has been working in environmental consultancy for 28 years in which time has carried out numerous desk- and field-based projects covering a wide range of environmental and social issues as part of ESHIAs, ESM, monitoring plans and related studies. These projects have included terrestrial, coastal, and marine surveys covering physical, biological, chemical, and socio-economic impacts from development projects (including habitat mapping and ground truthing, fish and fisheries studies, seabed and water quality monitoring and socio-economic baseline studies).

Experience: Mark has wide experience in managing large and complex projects (fee value ranging from £0.5 to £1 million), and working with a wide range of specialists from within ERM and sub-contracted companies. Project work has often included large scale consultation and communication programmes with government and other regulatory bodies, local stakeholders and the wider public. Mark has worked primarily on projects in the oil and gas, ports and harbours, marine dredging and disposal, water, and offshore windpower industries. Mark's international experience includes working in Algeria, Azerbaijan, Brunei, Ethiopia, Ghana, Kenya, Libya, Nepal, Nigeria, Qatar, Russia (Sakhalin Island), Turkey, Turkmenistan and Uganda. Recent international projects have included ESHIAs, EMPs and associated consent submissions for the Jubilee and TEN developments in Ghana, and ESHIAs for oil and gas exploration activities in Ethiopia, Kenya, and Uganda.

Education

- MSc Water Resource Management (Distinction). Edinburgh Napier University, 1993
- BSc (Hons) Zoology, Class IIi. University of Aberdeen, 1984

Professional Affiliations and Registrations

- Member of the Institute of Environmental Management and Assessment

Fields of Competence

- Environmental Social, Health Impact Assessment (ESHIA);
- Environmental Auditing;
- consenting, licensing and planning;
- impacts of onshore and offshore oil and gas developments;
- impacts of marine and coastal zone developments on marine sediments and water quality;
- design and management of marine and aquatic monitoring surveys;
- fish and fisheries studies;
- liaison at all levels with clients, research establishments, central government departments, local authorities and non-governmental organisations;
- public communication and consultation;
- Expert Witness on EIA process and marine impact issues at two Public Inquiries.

Key Projects

Environmental and Social Support to the Nord Stream 2 Pipeline Project. Nord Stream. 2016-2017. ERM have been retained to provide environmental and social support to the Nord Stream 2 Project Team on a range of terrestrial and marine issues related to the NSP2 project, in particular in relation to IFC Performance Standards. Mark leads on providing advice on marine issues, including assessment of physical, chemical, and biological impacts from pipeline installation and landfall construction.

Operations Permit Support for the development of the Tweneboa, Enyenra, Ntomme (TEN) fields, Deepwater Tano Block, offshore Ghana, Tullow Oil, 2014-2017. Mark is the ERM project manager for the development of a series of management plans and procedures to implement the ESHIA and IFC Action Plan commitments for the TEN project. These include environmental management and monitoring plans, commissioning and decommissioning plans, waste management plan, and local content and social performance plans.

Independent Monitoring Group for compliance with IFC Performance Standards for Kenya and Ethiopia Oil and Gas Exploration and Development Projects Africa Oil Corp, 2015-ongoing. Mark is the team leader for the Independent Monitoring Group with respect to Africa Oil Corporation's compliance with the IFC Performance Standard for their interests in Kenya and Ethiopia. ERM is undertaking six-monthly monitoring visits which commenced in December 2015.

Best Practicable Environmental Option (BPEO) Studies for various clients, 1999-2017. ERM undertook a series of BPEO studies in support of licence applications for dredging and dredge spoil disposal. Habitats Regulations assessments were also undertaken to identify any potential issues with respect to European designated sites such as the Forth Islands SPA. Twenty-three separate BPEO studies have now been undertaken in the Firth of Forth and Tay Estuary.

Environmental Impact Assessment for Beatrice Offshore Wind Farm. Beatrice Offshore Windfarm Ltd, 2010- 2013. Mark was the Technical Director for the EIA for a 980 MW, 190 turbine offshore wind farm in the Moray Firth. Baseline studies include, coastal processes, seabirds, marine mammals, benthos, archaeology, shipping and navigation and aviation.

Environmental Assessment of Proposed Aggregate Dredging Operation, Liverpool Bay, Westminster Gravel Ltd, 1999 -2014. ERM was commissioned to conduct an EA for an offshore aggregate production licence in Liverpool Bay. A marine survey was carried out by ERM in 2001 and the Environmental Statement (ES) and Supplementary ES were issued. Ongoing monitoring support was provided during the licence period.

Area 351, area 340 and Area 451 Aggregate Production Licence Applications, Isle of Wight, Northwood (Fareham) Ltd, Westminster Gravels Ltd and Cemex Ltd, 2007 –2013. Mark was Project Director for three EIAs for licence renewal applications east of the Isle of Wight. Key issues are coastal impacts, navigation, archaeology, fishing activities and cumulative impacts from other dredging and dumping sites in the area.

Environmental Management Support for Jubilee Field Phase 1 Development, Tullow Ghana Ltd, 2010-2016. Mark was the Technical Director for a series of projects to provide support to Tullow Ghana Ltd to meet its permit requirements. These have included Waste Management Plan; Marine, Air Quality and Noise Monitoring Procedures; and a Fish and Fisheries Study.

Environmental Impact Assessment for Port of Mostyn: Maintenance of Navigation, 2006 - 2009. Mark was the Project Director for an EIA for capital and maintenance dredging of the navigation channel at the Port of Mostyn to further develop the port to allow it to receive large cargo vessels, including handing the wing sections for the Airbus 380. The Dee Estuary is designated as an SPA, SSSI, and RAMSAR site and the proposed development requires an Appropriate Assessment under the Habitat Regulations.

Environmental Impact Assessment of Proposed Aggregate Dredging Operation, Nobel Banks, Llanelli Sand Dredging, 2001- ongoing. ERM was commissioned to undertake an EIA for a new licence on Nobel Banks, off the Gower Peninsula (South Wales). Mark was the ERM Project Director and appeared as an Expert witness at a Public Inquiry in 2005. A licence was awarded for Nobel Banks in 2005. ERM continued to support LSDL in designing and interpretation of monitoring surveys during the licence period.

Environmental Monitoring of Clearance Operations in Holy Loch, MOD(N), 1997 - 2002. ERM was commissioned to undertake a major programme of field investigations to monitor the effect of the four year programme of debris clearance operations following the use of Holy Loch as a submarine maintenance depot. The monitoring programme covered water quality, sediment chemistry, ecotoxicology, bioaccumulation, radiation levels, and noise monitoring.

Environmental Assessment for CCGT Power Station. Intergen-Enka, Turkey 1999. ERM was commissioned by Intergen-Enka to carry out an Environmental Impact Assessment for a proposed 1500 MW CCGT power station near Izmir in south-west Turkey. The assessment was required to be carried out to World Bank standards. Mark's role was as survey manager working with consultants based in Turkey to produce an assessment of impacts of the cooling water intake and thermal discharge on the marine ecology of Nemrut Bay.

Catriona Munro, BSc (Hons)

University of Guyana: Marine Science Specialist

Catriona Munro is a Senior Consultant in ERM's Capital Projects team in Edinburgh. Catriona has ten years experience gained through positions in industry, including offshore oil and gas sector, renewable energy, aggregates and dredging, port construction and conservation organisations. She also has good experience of technical reporting and data quality control.

Her work has involved interaction with a variety of personnel within regulatory and licensing bodies, local stakeholders and the general public.

Catriona has primarily worked in the UK and Channel Islands, with experience of working on a wide range of projects in the North Sea, Atlantic Ocean, South China Sea, West African and Norwegian waters.

Experience: 10 years' experience in marine environmental surveying and consulting

Email: Catriona.munro@erm.com

LinkedIn: https://www.linkedin.com/in/catriona-munro-5798583b/

Education

- Applied Marine Biology, BSc (Hons). Heriot Watt University, UK, 2008

Languages

- English, native speaker

Fields of Competence

Catriona's experience covers a broad range of topics in environmental assessment. These include the following areas of work:

- Planning and managing marine and aquatic monitoring surveys.
- All aspects of marine environmental surveying, with particular expertise in acquiring high definition video and stills and accurate positioning.
- Consenting, licensing and planning (including preparing all Health and Safety documentation).
- Project Management.

Key Industry Sectors

- Ports and marine infrastructure
- Aggregates
- Oil and gas
- Marine renewable energy
- Unconventional power

Qualifications and Certificates

- Basic Offshore Safety Induction and Emergency Training (BOSIET).
- Offshore Medical ENG1.
- ISOS Fit to Work certification.
- Open Water PADI.
- Helicopter Underwater Escape Training (HUET).
- Travel Safely by Boat (OPITO).

Key Projects

Key Community, Infrastructure and Transport Experience

Environmental Assessment and associated Permit Applications in support of a new telecommunications cable, USA to Norway/Denmark, Subcom, 2018. Author of the Environmental Assessment for submission to Marine Scotland in support of a Marine Licence application for a telecommunications cable crossing Scottish Territorial Seas. Role required multiple permit applications in three different countries.

Community Development Plan (CDP) in support of construction of a new fertiliser plant, Lekki Free Trade Zone Nigeria, Dangote, 2016-2017. Project manager for the CDP of 14 communities displaced due to the forceful purchase of their land. The CDP was a requirement of the International Finance Corporation (IFC) prior to the award of any funding. Role included organising logistics for in country sub-contractors, managing budgets, health and safety and reporting of findings from the field.

AP1, 2, 3 ,4 and 5 - High Speed 2 Phase 1 London-West Midlands: London Metropolitan and Country South - for HS2 Ltd, 2014-2015. Assistant to the planning lead for the additional provisions work organising the future baseline and cumulative assessment screening of new planning application and allocation records for the London and Country South routes since the HB ES Submission. ERM worked within a consortium with Temple Group and Mott MacDonald on the EIA of the High Speed 2 rail network proposed by the Government from London to West Midlands.

East Rail Phase 1 – for Network Rail 2012. Undertaking the noise scheme of assessment East Rail Phase 1 involves new track installation between Bicester and Oxford, and new/improved stations along the route. ERM has been working on the project from concept development to the opening of the railway.

Key Marine Aggregate, Mining and Port Experience

Best Practicable Environmental Option (BPEO) in Support of a Marine Licence, Leith, Rosyth and Dundee, Forth Ports 2017. Assistant project manager and survey coordinator for a BPEO study into the disposal of dredged material from the maintenance dredge at the Ports of Leith, Rosyth and Dundee. Currently supporting client throughout marine licence application process.

Marine support and compilation of a Construction Environmental Management Plan for Waterside Apartments, Gibraltar, Ocean Village, 2016. Project manager and technical advisor to the client in support of full planning application for an apartment development over water within a marina in Gibraltar. Careful planning to determine if a number of sensitive species are present within the project footprint required, involving liaising with divers, benthic surveyors, taxonomists and laboratories. CEMP currently under development for submission with full planning application.

BPEO in Support of a Marine Licence, Grangemouth and Methil, Forth Ports 2016. Assistant project manager and surveyor for a BPEO study into the disposal of dredged material from the maintenance dredge at the Port of Grangemouth and Methil Docks. Currently supporting client throughout marine licence application process.

MIDAS Deep Sea Mining, International, European Commission, 2015 – 2017. The MIDAS project is an EC funded 3 year multidisciplinary research programme into the environmental impacts of deep sea resource extraction. ERM formed one of the work packages for the project, tasked with describing the industry activities involved in deep-sea mineral extraction, identifying the main activities leading to impacts on the environment, defining environmental management practices to control these impacts, and

disseminating this information to the other MIDAS work packages. ERM undertook engagement with industry stakeholders to define likely activities, and develop mining scenarios for assessment. Catriona wrote a number of deliverables for ERM's work package. Catriona also contributed to a review of standards and guidelines relevant to the environmental management of deep sea mining projects.

BPEO in Support of a Marine Licence, Newhaven, Forth Ports 2016. Project manager for a BPEO study into the disposal of dredged material from the maintenance dredge at Newhaven Harbour. Supported client throughout marine licence application process.

Five Year Monitoring Review, dredging operations at Area 457, Liverpool Bay, England, Westminster Gravels Ltd, 2015-2016. Primary author of the monitoring review of the five year monitoring review of dredging operations at Area 457. Role involved drawing on information provided from three site specific studies from different subcontractors to inform the assessment.

Environmental Statement (ES) for the proposed aggregate dredging operation at Area 476, Bristol Channel, England, Llanelli Sand Dredging Ltd, 2014-2015. Assistant project manager. Role included undertaking the physical processes technical chapter, assessing the socio-economic effects and compiling the relevant policies and legislations and part of an EIA supporting a licence renewal application on Nobel Banks, off the Gower Peninsula (South Wales).

Environmental and Social Impact Assessment (ESIA) for a harbour development, Gibraltar, Government of Gibraltar, 2015. Author of the marine biology and physical processes chapters of the ESIA. Responsibilities included reviewing the information from the survey reports from a number of sub-contractors and incorporating the physical processes modelling report.

BPEO in Support of a Marine Licence, Kirkcaldy, Forth Ports 2015. Project manager for a BPEO study into the disposal of dredged material from Kirkcaldy Harbour.

BPEO in Support of a Marine Licence, Inverkeithing, Tarmac Lafarge, 2014-2015. Project manager for a BPEO study into the disposal of dredged material from Inverkeithing Bay. Study included the collection of a number of sediment samples using a hand corer for physico-chemical analysis.

BPEO in Support of a Marine Licence, Newhaven, Forth Ports Ltd, 2014-2015. Project manager for a BPEO study into the disposal of dredged material from the capital dredge of Newhaven Harbour. Study included overseeing subcontractors during the collection of a number of sediment samples for physico-chemical analysis using a vibrocorer.

Environmental Baseline Survey and ESIA, Sierra Leone, Confidential Client, 2014. Responsible for planning and undertaking the marine survey to provide information on sediment and benthic composition. Data is provided to fill data gaps, required to run hydrodynamic models on the proposed dredging works to deepen the existing port. Also responsible for the marine environmental chapter of the Scoping Report and subsequent ESIA for this major iron ore mine development in West Africa to IFC standards.

ES to support the renewal of licence Area 515, Humber, England, Westminster Gravel Ltd, 2014.
ES undertaken in support of an application for a Marine Licence to dredge aggregates, made to the Marine Management Organisation (MMO) under the Marine Works (Environmental Impact Assessment) (Amendment) Regulations 2011. Responsibilities included contributing to the scoping report and authoring the physical and biological chapters of the ES.

ESHIA for a port expansion, Kazakhstan, Chevron, 2012 – 2013. Working in a small marine and freshwater team to undertake the screening matrix, scoping report and marine associated chapters in ESHIA.

Key Oil and Gas and Unconventional Power Experience

Environmental Impact Assessment for the development of a new offshore gas pipeline, Equatorial Guinea, Noble Energy, 2018-2019. Reviewer of the drafted EIA and responsible for incorporating client comments into the main text. Further responsibilities included interpreting marine baseline data to include in the EIA following the revision of the first draft.

Consolidation of Baseline data from across 10 years in support of offshore gas field developments, Egypt, Exxon Mobil International, 2018. Author of the nearshore marine baseline chapter. Project required the consolidation of multiple years of data from two offshore gas fields owned and operated by different entities.

ESIA for offshore gas and liquid fields, PICO, Egypt, 2018. Co-author of the marine environmental assessment for the development of new offshore platforms and associated supporting infrastructure in a sensitive marine environment.

Scoping Report, Preliminary Environmental Information Report (PEIR) and ES for a Combined Cycle Gas Turbine (CCGT) Power Station and DCO application support, UK, Sembcorp, 2017. Assistant project manager coordinating a large technical team to pull together a scoping report, PEIR and ES in support of a DCO application. Alongside day to day management support, invoicing, programming and logistical organisation, responsibilities included drafting the socio-economic chapter of the scoping report and PEIR.

Critical Habitats Assessment and EIA review, Nordstream 2, Black Sea, 2016-2017. Development of a presentation to identify and present habitats identified throughout the Black Sea as critically endangered or endangered Project and the critical habitat. Technical review of some of the EIAs produced by other consultancies in support of the Project.

Marine Monitoring Plans for Burullus Power Station, Egypt, EEHC, 2016. Lead author of the marine monitoring plans for the construction and operation of the Burullus Power Station in Egypt. Monitoring plans followed national and international best practice and aligned with commitments detailed in the original ESIA.

Environmental and Social Impact Assessment (ESIA) for a proposed power plant, Ghana, Globaleq, 2015. Author of the marine baseline chapter focussing on the Project Area of Influence. Desk based review of data and interpretation of results from site specific physico-chemical and biological surveys.

Environmental Impact Assessment (EIA) screening report and supporting documentation for Planning and Flood Defence Consent applications, England, Client Confidential, 2015. Phase manager and coordinator for the EIA screening report for a new jetty into a river. The purpose of the jetty was to receive large building components for a nearby Carbon Capture and Storage plant. Role included authoring the EIA screening report and coordinating planning team, transport statement team and flood defence consent team in support of the planning application. Weekly update meetings held with client and various teams involved in the project.

EIA, HRA and Sustainability report for a Carbon Capture and Storage project, UK, Confidential Client, 2014 – 2015. Contribution to the marine environmental chapter within the EIA, identifying impacts as presented by modelling outputs.

Managing the marine plume modelling subcontractors. Maintaining open lines of communication between client Project Manager and own project team.

Environmental and Social Baseline Study for a Seismic survey, Caspian Sea, Confidential Client, 2014 – 2015. Desk based baseline data assimilation and presentation to provide an understanding of impacts of a 2D and 3D seismic survey. Responsible for the offshore chapters of the project.

EIA for onshore LNG plant in Tanzania, Statoil, 2014 – 2015. Undertaking the marine environment chapter for an EIA of a new LNG pipeline and onshore plant. Baseline data collation and subsequent assessment of impacts and risks of proposed development on the marine environment.

Production of offshore Marine Monitoring plans, Southstream Transport B.V. Bulgaria, 2014. Identifying potential receptors to planned pipeline works and providing monitoring plans during pre-construction, construction and operational phases to mitigate environmental risks of the project.

Southstream Gas Pipeline, Southstream Transport B.V. Bulgaria, 2014. Supporting SST B.V. in managing and reviewing the offshore (and landfall) Bulgarian section of this pipeline from Russia, across the Black Sea to Bulgaria as part of the wider Southstream project. Responsibilities include ongoing support to the post consent process including supporting production of project monitoring plans.

Shoreline Sensitivity Mapping, Firth of Forth to Peterhead, BP, September 2013 – 2014. Provision of marine technical expertise to create a comprehensive shoreline map of biological and socio-economic features. A sensitivity ranking was then assigned to gauge how sensitive an extensive stretch of shoreline would be to an oil spill from the Forties pipeline. Presented in GIS format.

EIA for the installation of cuttings cleaner units in Azerbaijan, BP, 2013. Contribution to a number of chapters within the EIA concerning proposed changes to the treatment of cuttings and possible consequent impacts to the surrounding environment. Mitigation of impacts identified to ensure compliance to internal and international standards.

Environmental Addendum and Technical Note for two drilling platforms in the Caspian Sea, BP, 2012 –2013. Study into the impacts of two drilling platforms on the surrounding marine environment. Potential impacts to a number of species were assessed, including the Caspian Seal. Mitigation measures were provided where necessary.

Preliminary ESHIA for a LNG development in eastern Africa, Client Confidential, 2012 –2013. Marine environmental specialist contributing to baseline studies and preliminary ESHIA marine chapters, aiding in gathering information for onshore site selection.

Key Renewables Experience

Scoping report and ESIA for a wind farm development, Ghana, EM Power, 2016-2017. Assistant project manager for a scoping report and ESIA of a small wind farm in Ghana. Responsibilities include logistics and coordination of teams in country during scoping and baseline field data collection trips. Co-author of environmental baseline and support to technical teams during ESIA.

Pre-scoping Report for the development of a tidal turbine barrage in North Wales, North Wales Tidal Energy, UK, 2016. Technical author for the pre-scoping report of the proposed tidal lagoon along the coast of North Wales. Report informed the Hendry Review, which was favourably received. Report presented in Word and Publisher format, making use of innovative infographics.

Topics authored included physical processes, metocean processes, sediment transport and coastal processes, marine mammals and terrestrial and coastal ecology.

ESIA for a Hydroelectric Dam, Sierra Leone, Joule Africa, 2016. Assistant project manager for an ESIA and survey support to teams in Sierra Leone. Role includes assisting the coordination of a team of over 20 surveyors in field in both the dry and wet seasons, addressing survey health and safety plans, managing logistics and organising import/export permits for samples. Co-author of a number of non-technical ESIA chapters.

Renewable Energy Projects EIA Process Review, UK Wind Power Projects, NEDO, 2015. Worked in a small team to review and collate up to date EIA policies and processed around onshore and offshore wind developments to inform the Japanese industry, where the EIA process is relatively long. An overview of typical environmental surveys, EIA process timeframes and procedures was provided to the client in support of streamlining the EIA process for wind power consent applications in Japan.

Baseline Habitat Mapping, Mull of Kintyre, RES, 2013. Lead environmental surveyor during a survey to recover underwater video footage of potential tidal device sites and cable landing options.

Other Selected Survey Experience

Deep Sea Site Investigation, South China Sea, BSP, 2013. Lead environmental scientist during a survey to recover deep water video and stills footage of potential and historic rig sites. Water profiling, sediment and water sampling also undertaken. Sediment and water collected for analysis of physico-chemical properties. Additional survey sites were undertaken investigating the potential for deep water coral reefs. Water depths ranged from 200 – 1200 m and data was collected using the DTS6000 deep water camera system, 0.25m^2 box core, Niskin water sampler and a Valeport multi-parameter water profiler.

Deep Sea Coral Habitat Mapping offshore Florida, PCCS, 2013. Identifying and mapping deep water corals along a 150 km proposed cable route corridor. Potential and probable coral areas identified from side scan sonar and multibeam echosounder data. Coral health and density assessed and recorded using drop down video and stills cameras. Advice provided where necessary on cable routing options to avoid areas of live coral.

Key Projects Prior to Joining ERM

Wave and tidal monitoring, SSE Renewables, Islay, 2012. Responsible for overseeing the deployment of three wave rider buoys, three guard buoys and an ADCP off the west coast of Islay as part of a data gathering exercise on the resource available to renewable energy at this site.

Current and tidal monitoring, SSE Renewables, Orkney, 2012. Lead environmental scientist on a number of current and tidal profiling surveys around the Orkneys. Involved developing new technology to work in extreme tidal races safely. Reporting included identification of any key species and habitats surrounding sites ear-marked for tidal turbine deployment.

Dredge plume monitoring, London Gateway, Thames, 2012. Characterisation monitoring of dredge plume involving following the dredger as it worked. A VMADCP was used to record suspended solids as backscatter, the data from which was input into Sediview to produce exact sediment plumes resulting from the dredger's excavations.

Water sampling, Sheerness Port Authority, Sheerness, 2011. Project manager on an extensive water and sediment sampling survey for a dredging licence. The survey also included the 30 day deployment of ADCPs to monitor current velocity and direction in the channel approaching the port. Responsibilities included liaising with the

Client and stakeholders, applying for licences and consents and managing survey teams and vessels.

Environmental baseline survey, Open Hydro, Northern Ireland, 2011. Project Manager. This study was conducted for a Client proposing to deploy an array of tidal turbines in a tidal race to the north east of Northern Ireland. A VMADCP and drop down video (DDV) survey were undertaken to determine the potential impacts of installing these devices in the proposed area, including potential cable landing sites. Responsibilities aside from Project Management included habitat mapping from DDV footage and proposing the most suitable cable landing site.

Acoustic and Environmental baseline survey, Alderney Commission for Renewable Energy, Alderney, 2010. Survey area encompassed a sand bank in close proximity to a proposed tidal turbine site. Side scan sonar, multi beam bathymetry, DDV and sediment sampler all utilised to produce a comprehensive dataset. Responsibilities included interpreting acoustic data with the aid of camera footage as ground truthing.

Marine Mammal Observation (MMO), Statoil, Sheerness, 2010. Lead supervisory role for MMO and supervision of Passive Acoustic Monitoring (PAM) system during the installation of the Sheringham Shoal wind farm. Responsibilities included ensuring watches were carried out at the right time and for the appropriate length of time before and during piling operations. All log keeping and paperwork. Communication with client representative onboard the piling vessel to ensure all parties were aware of piling operations and permission to pile.

Assessment of cold water coral reefs, Fugro Norske, North Sea (Norway), 2010. Lead environmental scientist during a site survey aimed at assessing quality and quantity of cold water coral reefs in an area of the northern North Sea. Sites were selected from low resolution side scan data. A Panther ROV was used to record the health and extent of reefs. Production of report at end of survey detailing location and health of reefs.

Oil rig site survey, Fugro, North Sea, 2010. Lead environmental scientist on a site and pipeline route survey in the North Sea. Responsibilities included side scan data analysis, selecting sites to ground truth using a high definition shallow water camera system and Day grab. Production of daily field report outlining findings.

Baseline habitat assessment, Gardline Environmental, North Sea, 2009. Lead environmental scientist on potential oil rig and pipeline surveys. Responsibilities included selecting sites to ground truth using DDV and sediment sampler from acoustic data sets. Production of daily field reports.

Habitat mapping, SSE Renewables, Sound of Islay, 2008- 2009. On board environmental scientist during habitat mapping and ground truthing survey using DDV. Responsibilities included assessing the suitability of several sites for the deployment of ADCPs and ultimately tidal turbines.

Position Title and No.	ENVIRONMENTAL OFFICER, K-4
Name:	Hemwantie Singh, Marine Water Quality Specialist
Date of Birth:	26/10/1983
Country of Citizenship/Residence	Guyana

Education:

Institution	Degree/Diploma/Certificate	Year
University of Guyana	MSc. Natural Resource Management	2016
University of Guyana	Post Graduate Diploma in Environmental Management	2012
University of Guyana	*Bachelor Degree (BSc)*, Environmental Science	2004

Employment Record:

Period	Name of employer, position / position. Contact info for references	Country	Summary of activities carried out, related to this Assignment
June 2011 to Present	Employer: CEMCO Inc *Position: Senior Environmental Environmentalist* For Reference Tel: 592-226-2773/ rlatchmansingh@cemcoguyana.com; Mr. R. Latchmansigh, Managing Director	Guyana	• Environmental Impact Assessments • Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan. • Review of ESIA and ESMP • Preparation of Environmental risk assessments and risk management plans. • Preparation of traffic and water management plans. • Conducted stakeholder consultation sessions. • Assisted with Preparation of Stakeholders Engagement Plan and Review Process. • Community Liaison. • Environmental Quality testing including water and air quality. • Environmental quality monitoring.
August 2010 to March 2012	Employer: H.Nauth and Sons Civil Engineering Contractors *Position Environmental Manager* For Reference Tel 592 6232701 hnauthandsons@hotmail.com Mr. Kiran Nauth, Manager	Guyana	• Preparation of Site Environmental Management Plan • Preparation of Traffic Management Plan • Preparation of Health and Safety Plan • Preparation of Emergency Response Plan. • Environmental quality and compliance monitoring.
September 2008 to March 2012	Employer: Environmental Management Consultants *Position: Projects Environmental Officer* For Reference: Tel: 222-4565 emc@networksgy.com	Guyana	Worked on. • Environmental Impact Assessments and Management Plans. • Sea-Defence Legality Study. • Monitoring of numerous roadway construction projects

	Mr. Shyam Nokta, Managing Director		
May 2008 to October 2010	Employer: Falcon Construction and Transportation Services *Position : Environmental manager* *For Reference:* Meerza65@hotmail.com Mr. Azad Meerza, Managing Director	Guyana	• Routine inspection of construction activities and staging area for compliance with EMP. • Health and Safety Inspection • Weekly Inspection reports • Provision of Mitigation measures for non-compliances and other environmental problems. • Liaison with MOA, EPA and other agencies involved in the project • Community liaison in the project area. • Conduct Baseline Surveys

Membership in Professional Association and Publications: NIL

Language Skills:

Language	Reading	Speaking	Writing
English	Excellent	Excellent	Excellent

Adequacy for the assignment:

Detailed tasks assigned on consultant's team of experts:	Reference to Prior Work/ Assignments that Best Illustrates Capability to Handle the Assigned tasks
• Develop ESMP • Ensure the Environmental Social Assessment Framework (ESAF) and health and safety regulations are compiled with. • Supervise and provide guidance to the Health and Safety Officers on site. • Monitor the Contractor's HSE performance against requirements.	**Assignment No. 1** **Name of assignment or project: FLOOD RISK MANAGEMENT PROJECT (FRMP). PROJECT ID NO: P 147258. Lots 1, 2 and 3, Construction of Pump stations at Lusignan, Buxton and Enmore.** **Year**: July 2016 to March 2018: **Location**: Region 4, Guyana **Client:** Ministry of Agriculture (ASDU). **Positions held:** Senior Environmentalist. ***Duties*** • Environmental Impact Evaluation • Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan. • Attend and conducted stakeholder consultation sessions. • Compliance Monitoring • Preparation of Non-Compliance and Inspection reports. **Assignment No. 2** **Name of assignment or project: Sheriff street- Mandela Avenue Roadway Design.** **Year**: July 2012 **Location**: Region 4, Guyana **Client:** Ministry of Public Works and Communication. **Positions held:** Senior Environmentalist. ***Duties*** • Environmental Impact Evaluation • Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan.

- Attend and conducted stakeholder consultation sessions.
- Assisted with Preparation of Stakeholders Engagement Plan and Review Process.

Assignment No. 3
Name of assignment or project: Grove-Timehri Roadway Rehabilitation Project.
Year: July 2014
Location: Region 4, Guyana
Client: Ministry of Public Works and Communications
Positions held: Senior Environmentalist

Duties

- Environmental Impact Evaluation
- Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan.
- Attend and conducted stakeholder consultation sessions.
- Assisted with Preparation of Stakeholders Engagement Plan and Review Process.

Assignment No. 4
Name of assignment or project: East Bank Berbice Roadway Design.
Year: July 2014
Location: Region 6, Guyana
Client: Ministry of Public Works and Communications
Positions held: Senior Environmentalist

Duties

- Environmental Impact Evaluation
- Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan.
- Attend and conducted stakeholder consultation sessions.
- Assisted with Preparation of Stakeholders Engagement Plan and Review Process.

Assignment No. 5
Name of assignment or project: Canals Polder Roadway Design Project.
Year: July 2014
Location: Region 3, Guyana
Client: Ministry of Public Works and Communications
Positions held: Senior Environmentalist

Duties

- Environmental Impact Evaluation
- Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan.
- Attend and conducted stakeholder consultation sessions.
- Assisted with Preparation of Stakeholders Engagement Plan and Review Process.

Assignment No. 6
Name of assignment or project: Ministry of Public Works and Communication, **CJIA- Expansion Project.**
Year: July 2012 to present
Location: Region 4, Guyana

Client: Ministry of Agriculture, National Drainage and Irrigation Authority
Positions held: Senior Environmentalist

Duties

- Environmental Impact Evaluation
- Preparation of Project Environmental and Social Impact Assessment and Environmental and Social Management Plan.
- Attend and conducted stakeholder consultation sessions.
- Assisted with Preparation of Stakeholders Engagement Plan and Review Process.

Assignment No. 7
Name of assignment or project: University of Guyana Science and Technology Support Project.
Year: July 2012 to present
Location: Region 4, Guyana
Client: Ministry of Education- World Bank
Positions held: Senior Environmentalist

- Review of Project ESA and ESMP.
- Preparation of Risk Assessment and Risk Management and health& Safety Plan
- Preparation of Environmental Management Plan.

Assignment No. 8
Name of assignment or project: Ministry of Public Works and Communication Bridges Rehabilitation Project, Phase II, Rehabilitation of Lot II Structures Lots B1 and B2.
Year: May 2010 to Present
Location: Regions 4 and 5, Guyana
Client: Ministry of Public Works and Communications**.**
Main project features: Rehabilitation of Roadway Structures (Timheri to Rosignol, Berbice), Rehabilitation of culverts, construction of 21 new pre-cast culverts and pre-stressed bridges as well as associated traffic and water diversions.
Positions held: Senior Environmentalist
Activities performed:

- Compliance Monitoring in accordance with ESIA and EMP.
- Addressed Non- Compliant activities.
- Supervised Implementation of Mitigation Measures
- Convened and Conducted Site meetings related to Environmental Management.

Assignment No. 9
Name of assignment or project: Conservancy Adaptation Project
Year: July 2012 to present
Location: Region 4, Guyana
Client: Ministry of Agriculture, National Drainage and Irrigation Authority

Main project features: The project aims to strengthen government and donor understanding of the East Demerara Water Conservancy (EDWC) system and coastal drainage patterns through the integration of advanced mapping and engineering analysis. The project also aims to carry out the design of infrastructure investments to improve drainage performance within the

Region 4 coastal lowlands, to improve the stability of the EDWC dam, to strengthen the institutional capacity for managing water and floodwater levels, and to guide interventions to reduce Guyana's vulnerability to floods.
Positions held: Senior Environmentalist
Activities performed: Data collection, review and preparation of necessary project documents (EIA and EMP) for Dam Feasibility aspect of project as well at Coastal Infrastructure works.

Assignment No. 10
Name of assignment or project: East Bank Demerara Public Road Four Lane Extension.
Year: November 2011- March 2012
Location: East Bank Demerara (Region 4), Guyana
Client: Ministry of Public Works and Communications
Main project features: Upgrading 5.4km of the main road and improvement of associated infrastructure to accommodate four lanes of traffic (upgrading from existing two lane).

- Widening and rehabilitation of existing carriageway
- Construction of additional two lanes
- Construction and expansion of bridges and culverts along road alignment
- Relocation of public utilities

Positions held: Environmental Inspector
Activities performed: Routine inspection of construction activities and staging area for compliance with EMP; Health and Safety Inspection; Weekly Inspection reports; Provision of Mitigation measures for non-compliances and other environmental problems; Liaison with MPW&C, EPA and other agencies involved in the project; Community liaison in the project area; Conduct Baseline Surveys

Assignment No. 11
Name of assignment or project: East Demerara Water Conservancy Northern Relief Channel and Associated Drainage and Irrigation Canals at Hope Doch Four
Year: June 2011- March 2012
Location: Guyana
Client: Ministry of Agriculture, National Drainage and Irrigation Authority
Main project features:
Excavation of a 10.3km long channel x 30m wide (bottom width) through clays as well as very weak organic soils (6.5km over clay, 2.3km over a mixture of clay and organic soils and 1.5km through organic soil – pegasse). This new channel with discharge capacity of 58 cubic metres per second will provide another relief to the East Demerara Water Conservancy; Construction of impervious embankments and berms
Positions held: Environmental Inspector
Activities performed:

- Compliance Monitoring in accordance with ESIA and EMP.
- Address Non- Compliant activities.
- Supervise Implementation of Mitigation Measures
- Convene and Conduct Site meetings related to Environmental Management.

Assignment No. 12
Name of assignment or project: Road Improvement and Rehabilitation Project: Rehabilitation of East and West Canje Road
Year: August 2010
Location: Berbice (Region 6), Guyana
Client: Ministry of Public Works and Communications, Works Services Group
Main project features: Roadway reconstruction, construction of pre-cast culverts and pre-stressed bridges
Positions held: Environmental Monitor
Activities performed:
Routine inspection of construction activities and staging area for compliance with EMP; Health and Safety Inspection; Weekly Inspection reports; Provision of Mitigation measures for non-compliances and other environmental problems; Liaison with MPW&C, EPA and other agencies involved in the project; Community liaison in the project area.; Conduct Baseline Survey.

Assignment No. 13
Name of assignment or project: Black Bush Polder Road Rehabilitation Project.
Year: May 2010 - May 2012
Location: Berbice (Region 6), Guyana
Client: Ministry of Public Works and Communications, Works Services Group
Main project features: Rehabilitation and reconstruction of approximately 35 km of flexible pavement with an AC finish and rehabilitation of timber and concrete bridges.
Positions held: Environmental Inspector
Activities performed:

- Compliance Monitoring in accordance with ESIA and EMP.
- Address Non- Compliant activities.
- Supervise Implementation of Mitigation Measures
- Convene and Conduct Site meetings related to Environmental Management.

Assignment No. 14
Name of assignment or project: Agricultural Export Diversification Programme: Canals Polder Control Structures and Access Roads.
Year: 2008
Location: Region 3, Guyana
Client: Ministry of Agriculture, National Drainage and Irrigation Authority
Main project features: Upgrade of access roads to fair weather status (≈14.5kmm)**;** Rehabilitate timber access bridges and reinforced concrete culverts; Desilting and widening of canals (≈14.5kmm); Rehabilitation and construction of drainage and irrigation control structures
Positions held: Environmental Inspector
Activities performed: Routine inspection of construction activities and staging area for compliance with EMP; Health and Safety Inspection; Weekly Inspection reports; Provision of Mitigation measures for non-compliances and other environmental problems; Liaison with MPW&C, EPA and other agencies involved in the project; Community liaison in the project area.; Conduct Baseline Surveys

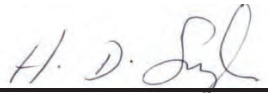
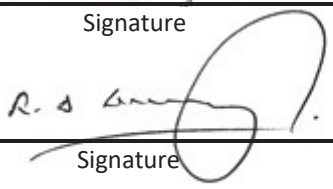
Assignment No. 15

	Name of assignment or project: Project: Ministry of Public Works and Communication Bridges Rehabilitation Project, Phase 11, Rehabilitation of Lot 11 Structures Lot A1, A2 and 2B **Year:** August and Sept 2009 **Location:** Regions 4 and 5**,** Guyana **Client:** Ministry of Public Works and Communications **Main project features:** Rehabilitation of Roadway Structures (Timehri to Georgetown, installation of ore-cast box culverts and bridges), Rehabilitation of culverts, construction of new culverts and bridges, permanent revetment; permanent relocation of utilities and associated temporary traffic and water diversions. **Positions held:** Environmental Inspector **Activities performed:** Routine inspection of construction activities and staging area for compliance with EMP; Health and Safety Inspection; Weekly Inspection reports; Provision of Mitigation measures for non-compliances and other environmental problems; Liaison with MPW&C, EPA and other agencies involved in the project; Community liaison in the project area.; Conduct Baseline Surveys **Assignment No. 16** **Name of assignment or project:** Shawnee Service Station Soesdyke Linden Highway Junction (EMC) **Year:** 2008-2009 **Location:** Region 4, Guyana **Client:** Private Sector **Main project features:** Construction of gas station and other ancillary facilities including a food court and convenience store. **Positions held:** Environmental Inspector

Expert's contact information:
Email: amandatiwari@yahoo.com
Phone: +592 6099319

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience, and I am available to undertake the assignment in case of an award. I understand that any misstatement or misrepresentation described herein may lead to my disqualification or dismissal by the Client, and/or sanctions by the Bank.

Hemwantie Singh		14/01/2018
Name of Expert	Signature	Date
R.B. Latchmansingh		14/01/2018
Name of authorized Representative of the Consultant (same who signs the Proposal)	Signature	Date

FORM TECH-6 CURRICULUM VITAE (CV) FOR PROPOSED PROFESSIONAL STAFF

Position Title and No.	**Environmental, Health and Safety**
Name of Expert:	Michael Lowe
Date of Birth:	August 1st, 1997
Country of Citizenship/ Residence	Guyana

Education:

INSTITUTION	**Diploma / Certificate**	**YEAR**
Coursera	Global Environmental Management	2021
New Guyana School	Basics of Occupational Health and Safety	2019
University of Guyana	Bachelors of Science Degree in Environmental Studies	2018
St. Roses High School	Caribbean Examination Council – 9 Subjects	2014

6. **Membership of Professional Associations**:

7. **Other Training**:

8. **Countries of Work Experience**: Guyana

9. **Languages:**

Language	**Reading**	**Speaking**	**Writing**
English	Excellent	Excellent	Excellent

10. **Employment Record:**

PERIOD	**EMPLOYER**	**POSITIONS HELD**
July 2018 - Present	CEMCO Inc.	Environmental Officer

11. Detailed Tasks Assigned	**12. Work Undertaken that Best Illustrates Capacity to Handle the Tasks Assigned**
Task 4.4 – Manage Implementation of EMP	**Assignment No. 1**
	Name of assignment or project: Cunha Canal Rehabilitation Project **Year:** 2018 – 2019 **Location:** Land of Canaan, East Bank Demerara **Client:** Agriculture Sector Development Unit- Ministry of Agriculture **Main project features:** The objective of the Cunha Canal Rehabilitation Project for Guyana is to increase the capacity of the Cunha Canal to drain the East Demerara Water Conservancy and local agricultural areas in the recipient's territory. The flood of 2005 highlighted the significance of the risks posed by the weakened containment and drainage capacities of the

11. Detailed Tasks Assigned	12. Work Undertaken that Best Illustrates Capacity to Handle the Tasks Assigned
	EDWC and coastal drainage system. The project entails construction of two Sluices and a Bridge over the existing roadway to facilitate re-alignment of the canal. **Positions held:** Environmental Officer **Activities performed:** - Routine inspection of construction activities and staging area for compliance with Environmental Management Plan - Tri weakly Health and Safety Inspection - Weekly Inspection reports - Provision of Mitigation measures for non-compliances and other environmental problems - Liaison with MOA, EPA and other agencies involved in the project - Community liaison in the project area.
	Assignment No. 2
	Name of assignment or project: Cheddi Jagan International Airport Expansion Project **Year**: 2018 - 2019 **Location**: Timehri, **Client:** Ministry of Public Infrastructure **Main project features**: The Cheddi Jagan International Airport Expansion Project entails construction of the New Arrivals Terminal Building (NATB); Existing Terminal Building (ETB); Remote Apron; North East (NE) Runway Extension; South West (SW) Runway Extension; Diesel Generator Room (DGR); and Fire Pump Station. **Positions held:** Environmental Officer **Activities performed:** • Routine inspection of construction activities and staging area for compliance with EMP. • Health and Safety Inspection • Weekly Inspection reports • Provision of Mitigation measures for non-compliances and other environmental problems. • Liaison with MPI, EPA and other agencies involved in the project • Community liaison in the project area.
	Assignment No. 3
	Name of assignment or project: Community Based Livelihood Enhancement Fisheries Development Project - Lot 1 **Year:** 2019 – 2020 **Location:** Victoria, East Coast Demerara **Client:** Basic Needs Trust Fund - Ministry of Finance **Main project features:** Development of a 1600 Kg to a maximum of 3700 Kg per day Processing Facility that would cater for artisanal fishing operators and trawler owners.

11. Detailed Tasks Assigned	12. Work Undertaken that Best Illustrates Capacity to Handle the Tasks Assigned
	Positions held: Environmental Officer **Activities performed:** - Preparation of the Environmental and Social Management Plan. - Attend team meetings - Provision of Mitigation measures for environmental problems during design phase.
	Assignment No. 4
	Name of assignment or project: Construction of Processing and Packaging Facility – Lot 2 **Year:** 2019 – 2020 **Location:** NAREI, Mon Repos, East Coast Demerara **Client:** Basic Needs Trust Fund - Ministry of Finance **Main project features:** Project entail the construction of a modern agro-processing and packaging facility to support value added production in the agricultural sector. **Positions held**: Environmental Officer **Activities performed:** - Preparation of the Environmental and Social Management Plan. - Attend team meetings - Provision of Mitigation measures for environmental problems during design phase. - Routine inspection of construction activities and staging area for compliance with EMP. - Health and Safety Inspection. - Weekly Inspection reports.
	Assignment No. 5
	Name of assignment or project: Water and Sanitation Systems Enhancement Projects **Year:** 2019 – 2020 **Location(s):** Wowetta, Rupertee, Aranaputa, Kwaimatta, Fly Hill, and Shulinab; Region 9 **Client:** Basic Needs Trust Fund - Ministry of Finance **Main project features:** Water supply to the isolated deemed villages in Region 9 was insufficient and unsafe in some cases. Residents obtained water from hand dug wells, approximately 15-30 minutes (or more in some cases) to the water source. With the recognition of the challenge for clean and safe water, installation of a distribution network with stand pipes at strategic locations, became a necessity for development of the villages. **Positions held:** Environmental Officer

11. Detailed Tasks Assigned	12. Work Undertaken that Best Illustrates Capacity to Handle the Tasks Assigned
	Activities performed: - Routine inspection of construction activities and staging area for compliance with Environmental Management Plan. - Weekly Health and Safety Inspection. - Monthly inspection reports. - Preparation for the Environmental Management Plan. - Attend team meetings.

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience, and I am available to undertake the assignment in case of an award. I understand that any misstatement or misrepresentation described herein may lead to my disqualification or dismissal by the Client, and/or sanctions by the Bank.

Michael Lowe

Name of Expert | Signature | Date: 22/03/2021

Amanda Persaud

Name of authorized Representative of the Consultant | Signature | Date: 22/03/2021

Shwet Prakash

Partner
Hydrodynamic Modeling Specialist

Shwet is a Partner who manages ERM's Water Resources, Climate Change and Modeling Group. He is an oceanographer and has been managing and delivering water resources and modeling services. Shwet has been involved in developing state of the art chemical fate and transport models for a variety of offshore, coastal and inland water quality applications. His experience includes directing projects that include hydrodynamic studies, groundwater contamination, fate and transport, accidental oil spill studies, sediment transport and scour studies, regulatory permitting climate change risk analysis and adaptation. Shwet has provided these services to most of the major oil & gas companies

Experience: 14 years' experience in oil & gas, power, chemical, mining and manufacturing industry.

Email: Shwet.Prakash@erm.com

Education

- M.S. (Civil Engineering), University at Buffalo, State University of New York, NY, February 2004
- B.S. (Civil Engineering), Indian Institute of Technology, Bombay, India, May 2001
- Professional Development courses in Environmental Hydrodynamics and Sediment Transport Modeling with POM and ECOMSED, Stevens Institute of Technology, Hoboken, NJ

Languages

- English, native speaker

Fields of Competence

- Computational fluid dynamics
- 1-D, 2-D and 3-D numerical modeling of coastal and shelf processes including hydrodynamics and waves
- Chemical transport and fate and water quality modeling
- Ecological risk assessment & spill modeling
- Sediment transport modeling
- Particle tracking and entrainment modeling
- Groundwater modeling
- Programming in FORTRAN, C, Visual Basic and HTML
- Field data processing and analysis
- Marina design and water quality
- Coastal zone protection

Key Industry Sectors

- Oil and Gas
- Electric Utility (fossil fuel, nuclear, wind and hydropower)
- Mining

Key Projects

Water Quality Impact Assessment from offshore FPSO, Guyana
Managed a comprehensive modeling exercise to quantify environmental impacts related to the commissioning of an FPSO offshore Guyana. Environmental risks associated to wastewater discharge, dredging, drill cuttings, mud discharge, pipeline hydrotesting and accidental spills were estimated using numerical models. Individual wastewater components were modeled and evaluated against relevant ambient water quality standards. Assessments were performed based on detailed metocean study of the region to identify critical circulatory patterns. Conducted workshops for local Guyanese government agencies including Guyana EPA.

Multiple Specialist Studies related to offshore O&G development in Gulf of Mexico
Managing and developing various large scale comprehensive water quality and thermal impacts studies in Gulf of Mexico. Modeling studies typically included oceanography and metocean assessments, assessment of chlorine discharges, thermal discharges, wastewater discharges, brine water discharges and accidental spills into the open waters of the Gulf.

Brine Discharge Study for Onshore LNG Facilities, Ras Laffan Industrial City, Qatar
Directed a comprehensive study to assess the impacts of brine discharge from various operators in Ras Laffan Industrial City (RLIC). Assessment included performing a complete three-dimensional hydrodynamic and water quality model for the waters offshore RLIC. Multiple scenarios were developed including normal and upset cases along with a combination of various ambient conditions such as Shamal winds, typical and extreme water temperatures, and multiple tidal cycles. Three different locations of potential discharge of brine release were evaluated to identify the location that would result in least environmental impact. Study results were presented to Qatar's MME.

Multiple Studies Related to Water Quality and Thermal Impacts from Onshore LNG facilities, Qatar
Managing and developing various large scale comprehensive water quality and thermal impacts studies in Ras Laffan Industrial City, Qatar. Modeling studies included assessment of chlorine discharges, thermal discharges and brine water discharges into the Arabian Gulf.

Multiple Specialist Studies related to FLNG development offshore Mozambique
Managed five specialist studies related to the environmental impacts from operational and accidental discharges from an FLNG. Study included development of a comprehensive flow, transport and fate model for thermal, produced water and wastewater discharge along with consideration of accidental oil spill and planned drilling operations.

Development of Constructed Wetlands Model for Water Reuse, Qatar
Directed development of numerical model for constructed wetlands that could aid in designing these wetlands for treatment of wastewater through the removal of nutrients, metals and organic compounds. A functioning wetlands system would allow for the reuse of treated process water for irrigation or recharging groundwater.

Water Quality Impact Assessment from Onshore LNG Terminal Expansion, Indonesia
Managed a comprehensive modeling exercise to quantify environmental impacts related to expansion of an onshore LNG facility in Indonesia. Environmental risks associated to wastewater discharge, dredging, drill cuttings and mud discharge and pipeline hydrotesting were estimated using a 3-D hydrodynamic and transport model. Individual wastewater components were modeled and evaluated against relevant ambient water quality standards.

Lower Passaic River Superfund Site Hydrodynamic and Contaminated Sediment Transport Modeling
This confidential study included analysis of current meter and water surface elevation data and modeling of the hydrodynamics and transport of sediments. The purpose of the study was to support our client, a PRP, in the interim allocation process and to help establish the magnitude of dispersal of material introduced into the prominent Newark Bay river-estuary system. This effort also included review of EPA- and Cooperating Parties Group-generated documents and datasets (particularly EPA's Framework Document and modeling reports), submission of comments, and attendance at Technical Committee meetings.

Dredging Impact Assessment, Saigon Premier Container Terminal, Vietnam
The purpose of this project was to estimate the potential impacts of proposed dredging operations for the Saigon Premier Container Terminal. Three types of impacts were examined: re-suspended sediments entering the water column; suspended and newly exposed bottom sediments exerting a demand on the water column's dissolved oxygen (DO); and, changes in currents caused by the new bottom configuration. Model results predicted magnitudes, durations, and locations of the suspended solids and dissolved oxygen reductions compared to criteria.

Deposition and erosion studies in Tawau Harbor, Vietnam
The hydrodynamic and sediment transport modules of GEMSS were used to evaluate the deposition and erosion characteristics of bottom sediments in Tawau Harbor, Vietnam. The hydrodynamic circulation in the harbor was obtained using tides and winds. Sediment bed characteristics were assumed as non-cohesive and deposition and erosion probabilities were estimated for each model grid cell in the harbor by comparing the bottom currents with the threshold velocities for the movement of sediment particles of different sizes.

Submarine Tailings Disposal Studies in Stephens Passage, Juneau, Alaska
The purpose of this study was to evaluate the impact of proposed submarine tailings outfall in Stephens Passage. The only practical way to include the effects of the complex bathymetry and ocean currents on tailings distribution on the ocean bottom was to use a numerical model to simulate the relevant processes. The models were used to evaluate the distribution of tailings on the ocean bottom based on design parameters for the tailings pipe, and on the model predicted ocean currents. The model results were used to set up sediment monitoring program in the Passage.

Oil Spill Response Planning and Impact Assessment for various clients and fields, offshore Malaysia
Currently developing models to estimate the environmental impacts from accidental spills during the operations of MOPUs and FSOs offshore Malaysia. Responsibilities include overall project management of these modeling projects, client liaison and regulatory support.

Oil Spill Impact Assessment for confidential field development, offshore Western Australia
Currently developing models to estimate the environmental impacts from accidental spills during the operations of FLNGs (Sunrise, Prelude and Scarborough), MOPUs and FSOs offshore Australia. Responsibilities include overall project management of these modeling projects that include three individual clusters.

Oil Spill Response Planning and Impact Assessment for various clients and fields, offshore Africa
Currently directing several model developments to estimate the environmental impacts from accidental and operational discharges including spills during the operations of offshore production units offshore Africa. Responsibilities include overall project management of these modeling projects, client liaison and regulatory support.

Oil Spill Modeling, MA
Involved in development of an oil spill fate model. The model was developed using GEMSS-COSIM (Chemical and Oil Spill Impact Module). The study required analysis of oil spill fate and its shoreline interaction under varying meteorological and hydrodynamic conditions.

Entrainment Modeling Regassification Facility, New Jersey
Proposed development of an LNG import terminal on the Delaware River in Gloucester County, NJ. During vessel unloading while at berth, LNG carriers take on about 30,000 m3 of water to maintain hydraulic stability when empty. Concerns exist regarding the entrainment effects and possible fishery losses due to this ballast water intake. Striped Bass, White Perch and Bay Anchovy are the species of concern since they consistently dominate the ichthyoplankton population in the Delaware River. ERM simulated intake effects using a high resolution hydrodynamic model to estimate entrainment rates for various life stages of these species of concern. These rates were used to estimate the loss of equivalent adults using a specialized module developed by ERM.

Publications

- Saeed, S.; Prakash, S.; Deb, N.; Campbell, R.; Kolluru, V.; Febbo, E.; Dupont, J. “Development of a Site-Specific Kinetic Model for Chlorine Decay and the Formation of Chlorination By-Products in Seawater”. J. Mar. Sci. Eng. 2015, 3, 772-792.
- Wilcock, Ronni, D. Newbold, V. S. Kolluru and S. Prakash, 2015. “Chasing Black Swans: Identification, Adaptation and Resilience”, Presented at the climate change impacts mini symposium organized during the A&WMA’s 108th Annual Conference & Exhibition Connecting the Dots: Environmental Quality to Climate, June 22-25, 2015. Raleigh Convention Center, Raleigh, North Carolina. USA
- Wilcock, Ronni, V. S. Kolluru and S. Prakash, 2015. “A Tool to Determine the Impacts of Climate Change”, Presented at the 35th Annual Conference of the International Association for Impact Assessment – Impact Assessment in the Digital Era”, April 20-23, Florence, Italy, 2015.
- Prakash, S., J. A. Vandenberg, E. M. Buchak. 2014. “Sediment Diagenesis Module for CE-QUAL-W2 Part 2: Numerical Formulation”. Environmental Modeling & Assessment. (in press).
- Vandenberg, J. A., S. Prakash, E. M. Buchak. 2014. “Sediment Diagenesis Module for CE-QUAL-W2. Part 1: Conceptual Formulation”. Environmental Modeling & Assessment. DOI 10.1007/s10666-014-9428-0. Print ISSN 1420-2026. Online ISSN1573-2967. Springer International Publishing. November.
- Prakash, S., Kolluru, V. and Young, C. “Evaluation of the Zone of Influence and Entrainment Impacts for an Intake Using a 3-Dimensional Hydrodynamic and Transport Model”. Journal of Marine Science and Engineering 2014. Vol. 2, 306-325.
- Febbo, E., Duggan, J., Kolluru, V. and Prakash, S. “Integration of a Geospatial Framework with a Suite of Numerical Models for Operational, Environmental and Regulatory Aspects of Cooling Water Usage”. Proceedings of the 2014 International Petroleum Technology Conference, held January 20–22, 2014, in Doha, Qatar.
- Saeed, S., Deb, N., Campbell, R., Prakash, S., Kolluru, V. and Febbo, E. “Laboratory Experiments to Validate 3D Numerical Modeling of Chlorine Decay in Industrial Cooling Water Discharge”. SETAC Europe 23rd Annual Meeting. May 12th to May 16th, 2013. Glasgow, UK.
- Febbo, E.J., Kolluru, V.S. and S. Prakash. “Numerical Modeling of Thermal Plume and Residual Chlorine Fate in Coastal Waters of the Arabian Gulf”. Society of Petroleum Engineering International Conference 2012. September 11-13. Perth, Australia.
- Kolluru, V.S., S. Prakash and E. Febbo. 2012. “Modeling the Fate and Transport of Residual Chlorine and Chlorine By-Products (CBP) in Coastal Waters of the Arabian Gulf”. The Sixth International Conference on Environmental Science and Technology 2012. June 25-29. Houston, Texas, USA.
- Prakash, Shwet, J.A. Vandenberg and E. Buchak. 2012. “CEMA Oil Sands Pit Lake

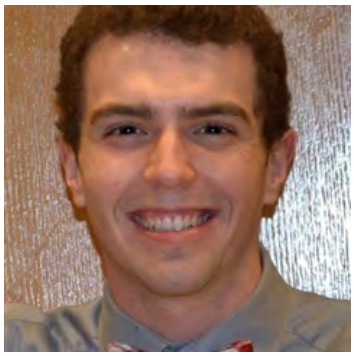
Model". CONRAD 2012 Water Conference. April 20-22. Edmonton, Alberta.

- Kolluru, V.S. and S. Prakash. 2012. "Source Water Protection: Protecting our drinking waters". India Water Week 2012. April 10-14. New Delhi, India.
- Prakash, S., J.A. Vandenberg and E. Buchak. 2011. "The Oil Sands Pit Lake Model - Sediment Diagenesis Module." MODSIM 2011. Modelling and Simulation Society of Australia and New Zealand, December 12-16, 2011. Perth, Australia.
- Vandenberg, J.A., S. Prakash, N. Lauzon and K. Salzsauler. 2011. "Use of water quality models for design and evaluation of pit lakes." Australian Center for Geomechanics. Mine Pit Lakes: Closure and Management. Page 63-81.
- Kolluru, V.S., M.J. Fichera, S. Prakash. 2006. "Multipurpose modeling tool for aquatic and sediment contaminant fate and effect assessments". SETAC North America 27th Annual Meeting. Montreal, Canada. November 2006.

Jacob Guise

Hydrodynamic Modeling Specialist

Jacob has over 2 years of experience in environmental consulting, focusing on environmental impact assessments, remediation, risk assessment, water quality/resources modeling, thermal, and chemical discharge modeling. With a background in environmental engineering, his primary focus is on the Power, and Oil and Gas sector. He has prepared environmental impact assessments for projects located around the coast of Africa (Cote d'Ivore, Sao Tome and Principe, and Equatorial Guinea), Southeast Asia, Montenegro, and in the Gulf of Mexico. Jacob has worked with Exxon Mobil for about a year, and has been part of ERM's support to EEPGL in Guyana since 2019.



Experience: 2 years of experience in Water Resources and Water Quality Modeling

Email: Jacob.Guise@erm.com

Education

- Bachelors of Environmental Engineering, Biological and Chemical Processes, University of Delaware, USA, 2018

Languages

- English, native speaker

Fields of Competence

- CORMIX thermal plume modelling
- COSIM-Oil Spill Modelling
- Chemistry
- Geographic Information System (GIS)
- Python/Visual Basic
- Water resources

Key Industry Sectors

- Oil and Gas
- Power

Key Projects

Water Quality Analysis off the Coast of Brunei
This project focused on the impacts of an oil and gas company's produce water discharge off the coast of Brunei. A three-dimensional, hydrodynamic model was built in order to capture the near field area, and the effects of a neighboring estuary. Jacob supported this work in preparing input files and processing output files from the Generalized Environmental Model for Surface water Systems (GEMSS). Constituent concentrations were compared to Brunei water quality standards.

Discharge Modeling for EEPGL off the Coast of Guyana
Assessed compliance of thermal and chemical discharged due to changes in water quality standards relative to the mixing zone. CORMIX Modelling was ran with local water body conditions and discharge characteristics to determine concentration and percent reduction at multiple distances from the discharges.

Oil Spill and Drill Cuttings Deposition Modeling
Performed oil spill and drill cuttings deposition modeling for Environmental Impact Assessments (EIA) for over 20 projects around the world including around the coast of Africa (including, Cote d'Ivore, Sao Tome and Principe, and Equatorial Guinea), Southeast Asia (including Brunei), Montenegro, and in the Gulf of Mexico. Supported these projects through creation of control files, executing model runs, producing figures, analyzing results, and writing reports.

Wastewater Discharge Temperature Modeling of in United States
Assessed compliance of a thermal discharge due to changes in water quality standards relative to the mixing zone using data analysis and CORMIX Modelling was based on local water body conditions and discharge characteristics.

Hydraulic Zone of Influence Calculations in Southern United States
Assessed compliance of hydraulic intake zones as it relates to meeting the requirements of the United States' Clean Water Act (CWA) 316(b) rule issued on October 14, 2014. The zone of influence shape are based on the dimensions, design intake flow, and surrounding lake/river velocity.

Mark E. Garrison

Air Quality Modeling Specialist

Mark works out of the ERM Philadelphia office in Malvern. He has several years of experience providing expert consultation related to litigation, including expert testimony. His extensive experience in the application of air quality models to assess releases of criteria and toxic air pollutants. Mark has detailed knowledge of the technical, regulatory, and policy issues related to dispersion modeling of new and existing sources and modeling the effects of accidental releases of toxic chemicals; special expertise in modeling sources in complex terrain and in the application of advanced models. He has extensive experience in modeling for PSD and NA-NSR permitting, with special emphasis on electric utility power plants. Mark is author of numerous papers presented at technical conferences on a wide variety of modeling topics.

Experience: 40 years' experience as a meteorologist and air quality dispersion modeler in the environmental consulting field.

Email: Mark.Garrison@erm.com

Education

- M.S., Environmental Science, Drexel University, 1981
- B.S., Environmental Engineering Technology, Temple University, 1977

Professional Affiliations and Registrations

- Air and Waste Management Association
- American Meteorological Society

Languages

- English, native speaker

Fields of Competence

- Air quality dispersion modeling
- Analysis of the consequences of accidental releases
- Meteorological data evaluation and processing
- Dispersion model development
- Expert testimony
- PSD and Nonattainment New Source Review (NA-NSR) modeling
- Electric utility power plant permitting
- Exposure assessment and toxic pollutant impact evaluations
- Air emissions inventory development
- Ambient impact assessments of hazardous waste sites
- Clean Air Act strategic planning
- Modeling in support of risk assessment
- Title V permitting

Key Industry Sectors

- Power
- Oil & Gas
- Waste Management
- Mining

Key Projects

Modeling
Currently directing and conducting modeling for sulfur recovery units (SRUs) at ten facilities in Saudi Arabia. Modeling is being conducted with CALPUFF and meteorological data developed using WRF and MMIF at grid resolutions down to 1.3 km.

Modeling
Directed and conducted modeling in support of an EIA for a 2.4GW Integrated Gasification/Combined Cycle (IGCC) project north of Jazan, Saudi Arabia. Both CALPUFF and AERMOD were used to model emissions from the facility and an adjacent refinery. Meteorological data prepared by CALMET was based on WRF prognostic model wind fields.

Modeling for Gas Facility
Directed and conducted modeling in support of an expansion at a gas processing facility in Saudi Arabia. AERMOD and CALPUFF were both used in this study, and several approaches to developing meteorological inputs were tested, including: single point measurements, gridded meteorological data from MM5, single point and full profile winds extracted from MM5 output data sets. An in-depth analysis was conducted that examined the underlying scientific basis for differences in predictions between different models and different meteorological approaches.

Modeling for a Refinery
Directed and conducted modeling in support of an EIA for a major expansion project at a refinery in Saudi Arabia. CALPUFF was used for this project, with meteorological data prepared by CALMET based on MM5 prognostic model wind fields.

Modeling for a Gas Facility
Completed a modeling analysis of ambient impacts due to emissions from a Greenfield gas processing facility in Saudi Arabia. CALPUFF was used for this project, with meteorological data prepared by CALMET based on MM5 prognostic model wind fields. Numerous scenarios were modeled to determine the optimum plant configuration; modeling of releases from high pressure and acid gas flares was conducted to determine impacts.

Modeling for Mining
Directed and conducted modeling using CALPUFF with WRF meteorological inputs for two mining projects in Canada. Analyses included modeling of hundreds of individual sources at up to 40,000 receptors, to assess compliance with ambient air quality standards, deposition impacts to local vegetation and wildlife, and acid deposition impacts.

Modeling
Conducts modeling as the lead air quality modeling specialist for the Maryland Department of Natural Resources Power Plant Research Program (PPRP) review of several new power plant applications, including the use of AERMOD with special emphasis on addressing the 1-hour NAAQS for SO2 and NO2. Recent work includes use of the SCICHEM model to address secondary impacts on ozone and PM2.5 due to emissions from single sources.

Legal/Expert Witness
Serves as an expert witness in Maryland Public Service Commission cases involving new power plant air quality impacts.

Modeling for Oil Project
Directed and conducted modeling using CALPUFF with WRF meteorological inputs for an oil exploration and production project in the Atlantic Ocean off the coast of Georgetown, Guyana in South America. Modeling included consideration of offshore sources and emissions from delivery ships from shore to the project area.

Modeling
Directed a study that focused on the use of developing meteorological inputs to AERMOD based on WRF model outputs processed with MMIF and AERMET, evaluating the performance of WRF compared to measured wind profiles, and evaluating the performance of AERMOD compared to measured concentrations.

The study is using the Martins Creek data set, consisting of a full year of wind profile measurements and hourly SO2 concentrations at eight monitors in complex terrain. Results of the study were presented at an AWMA Specialty Conference (April 2016).

Modeling for Power Plant
Directed and conducted modeling of SO2 emissions from four coal-fired power plants for confidential clients in Texas to address compliance with the new 1-hour NAAQS for SO2. Modeling included exploration of numerous options for creating and using different meteorological data, the use of CEMs data to estimate the effects of actual emissions variability, and options involving the identification and processing of measured background concentrations.

Modeling and Permitting
Directing an on-going project for a confidential client, in support of PSD permitting of a new generating station in complex terrain. The project is focused on developing meteorological inputs to AERMOD based on WRF model outputs processed with MMIF and AERMET. The modeling with WRF includes innovative approaches to developing refined land use and terrain grids which are key to simulating winds in complex terrain. A protocol was developed for review by EPA OAQPS, intended to gain approval of this approach consistent with EPA's proposed revisions to the Guideline on Air Quality Models.

Modeling
Directing an on-going project for the Maryland Department of Natural Resources Power Plant Research Program (PPRP) that involves development and evaluation of WRF data sets across the State, for possible use in local scale modeling using the WRF data processed by MMIF and AERMET.

Modeling for Gas Facility
Directed a PSD air quality modeling analysis for a new natural gas fired power generation facility in Northeast Pennsylvania. Meteorological data from a nearby tall tower were used in the analysis. An innovative technique using the Weather Research and Forecast (WRF) meteorological model was used, and approved, to demonstrate that the tall tower observations were representative of the project site in an area of complex terrain.

Modeling for Glass Manufacturing Facility
Conducted modeling and prepared a justification document for the use of the ARM2 NOx to NO2 conversion technique, for a glass manufacturing facility in New York State. The U.S. EPA Office of Air Quality Planning and Standards (OAQPS) issued a clearinghouse memorandum approving the justification; this was the first ARM2 approval in the U.S.

Modeling
Supervised and conducted modeling with CALPUFF to determine visibility impacts on Class I areas using MM5-based data for facilities in Alaska (Fertilizer plant), South Carolina (Steel Mill), Pennsylvania (Two Petroleum Refineries), Nebraska (Fertilizer Manufacturing), Oklahoma (Petroleum Refinery), and Texas (Three Carbon Black Facilities). Modeling was conducted in support of BART exemption for the regional haze rule and BART engineering analyses. These projects included the development of meteorological inputs to CALPUFF using CALMET with native format MM5, incorporating local observations, and extraction and evaluation of the effects on regional haze of modeled concentrations.

Modeling
Conducted modeling of two industrial facilities to address compliance with the new 1-hour NAAQS for NO2 and SO2, including in-depth source culpability analyses and in-depth analysis of the OLM and PVMRM Tier 3 approaches to addressing NO to NO2 conversion.

Modeling
Directed and conducted modeling of PM10 and PM2.5 emissions from a biomass power plant in Minnesota. Conducted detailed diagnostic modeling to determine source culpabilities.

Legal/Expert Report
Assisted in the preparation of an expert report in support of a power company defendant involving allegations by the government of avoidance of New Source Review (NSR) requirements for over a dozen mid-western and eastern coal-fired power plants.

Modeling
Directed and conducted modeling with AERMOD in support of an EIA for a proposed fluidized bed power plant firing coal and petroleum coke in Guatemala. Modeling included numerous existing sources, and incorporated measured concentrations as background. Represented client in meetings, conference calls, and correspondence with the IFC.

Modeling
Directed and conducted modeling with AERMOD in support of an EIA for a proposed gas-fired combustion turbine in Peru. Modeling included numerous existing sources. Meteorological inputs were developed from MM5 files, and the advanced PVMRM technique was used to evaluate conversion of NOx to NO2.

Legal/Expert Witness
Served as an expert witness and prepared an expert report in litigation involving the air quality impacts of a gasoline spill, successfully avoiding class certification.

Modeling
Directed and conducted modeling of PM10 emissions from a refinery in New Jersey as part of an update to a PSD application. Project successfully demonstrated compliance with the NAAQS for PM10 based on a region-wide, multi-source analysis.

Modeling
Conducted modeling with the Offshore Coastal Dispersion (OCD) model to evaluate the effects of drilling operations in Bock 15 off of the coast of Angola. Project included processing and evaluation of both land and overwater meteorological data.

Modeling
Directed and conducted modeling in support of a proposed new refinery for a confidential client. CALPUFF was used for this analysis for estimating near-field impacts, with meteorological inputs developed from WRF prognostic model output data files. Since complex terrain was involved, the advanced terrain treatment within CALPUFF was employed and direct comparisons were made between the CALPUFF predictions and predictions from the CTDMPLUS model.

Modeling for Aluminum Smelting
Conducted modeling using CALPUFF of proposed greenfield aluminum smelters in Algeria and Saudi Arabia. Analyses included utilizing specialized approaches for modeling buoyant line sources (potroom exhaust), and evaluations of hydrogen fluoride, SO2, NOx, PM10 and PM2.5, and PAH emissions to determine ambient impacts for comparison to relevant Algeria, Saudi Arabia, WHO, IFC, and EU standards. The Saudi Arabia project was evaluated as part of the King Abdullah Economic City (KAEC) development.

Modeling for Aluminum Smelting
Conducted modeling in support of an aluminum smelter modernization project in New York State. The BLP, AERMOD, and CALPUFF models were evaluated as part of this project. Pollutants modeled include SO2, NOx, and HF from stack and fugitive sources.

Modeling for Aluminum Smelting
Conducted modeling using CALPUFF of a proposed aluminum smelter expansion project in Brazil. Analyzed impacts of hydrogen fluoride, SO2, NOx, and PM10 emissions to compare modeled concentrations to ambient measurements as well as for comparison to relevant ambient standards.

Modeling
Conducted extensive modeling with AERMOD to evaluate the ambient impacts of potential repowering projects at two sites on Long Island, as part of a larger repowering feasibility study. Numerous optional scenarios were modeled and recommendations provided to address air quality requirements of PSD, NNSR, and the State and City Environmental Quality Review (SEQR and CEQR) processes.

Modeling for Aluminum Refinery
Utilized AERMOD to evaluate the impacts of a proposed expansion project at an aluminum refinery in Suriname. The pollutants which were evaluated included nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide (CO), and particulate matter (PM). The results of the modeling analysis were compared to United States Environmental Protection Agency's (USEPA) ambient air quality standards. In addition, the impacts of emissions of hazardous air pollutants (HAPs) from the project on health risks were evaluated.

Modeling
Conducted modeling of the atmospheric transport, transformation and fate of mercury emitted by coal-fired power plants and other source types for the Maryland Department of Natural Resources Power Plant Research Program (PPRP). Developed a speciated mercury emissions inventories for the Eastern U.S., and developed a simplified mercury transformation scheme that has been incorporated into CALPUFF. Model evaluations were performed comparing model predictions to, and analysis of data collected at Mercury Deposition Network (MDN) sites.

Impact Analysis
Performed a cumulative impact analysis for several new electric generation facilities in Maryland utilizing CALMET and CALPUFF, including the effect of multiple plants on visibility resources in the Shenandoah National Park and an assessment of ambient standards in Maryland.

Scientific Peer Review
Participated in scientific peer review panels for the new AERMOD and CALPUFF models at the invitation of the U.S. EPA. Developed comments on the scientific and performance aspects of AERMOD and CALPUFF.

Analysis
Performed a full-scale analysis using the CALMET/CALPUFF modeling system to assess Nitrogen deposition to the Chesapeake Bay resulting from NOx emissions from sources located up to 1000 kilometers from the Bay. Conducted evaluations of the performance of CALPUFF and developed proposed improvements.

Modeling
Performed dispersion modeling in support of accidental release assessments for Clean Air Act 112(r) Risk Management Plan for chemical, paper and other industries at over a dozen facilities using the ALOHA, SLAB, and DEGADIS models.

Modeling
Conducted modeling for input to a risk assessment for a manufacturing facility in Albuquerque, New Mexico using CALPUFF for a local, complex wind application.

Air Quality
Prepared a comprehensive set of input files including MM4, upper air, surface, precipitation, buoy, ozone, land use, and terrain and ran CALMET for Public Service Electric and Gas in New Jersey. Provided evaluation of resultant wind fields.

Legal/Expert Reports
Prepared expert reports including dispersion modeling to address exposure to airborne asbestos particles in two court cases, both of which were settled with plaintiffs prior to trial.

Legal/Expert Report
Prepared an expert report in support of defendant involving the effects of airborne fluoride on the environment in the vicinity of an industrial facility in

Pennsylvania; was deposed by plaintiffs attorney in this case which was settled before going to trial.

Legal/Expert Oversight
Provided expert oversight in a project to estimate metals deposition to several watersheds in the L.A. Basin, due to emissions from seven petroleum refineries. Accomplishments include the development of meteorological input files using CALMET, based on MM5 data developed by the California Air Resources Board and available local observations.

Modeling
Directed and conducted modeling of criteria and toxic emissions, including mercury, from a proposed waste-to-energy facility in Baltimore, MD. Modeling was conducted on behalf of PPRP as part of the environmental review of the facility, and includes modeling of NOx and SO2 emissions to address the new 1-hour NAAQS for NO2 and SO2.

Air Quality Modeling
Conducted extensive air quality modeling to address SO2 ambient standards compliance issues for a refinery in Oklahoma. Work involved model evaluation comparing predicted to measured ambient concentrations. Models included AERMOD and ISCST3. Project included processing and evaluation of meteorological data for ISCST3 and AERMOD.

Olga Samani

Senior Scientist

Olga Samani is a Senior Scientist based in Boston, Massachusetts. She has extensive experience with air quality modeling, emissions inventory development, source characterization, and risk assessment. Olga has conducted a wide range of projects involving the application of dispersion models (e.g., AERMOD, CALPUFF, VISCREEN, PLUVIEW, OCD) for industrial clients ranging from simple stack applications to complex projects involving an array of stacks and fugitive emission sources in the US and many countries around the world. Performed daily "predictive modeling" to confirm that planned operations for the following day will not cause or contribute to a modeled NAAQS exceedance. Performed monthly "hindcast modeling" using actual station emissions parameters and actual hourly meteorological conditions for each day, for comparison to the NAAQS as well as actual monitored concentrations. She has also been involved a number of challenging modeling applications designed to demonstrate compliance with the newly promulgated NO_2, SO_2, and $PM_{2.5}$ ambient standards ranging from small indusial boilers to combined cycle, coal fired power plants, steel and paper mills in support of NAAQS, PSD, BART project, SIP attainment demonstrations, and Hazardous Air Pollutants heath and ecological risk assessments.

Experience: 18+ years of experience in consulting and air quality analysis services in the oil & gas, power industry, chemical, and manufacturing sectors

LinkedIn: https://www.linkedin.com/in/olga-samani-b649b0104/

Email: Olga.Samani@erm.com

Education

- MS. Atmospheric Sciences, University of Massachusetts-Lowell, USA, 2003
- Freedom Support Act Program Fellow. University of Alabama, USA, 1998-1999
- BS. Environmental Sciences and Ecology, National University of Kyiv-Mohyla Academy, Ukraine, 2000

Professional Affiliations and Registrations

- Air & Waste Management Association (A&WMA)

Languages

- English, proficient
- Russian, native speaker
- Ukrainian, native speaker

Fields of Competence

- Air quality dispersion modeling
  - AERMOD
  - CALPUFF
  - SCICHEM
  - OCD
  - VISCREEN, PLUVIEW
  - Air toxics
- Geographic Information System (GIS)
  - ArcMap
  - EQuIS Professional

Key Industry Sectors

- Power
- Oil & Gas (on and off-shore development)
- Manufacturing
- Chemical

Key Projects

Environmental Impact Assessment

Environmental Impact Statement for a Proposed Prince Rupert LNG Terminal, British Columbia, Canada
Led the effort of the air dispersion modeling team to develop the Environmental Impact Statement for an LNG terminal. Worked closely with the BC Ministry of Environment to address concerns related to the modeling procedures and meteorological data development. Developed high-resolution meteorological data and conducted CALPUFF modeling of the sources associated with the proposed LNG facility construction and operation to demonstrate compliance with ambient standards.

Air Quality Assessment of the Vancouver Fraser Port Authority Centerm Expansion Project, Vancouver, British Columbia, Canada
Led the effort of the air dispersion modeling team to develop the Air Quality Assessment for the terminal expansion. Worked closely with the BC Ministry of Environment to address concerns related to the modeling procedures and meteorological data development. Developed high-resolution meteorological data and conducted CALPUFF modeling of the sources associated with the proposed terminal expansion to demonstrate compliance with ambient standards.

Environmental Impact Assessment for the Proposed Toco Marine Port, Trinidad
Conducted air dispersion modeling of the construction and operational phase. Performed CALPUFF modeling of marine vessels, onshore sources, and construction equipment to demonstrate compliance with the Trinidad and Tobago ambient air standards and International Finance Corporation guidelines.

1-Hour SO_2 Data Requirement Rule in Complex Terrain

1-Hour SO_2 Demonstration for Eastman Chemical Manufacturing Facility, Tennessee
Primary investigator for site-specific monitoring and modeling study to resolve an SO_2 non-attainment area in Kingsport, TN. The study has involved installation of meteorological and monitoring equipment, negotiation of monitoring and modeling protocols with reviewing agencies, and EPA approval of a site-specific dispersion model. Performed meteorological data sensitivity analysis utilizing the collected meteorological data and the Weather Research Forecast (WRF) prognostic meteorological data. Conducted numerous CALPUFF and AERMOD model runs to find a compliance scenario for several continuously operating industrial sources using actual emissions.

1-Hour SO_2 Demonstration for GenOn Facilities, Pennsylvania and Ohio
Primary investigator for modeling study to resolve 1-hour SO_2 non-attainment area near the Conemaugh and Seward Generating Stations. Conducted AERMOD modeling using actual emissions from the major coal-fired power plants (Keyston, Homer City, Seward, and Conemaugh) to demostrate complaince with the 1-hour SO_2. Innovative approach was implemented and approved to model complex terrain receptors with the onsite met data and simple terrain was modeled with the airport met data. Applied EPA procedure of randomly reassigned emissions to establish a longer-term averaging.

Litigation Support

Provided litigation modeling expertise for the expert witness report and declarations in support of defendants for Sierra Club vs. Ameren Misouri. Provided litigation modeling expertise for the expert witness report and declarations in support of defendants for Sierra Club vs. Energy Future Holdings Corporation and Luminant Generationg

Company LLC regarding self-reported opacity excursions at the Big Brown Steam Electric Station in Texas during the period 2007-2010.

PSD Permit Applications

PSD Permit Application for Nucor **Steel Mill, Illinois**
Lead the effort to prepare a PSD permit modification application for a large steel mill. The project triggered PSD Review for all pollutants. Performed NAAQS and PSD increment modeling for all pollutants. Performed screening and review of potential impacts at Class I areas in the region. Performed VISCREEN visibility modeling. Performed Tier-I screening for potential ozone and secondary PM2.5 impacts using the MERPs approach. Worked closely with the ADEQ to address all concerns related to the modeling approach and inventory.

PSD Permit Application for Alaska LNG
Liquefaction Facility, Nikitski, Alaska
Lead the effort to prepare a PSD permit application for an onshore LNG facility. Processed meteorological data and conducted CALPUFF modeling of the onshore stationary and marine sources to demonstrate compliance with the PSD increments, AQRVs (visibility and acidic deposition), and NAAQS at nearby Class I and sensitive Class II areas.

PSD Permit Application for Alaska LNG Gas Treatment Plant Permit Application, North Slope, Alaska
Lead the effort to prepare a PSD permit application for the onshore GTP facility. Processed meteorological data and conducted CALPUFF modeling of the stationary sources to show compliance with the PSD increments, AQRVs (visibility and acidic deposition), and NAAQS.

PSD Permit Application for ConocoPhillips **Chukchi Sea, Exploratory Drilling Project, Devil's Paw Prospect, Alaska**
Lead the effort to prepare a PSD permit application for the offshore drilling project. Processed meteorological data for CALPUFF and OCD models. Conducted modeling of the project-related and mobile emissions associated with the exploratory drilling activities to demonstrate compliance with the NAAQS.

PSD Permit Application for ConocoPhillips **Beacon Port LNG Terminal, Gulf of Mexico**
Lead the effort to prepare a PSD permit application for the LNG project. Processed meteorological data for CALPUFF, OCD, and OZIPR (ozone) models. Conducted modeling of the LNG terminal sources and the riser platform in the Gulf of Mexico to demonstate compliance with the PSD increments, AQRVs, and NAAQS.

Publications

- Samani, O., Borissova M., Szembek C., Garrison M., Ramaswamy S., 2020. Air Dispersion Modeling Evaluation of Predicted Fine Particulate Concentrations from Select North American Forest Fires. 113th Annual Virtual Conference, Air & Waste Management Association.
- Paine, R., O. Samani, 2019. Sensitivity Evaluation Analysis of Updates to PRIME and BPIP Downwash Algorithms. 112th Annual Conference, Air & Waste Management Association, Quebec City, Canada.
- Paine, R., J. Connors, C. Warren, O. Samani, 2019. Conditions Associated with Peak Observed SO2 Concentrations and AERMOD's Skill in Simulating These Events. 112th Annual Conference, Air & Waste Management Association, Quebec City, Canada.
- Paine, R., C. Warren, and O. Samani, 2016. AERMOD Low Wind Speed Improvements: Status Report and New Evaluations. 109th Annual Conference, Air & Waste Management Association, New Orleans, LA.

- Paine, R., O. Samani, M. Kaplan, E. Knipping and N. Kumar, 2015. Evaluation of low wind modeling approaches for two tall-stack databases, Journal of the Air & Waste Management Association, 65:11, 1341-1353, DOI: 10.1080/10962247.2015.1085924
- Paine, R., Samani, O., and Mary Kaplan, 2015. Evaluation of Low Wind AERMOD Modeling Approaches for Tall-Stack Databases. 108th Annual Conference, Air & Waste Management Association, Raleigh, NC.
- Heinold D., O. Samani (née Kostrova), 2012. Evaluation of Heat Impacts of a Utility Air Cooled Heat Exchanger in an Urban Setting. 105th Annual Conference, Air & Waste Management Association, San Antonio, TX.
- Shea D., O. Samani (née Kostrova), A. MacNutt, R. Paine, D. Cramer, L. Labrie, 2007. Model Evaluation Study of AERMOD Using Wind Tunnel and Ambient Measurements at Ground-Level and Elevated Locations. 100th Annual Conference, Air & Waste Management Association, Pittsburgh, PA.
- Heinold D., O. Samani (née Kostrova), 2007. Modeling Dispersion During Prolonged Calm Conditions. 100th Annual Conference, Air & Waste Management Association, Pittsburgh, PA.

Surya Ramaswamy

Air Quality Modeling Specialist

Surya is a Principal Consultant working out of ERM's Philadelphia office in Malvern, PA. He has experiences in air quality modeling including emulating, evaluating and processing the meteorological data from prognostic models. His meteorology experience includes implement, update and maintain an ensemble prognostic modeling system such as MM5, WRF, CAMx, and SMOKE on Linux clusters. In addition, he has also extensive experience in Shell, C, FORTRAN, python, R, and Visual Basic (VB) programming. His modeling experience also includes compiling regional scale emission inventory, and evaluating model performance with monitoring data. He has worked extensively in AERMOD, CALPUFF, SCICHEM, MMIF, MOVES, CAMx, SMOKE, and CMAQ. He also has experience in build, and configure Linux clusters to ensemble various models.

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Experience: 14 years' experience of experience in meteorological data evaluation and processing.

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Education

- Certificate in Weather Forecasting, Penn State, Graduating in Fall 2012
- M.S., Environmental Engineering, University of Tennessee, 2005
- B.E., Mechanical Engineering, University of Madras, India, 2001

Languages

- English, native speaker
- Tamil, Fluent
- Hindi, Fluent

Fields of Competence

- Air quality dispersion modeling (CALPUFF, AERMOD, ISC-PRIME, and ISCST3)
- Use of regional scale models including SMOKE, CAMx, and CMAQ
- Programming experience in C, FORTRAN, python, R, and VB
- Proficiency in Linux system administration and shell programming (C shell and Bash)
- Experience in scientific programming and familiarity with netCDF format and visualization tools including pynetCDF, SURFER, Panoply, CDO, NCAR Graphics, ncBrowse, and ncview
- Developing prognostic model data using WRF/MM5

Key Industry Sector

- Power
- Metals/Mining
- Oil & Gas

Key Projects

Air Quality & Meteorological Modeling

Performed detailed modeling for power plants related to review of licensing projects for the State of Maryland Power Plant Research Program (PPRP) for construction and modification at electrical generating units. These projects involved the preparation of environmental review documents (ERD) in addition to modeling using AERMOD and CALPUFF.

Developed gridded meteorological data using MM5 from various analyzes data for use in various projects including Middle East Countries, Caribbean Islands, and Eastern United States. In addition, performed MM5 runs with various analyses data (FNL, NNRP, GDAS, and ETA) and with or without LSM option and evaluated the runs with onsite meteorology data.

Conducted regional scale modeling analysis using CAMx, SMOKE, AMET, SCICHEM and VERDI for Ozone and PM2.5.

Managed and performed numerous ambient impact analyses including supporting PSD permit applications using AERMOD, and CALPUFF. These analyses included both Class I and Class II area impacts and deposition modeling studies.

Air Quality Permitting Project

Assisted Indiana Department of Environmental Management (IDEM) in the issuance of over 40 air quality permits including construction and operating permits. Reviewed air permits related to refineries, power plants, landfills, auto, and paint manufacturing. Review includes computing source-wide potential emissions for all applicable air pollutants. Responded to all comments/issues received during the public notice period, including comments from the public, and U.S. EPA. Reviewed BACT analyses, NSPS, and NESHAP (40 CFR 60, 61 & 63). Conducting regulatory reviews and compliance assessments with applicable state and federal regulations. Established special operating conditions, testing, record keeping, and reporting requirements. Comprehensive knowledge in control devices like Thermal Oxidizers, Dry Filters, Baghouse, and Scrubber.

Surface Modeling Projects

Developing and automating the collection of input files required to run the ERM's surface water hydrodynamic and oil spill dispersion modules of — GEMSS (Generalized Environmental Modeling System for Surfacewaters). This includes preparing the files in the format required by the model, i.e., netCDF format. In addition, in order to complete the time-critical model runs in an expedited manner, develop algorithms which will assist with transitioning the Windows based GEMSS model runs to a Linux platform. Providing support on the review of existing hydrodynamic models for Gulf of Mexico and setting up models in-house for getting real time high resolution currents for spill modeling.

Assisted in developing and automating comprehensive statistical analyses on the met parameters and pollutants from various data source including WRF and CAMx in netCDF format. In addition, developed in-house statistical tools including wind rose and multi-rose to evaluate various meteorological parameters using SURFER, FORTRAN and shell scripting.

Developed WRF data at higher resolution (148 mt) using the high-resolution (10-meter) geo spatial data for multiple complex terrain regions.

Developed numerous handy tools for WRF, AERMOD and CALPUFF to perform pre and post-processing job using FORTRAN and python.

Publications

- Ramaswamy, S., Seaman, S., “Application of CAMx to refine MERPs for Maryland”, submitted and presented to AWMA Modeler’s Specialty conference, Raleigh, NC. November 2017.
- Ramaswamy, S., Garrison, M., Sherwell, J., “Highlighting the Performance of WRF in Complex Terrain”, submitted and presented to AWMA Modeler’s Specialty conference, Raleigh, NC. April 2016.
- Ramaswamy, S., Garrison, M., Sherwell, J., “An Evaluation of the MMIF Program as Applied with AERMOD”, submitted and presented to AWMA Modeler’s Specialty conference, Raleigh, NC. March 2013.
- Ramaswamy, S., Garrison, M., Sherwell, J., “Evaluation and Application of the CALPUFF Model for Evaluating Deposition Impacts of Regional Sources of Air Emissions”, submitted and presented to AWMA conference, San Antonio, TX. June 2012.
- Garrison, M., Yegnan, A., Ramaswamy, S., Sherwell, J., 2011. “Challenges and Solutions for Compliance with Short-term NAAQS for NOX, SO2, and PM2.5”. Presentation given at the 14th Energy, Utility & Environment Conference (EUEC), Phoenix, AZ. February 2011.
- Garrison, M., Yegnan, A., Ramaswamy, S., Sherwell, J., 2011. “Exploring the Use of Gridded Meteorological Data in AERMOD”. Presentation given at the 14th Energy, Utility & Environment Conference (EUEC), Phoenix, AZ. February 2011.
- Ramaswamy, S., Miller, T., “A Performance Analysis of the CMAQ Model and Its Sensitive to Ozone Precursors in East Tennessee”, submitted and presented to AWMA conference, Minneapolis, MN. June 2005.
- Ramaswamy, S., Miller, T., “The Effectiveness of Vehicle Idling Bans in Reducing Emissions”, submitted and presented to AWMA conference, Indianapolis, IN. June 2004.

Anna Sundby, MSc

Socioeconomic Resources/Stakeholder Engagement Specialist

Anna is an experienced and versatile consultant with a background in social performance, communications, and project management. Her expertise includes community and indigenous engagement, land use, livelihoods, impact assessment, and risk management. She is skilled in rapid appraisals and due diligence, as well as comprehensive research and analysis over a project's lifecycle. In addition to consulting activities, Anna has spent extensive periods seconded to clients providing in-house advisory and management services. She has worked across Canada and internationally and is skilled in the application of IFC Performance Standards and other international guidelines. She is comfortable working in politically and culturally complex regions, and works with clients and stakeholders to manage expectations, improve communication, and achieve productive outcomes.

Experience: 13 years' experience in social performance for extractives industries and other sectors.

Email: anna.sundby@erm.com

LinkedIn: https://www.linkedin.com/in/anna-sundby-a4b63029

Education

- MSc. Environment and Development, University of Edinburgh, UK, 2005
- BSc (Hon). Environmental Sciences, University of British Columbia, Canada, 2002

Professional Affiliations and Registrations

- International Association for Impact Assessment (IAIA)
- International Association for Public Participation (IAP2)

Training and Certification

- Human Rights Impact Assessment
- Standard First Aid and CPR-C

Languages

- English, native speaker
- Spanish, intermediate
- French, intermediate

Fields of Competence

- Project management
- Community and indigenous engagement
- Social and environmental impact assessment
- Human rights impact assessment
- Risk identification and analysis
- Strategic plans and toolkits
- Baseline research and reporting
- Management planning
- Site assessments
- Environmental and social due diligence
- Facilitation and training
- Communications and messaging
- Non-technical writing
- IFC Performance Standards, Equator Principles, and other international guidelines

Key Industry Sectors

- Mining
- Oil and Gas
- Transportation
- Utilities

Key Projects

Facilitator
Managed and facilitated a comprehensive alternatives assessment process for a proposed mine in Yukon, Canada, involving a high level of engagement between the proponent, multiple indigenous groups, and regulatory authorities.

Social Impact Assessment
Managed social, economic, land use, and indigenous baseline studies and impact assessments for a proposed mine in BC, Canada. Also oversaw consultation and engagement programs.

Community-Based Research
Interviewed service providers and land users in remote Arctic communities to support socio-economic and land use impact assessments for a proposed mine in Nunavut.

Technical Oversight and Quality Control
On behalf of the client, provided senior technical review and quality control of social, economic, community health, and land use deliverables for a contentious proposed mine in Canada.

Plain Language Reports
Developed a series of non-technical summary reports describing the expected environmental, socio-economic and health effects of a proposed mine adjacent to a mid-sized city in Canada, including a review of studies completed, management measures, and monitoring programs.

Communities Audit
Completed a community-focused audit for a mine site in Canada. Included commitments from agreements with four indigenous groups and other social risks.

Community Liaison Group
Worked with a mining proponent and municipality to establish a framework and detailed terms of reference for a multi-stakeholder community liaison group to support ongoing engagement and monitoring programs for a sub-urban mine site.

Social and Economic Effects Management Plan
Developed a management plan to address social and economic effects, and community/indigenous engagement, throughout construction and operation of a mine in BC, Canada. Provides regular reports on company and contractor performance.

Due Diligence for Financing and Acquisitions
Led multiple due diligence assessments on behalf of potential investors and buyers, in accordance with international standards and guidelines including IFC Performance Standards and Equator Principles. Includes mining, LNG, and energy assets.

Fisheries Livelihoods Assessment
Assessed potential impacts on fishing activities and livelihoods in relation to a major marine infrastructure project in Nicaragua.

Social Responsibility Advisor
Seconded for two years as an in-house advisor on social responsibility, impact assessment, and stakeholder engagement for a natural gas pipeline through three countries. Provided review and quality control of EIA and ESIA reports for each country. Provided management oversight and quality control.

Construction Management Plans
In Bulgaria, worked with client and contractors to ensure that construction management plans addressed expected socio-economic risks and impacts, and to optimize potential benefits of local employment and procurement.

Stakeholder Engagement Program
For a multi-national pipeline project, developed and implemented stakeholder engagement programs in Bulgaria, Russia and Turkey in collaboration with local consultants. Represented the proponent in public consultation activities, and in meetings with landowners and government.

Social Assessment and Management Plans
Completed a social impact assessment for a proposed power plant in Egypt. Prepared operational management plans related to employment and working conditions.

Social Impact Assessment
Led the social impact assessment for a 700 km rail line associated with a proposed mine in Guinea.

Monitoring and Evaluation
Developed indicators and monitoring measures to evaluate impact and outcomes of a women's economic development NGO activities in East Africa.

Environmental and Social Impact Assessment
Managed the ESIA process for a proposed mine in Greenland. Conducted community-based research to gather socio-economic baseline information. Challenges included remote communities and a relatively new legislative process.

Guidance Note on Community Development Agreements in the Mining Industry
Prepared a guidance note for the World Bank summarizing recent research, best practices, and recommendations related to community development agreements (e.g. IBAs), focused on the mining industry, and aimed at supporting the needs of proponents, governments, and civil society.

Global Stakeholder Management Platform
Worked with a major mining company to develop and implement a web-based system to manage their relationships with government, local communities, indigenous groups, landowners, and other stakeholders. The program was implemented across all of the client's sites worldwide.

Social Responsibility Toolkit
Developed a series of practical and informative social performance tools for site-level staff at a major mining company with global operations. Included thematic and process tools focused on gender, indigenous peoples, social impact assessment, health, stakeholder engagement, and other topics.

Resettlement Framework
Developed a resettlement framework for involuntary land acquisitions associated with a proposed mine, including guidance to ensure the objectives of the IFC Performance Standards are achieved through, and beyond, the government-led expropriation process.

Key Projects Prior to Joining ERM

Stakeholder Engagement and Needs Assessment
Needs assessment and in-country consultation program in Albania engaging government, community members, and employees. Identified potential issues or challenges from government and community perspectives, and ideas for local community investment, capacity building and other benefits. Included an assessment of gender challenges in rural Albania, and consultation with local women's groups.

Land Use Impact Assessment
Evaluated impacts on land users in rural Argentina in relation to a proposed mine and associated transportation and utility infrastructure.

Socio-Economic Impact Assessment
Led the socio-economic and land use assessments for a 350 km transmission line, including nine indigenous groups with varying land claim status. There was a high level of interest in the project, with contrasting priorities for industrial, recreation, and subsistence values. Also coordinated the stakeholder engagement program for this complex project.

Land Use and Livelihoods Study
Conducted workshops and interviews with land users in the Canadian Arctic to understand potential impacts of a proposed mine on land-based livelihoods and subsistence harvesting.

Candice Ramessar

Socioeconomic Resources/Stakeholder Engagement Specialist

Ms. Ramessar is part of ERM Guyana office acting as the Social Team Lead. She has More than 20 years of relevant professional experience as an international consultant in Guyana, Jamaica, St. Vincent & The Grenadines, Barbados, Trinidad and Tobago, Grenada, Antigua, Barbuda, and the United States. Along her career, she had been part of projects related to environmental and social issues including gender equality and mainstreaming. Ms. Ramessar is familiar with the EHS International Guidelines of the World Bank and IFC Performance Standards.

Experience: 20 years' experience in international consulting, environmental and social development, gender equality and environmental and social research in Guyana and across the Caribbean.

Email: Candice.ramessar@erm.com

Education

- Graduate certificate. Project Leadership, Cornell University, NY, 2011
- Certificate. Applied Project Management, Boston University, Boston, 2010
- Master of science. Geography Virginia Polytechnic Institute and State University, VA, 2003
- Master's certificate. International Research Development, Virginia Tech, VA, 2003
- Bachelors. Biology/ Geography, University of Guyana, Georgetown, 1995

Professional Affiliations and Registrations

- Women Organizing for Change in Natural Resources Management

Languages

- English

Fields of Competence

- International Consulting
- Environmental and social development issues
- Gender Equality
- Environmental and social research

Key Industry Sectors

- Sustainable Finance
- Governance
- Financial
- Agricultural

Key Projects

Applied Political Economy Analysis Consultant
Develop a country strategy for Pact USAID funded project on capacity building of indigenous organizations in Guyana and extractive industries and natural resources management issues.

Stakeholder and Institutional Assessment and Gender Expert
Gender, Social and Institutional Assessment expert for Guyana for the preparation of two UNDP-GEF proposals for USD 20 Million project in mainstreaming biodiversity in small-scale gold mining in Guyana. Conducted Stakeholder Analysis and Gender analysis through Key Informant Interviews etc

Social Specialist World Bank Projects
Ensure compliance of all World Bank-funded projects implemented by the Government of Grenada complies with the World Bank Environmental and Social Operational guidelines. Conduct training and workshops for the government of Grenada staff and local and international contractors

Consultant Results Based Framework
Conducted a two-day workshop on Results-Based Management and facilitation of the planning and development of the Work Plan for the agency for the year 2019. Application of ARC-D toolkit and integration of the Guyana Green State Development Strategy framework for resilient communities

Gender and socio-economic expert
Gender and socio-economic expert for Grenada and St Vincent and the Grenadines for the preparation of two UNDP-GEF proposals for USD 19 Million and 20 Million projects respectively in biodiversity mainstreaming and climate resilient agriculture. Conducted Stakeholder Analysis and Gender analysis through Key Informant Interviews.

Volunteer
Conducted project management and other training for the NGOs and CBOs associated with the Civil Defense Commission as part of the CDC activities to build resilient communities in Guyana and their Community-Based Disaster Management initiatives. Application of the ARC-D toolkit.

Consultant
Conduct an assessment of the users and holders of Biodiversity information including a needs assessment and a capacity development strategy.

Women and Child/Social Inclusive Expert
Designed and developed 10 children friendly regional profiles to be used by the Civil Defense Commission for the Ministry of Communities and the Civil Defense Commission in climate-smart and disaster planning for the 10 regions of Guyana using the data and indicators from the 2016 MICS Survey.

Environmental Sociologist
Conducted socio-economic analysis including gender analysis of the Rio Conventions implementation in Guyana (United Nations Convention on Climate Change, Desertification, and Biodiversity). Design and implement a national KAP survey to assess the perceptions of the public to the conventions. Conducted an assessment of the awareness of the Rio Conventions in 28 Governmental Agencies in Guyana.

Consultant Social Specialist
Serves as the social consultant for World Bank-funded projects at the Ministry of Agriculture, Guyana. Responsible for the implementation of social safeguards according to World Bank OP guidelines, including voluntary resettlement. Develop and implement a monitoring framework and collect baseline social indicators. Monitor social indicators.

Social Consultant
Part of a team that conducted an -ex-ante economic analysis of a USD 20 Million IDB housing project in

Sophia, Guyana. Served as the environmental/social consultant. Conducted Key Informant Interviews and provided social indicators in the development of the economic analysis tool.

National Researcher/Consultant Women
Researcher for a National Qualitative Study on Indigenous Women and Children in Guyana. Conducted focus groups, key informant interviews, and individual profiles in 20 indigenous hinterland communities across Guyana.

Gender Environmental and Social Consultant
Safeguards Consultant for the development of a stakeholder engagement plan, indigenous peoples plan and gender plan for a GEF 3.5 million USD project on the elimination of mercury in small-scale gold mining in Guyana.

Socio-economic and Gender Consultant
Conducted a rapid socio-economic impact assessment including a gender analysis of the Caribbean Marine Bio-diversity Project on the fisherfolk in the islands of St. Vincent and the Grenadines and Grenada

Researcher, Social Analysis
Prepared three country reports for Guyana, Saint Vincent and the Grenadines and Suriname on the HDI indices, institutional, gender and human capacities of the Water and Sanitation (WASH) sector in the respective countries. Interviewed key governmental officials in the water, health, and education sectors.

National Project Consultant
Consultant in the Sustainable Financing and Management of Eastern Caribbean Marine Ecosystems Project. Guided all the activities of the project especially the development of a conservation trust fund for funding of environmental NGOs by providing technical support, including baseline assessment of financing, sustainable finance options and the development of a business model. Collaborated closely with other project consultants, the NIE within the government of Saint Vincent and the Grenadines, the project focal point within the NIE, and other government, regional and international partners and stakeholders. Carried out gender and vulnerability analysis.

Consultant Environmental Communications
Designed and implemented a 7-day workshop and modules on Environmental Awareness and Communications for the staff of the Ministry of Agriculture and Rural Development of Saint Vincent and the Grenadines

Social and Gender Consultant
Georgetown Solid Waste Project/ Social Development Specialist as part of the study of an Environmental and Social Audit of the Haggs Bosch landfill; Eccles. Using PRA methodologies researched, analyzed, and present the findings, including a gender analysis of the impacts of the landfill on the surrounding communities. Data were analyzed using SPSS and differentiated impacts by gender calculated.

Consultant on Communications for Development
Developed and implemented a 5 module Communication for Development Programme for the farmers of the Peter's Hope Bordisen area in Saint Vincent and the Grenadines.

Social sector Consultant Project Management
Sustainable Grenadines GEF Civil Society Capacity Building Project Developed a toolkit for civil society organizations in SVG on Basic Project Management including data management and use of project management software. Conduct two-day training on Project Management for CSOs.

Consultant on Communications and Knowledge Management
Developed a toolkit for civil society organizations in SVG on Monitoring and Evaluation, Communications and Knowledge Management. Conduct two-day

training on M& E-communications and Knowledge Management for CSOs.

Consultant in gender in a DRM project
Conducted a vulnerability assessment of the agriculture sector of SVG including gender and social analysis using PRA methodologies and other qualitative tools. Major stakeholders included female farmers, farmers' association's cooperatives, NGOs and governmental bodies. Developed a methodological tool for the assessment of vulnerability. The gender dimensions of vulnerability were noted and actions to address impacts were recommended.

Consultant, Project manager
Served as the consultant and project manager for an IDB Funded Caribbean project targeting the capacity building and institutional strengthening of consumer organizations in three Caribbean countries, Jamaica, Trinidad, and Tobago, and Barbados. Reported to the Director of Global Operations and was responsible for all aspects of the project including financial management.

Social Specialist
Facilitated, designed and coordinated a Social Monitoring Study of Rose Place, Kingstown, Saint Vincent in collaboration with the Ministry of Agriculture and Fisheries and the fishermen society. Designed a qualitative study, coordinated interviewers and the collection of data, analyzed primary data using SPSS to produce a final document.

Consultant
Designed Public Awareness and Promotional materials for the Environmental Health Division of the Ministry of Health and Environment St Vincent and the Grenadines

Consultant in DRM
Designed and conducted a desk study on the status of and debate and actions on Community Disaster Management (CDM) in the Caribbean and recommendations for a workshop on Farmers Association and CDM in the Caribbean region.

Consultant
Prepared two modules and conducted two workshops on Solid Waste Management and Corporate Citizenship in Kingstown, SVG

Consultant
Prepared a Strategic Plan for the Caribbean Farmers Network for the years 2008-2010 and an Action Plan for the year 2008.

Volunteer Natural Resources Management Expert
Conducted research on areas such as the World Trading Organization, Economic Partnership Agreements, Served as Technical Adviser to several Agricultural Projects on Sustainable Agriculture and Climate Change

Adjunct Professor
Taught a senior level class of Human Geography to final year undergrad students.

Science Teacher
Taught 9th and 10-grade environmental science classes per New Jersey Core Curriculum in Biology and Physical science

Teaching Assistant
Taught undergrad classes in Environmental and Physical Geography, served as an Assistant to several Professors, also gave guest lectures on Caribbean environmental and social issues.

Program Officer
Designed and Implemented a one-year USAID funded programme to increase the political participation of women, youth and indigenous peoples in various aspects of governance in Guyana including capacity building of the organizations.

Director
Co-Founded and managed an environmental organization in Guyana focused on watershed issues particularly a cyanide spill in the Essequibo River. Research projects for GREEN were funded by several international organizations including the IUCN. The advocacy work of the organization was also featured in several international media outlets including German Public TV.

Cross-Cultural Facilitator
Conducted training exercises with new volunteers on Guyanese society particularly on topics of Guyanese women, African Guyanese, local geography and local dialect.

Technical Assistant to the Minister
Designed, implemented, and monitored and evaluated projects for women's groups and organizations across Guyana. Served as a contact with the press for the Women Affairs Bureau and the Ministry of Labour in Guyana. Represented the government minister at meetings.

Ashanta Osborne Moses

Social Specialist

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SERVING PEOPLE FOR DEVELOPMENT. GUIDED BY PRINCIPLES OF: HONESTY; INTEGRITY; RESPECT; DIGNITY; AND TRANSPARENCY

SUMMARY OF KEY COMPETENCIES

COMPETENCE	EXPERTISE	YEARS OF EXPERIENCE
Programme Management	Managing programmes that promote community resilience using integrated programming models. Focus areas: Gender; Health - Sexual and Reproductive Health (SRH), HIV and STI prevention, Non-Communicable Diseases, Vector-borne Diseases, First Aid; Disaster Risk Reduction and Management; Youth Development. Water and Sanitation. Leadership Capacity Development	18 years
Planning, Monitoring, Evaluation and Reporting (PMER)	Developing Monitoring and Evaluation frameworks for projects/programmes. Designing monitoring, evaluation and reporting tools. Training practitioners. Designing and implementing assessments and evaluations including but not limited to: performance appraisals, capacity assessments, impact evaluations, satisfaction surveys, Gap Analysis.	16 years
Facilitation (Facilitator, Trainer of Trainers and Coach)	Development of agenda using pedagogical and participatory approaches, coordination and facilitation of community, national, regional, and global level workshops, conferences, training, meetings, consultations, and other fora. Trainer of trainers (TOT)	18 years
Community Life Competence (CLC) Facilitator and Coach	Integrating CLC into community programming to identify and maximize strengths, capacities, and resources by harmonizing vision, conducting self and situation assessments, and developing action plans to achieve community goals	12 years
Designing for Behaviour Change (DBC)	Designing programmes using Social and Behaviour Change Communication (SBCC) models. Integrating behaviour change models in program implementation. Providing training for programme planners and implementers. Designing M&E tools for measuring change	8 years
Project/Programme Planning Process - Trainer of Trainers, Facilitator and Coach	Conducting certificate training adapted for Community Leaders, Civil Society groups, programme implementers, youth organizations, other institutions and agencies; enabling them to identify and analyze issues, develop strategies for comprehensively addressing them, and designing projects/programmes for implementation.	16 years

KEY ROLES/PROFESSIONAL EXPERIENCE

CONSULTANT: SOCIAL SPECIALIST – DEVELOPMENT OF THE LINDEN-MABURA HILL SOCIAL IMPACT AND GENDER ANALYSIS, NOVEMBER 2020 – JANUARY 2021

Supported the process by conducting stakeholder and community consultations for updating the feasibility study and prepare detailed designs for the Linden-Mabura Hill Road upgrade and bridge at Kurupukari through a review of the existing studies and undertake the necessary surveys, studies, analysis and designs. Contributed to the preparation of tender documents for the upgrade of the Linden-Mabura Hill Road and bridge at Kurupukari inclusive of, but not limited to, final detailed designs, bills of quantities, environmental and social impact assessment and management plan, technical specifications and conditions of contract. Specifically produced; revised Environmental and Social Impact Assessment (ESIA), and revised Environmental and Social Management Plan (ESMP).

PROJECT COMMUNITY LIAISON OFFICER/SOCIAL SPECIALIST – SHERIFF STREET MANDELA AVENUE ROAD EXPANSION PROJECT, FEBRUARY 2020 – PRESENT

Provide construction management, contract administration and resident engineering services to the Works Services Group of the Ministry of Public Infrastructure for the Implementation of the Sheriff Street – Mandela Avenue (SSMA) Roadway Enhancement Project funded by the Inter-American Development Bank (IDB). Implemented all activities and tasks outlined in the project's Stakeholder Engagement Plan (SEP). Provided oversight for the implementation of the social aspects of the project Environmental and Social Management Plan (ESMP). Coordinated and conducted quarterly frequent stakeholder consultation meetings to discuss all social and environmental issues on the project. Continuously monitored the conduct of workers towards neighbouring communities and the quality of the social engagement activities of the Contractor. Investigated and solved issues raised by communities related to abuses, violations and conflicts caused by the behaviour of workers and other construction activity (e.g., traffic, accidents with victims, dust, property damage, conflicts with communities, etc.).

CONSULTANT: TEAM LEADER – GENDER AND SOCIAL ANALYSIS, GEF-GOLD PROJECT, CONSERVATION INTERNATIONAL-GUYANA (CI), AUGUST 2019 – APRIL 2020

Lead the process of designing process, methodology and tools, and conducted a baseline gender and social
assessment to evaluate participation and contribution in the gold value chain. The assessment specifically identified and examined gender roles in the artisanal and small-scale gold mining value chain, with specific emphasis on constraints and opportunities for participation, livelihood options and income generation; evaluated awareness about the use, handling and effects of mercury on humans and the environment;
and assessed local interest, and potential incentives, for the transition towards more responsible use of mercury and mercury free approaches.

CONSULTANT: NATIONAL GREEN STATE DEVELOPMENT STRATEGY (GSDS) CONSULTATIONS, WWF GUIANAS CONTRACTED. JUNE, DECEMBER 2018

Facilitated planning and execution of national consultation processes conducted in Regions 1, 2, 7, 8, 9, and 10. Included leading preparation of detailed, well-designed consultation process document. Lead and facilitated consultation process at cluster locations according to plan. Ensured meaningful stakeholder engagement and inputs. Compiled regional reports. Analyzed data and drafted recommendations for the Green State Development Strategy

ORGANIZATIONAL DEVELOPMENT CONSULTANT: NATIONAL SOCIETY DEVELOPMENT, INTERNATIONAL FEDERATION OF RED CROSS RED CRESCENT. FEBRUARY – MAY 2018

Provided support to the thirteen Red Cross National Societies (Red Cross organizations) of the Caribbean in updating and modernizing their way of operating by primarily addressing internal pressures related to the areas of National Society leadership, integrity, accountability, development strategy, financial sustainability and internal reforms. This included related development areas such as Learning and Innovation, Federation Data Reporting Systems and Volunteering and Youth Development as prescribed in the Development Operational Plan.

CAPACITY DEVELOPMENT CONSULTANT: NORTH RUPUNUNI DISTRICT DEVELOPMENT BOARD AND SOUTH CENTRAL PEOPLES DEVELOPMENT ASSOCIATION CAPACITY BUILDING, WWF GUIANAS CONTRACTED. NOVEMBER – DECEMBER 2017

Designed and facilitate capacity building training with the North Rupununi District Development Board (NRDDB), South Central Peoples Development Association (SCPDA) Leadership and Community Monitors, and other direct and indirect project partners of the WWF SRJS Project.

AUTHOR: INTERNATIONAL RED CROSS RED CRESCENT GLOBAL YOUTH ENGAGEMENT STUDY REPORT 2017. AUGUST – DECEMBER 2017

Analyzed findings of the Global Youth Engagement Study of 2017 (122 National Societies /Countries participated), and wrote a comprehensive report: "IFRC Global Youth Engagement Study Report 2017". conducted a comparative analysis of the 2017 findings with those of the 2015 Global Report, and produced recommendations for improving and increasing meaningful youth engagement in the context of 'youth as leaders, 'youth as members of affected communities' and 'youth as volunteers.'

CONSULTANT: GENDER MAINSTREAMING AND INCLUSIVENESS WORKSHOPS, WWF GUIANAS AND IUCN GLOBAL GENDER OFFICE. NOVEMBER 2017 AND JUNE 2019

Coordinated, design methodology, and facilitated Gender Mainstreaming and Inclusiveness Workshop. Prepared substantive content for learning sessions covering the topics Gender, Intersectionality, Diversity and Mainstreaming; Rights based approach for environmental governance; and gender and inclusiveness.

CAPACITY DEVELOPMENT CONSULTANT: SOUTH CENTRAL PEOPLES DEVELOPMENT ASSOCIATION, CAPACITY DEVELOPMENT OF MONITORS - WWF GUIANAS. AUGUST 2017

Designed, prepared materials for and facilitated capacity development exercise to support SCPDA by training Community Monitors and technical/project staff in the areas behavioural change communication and advocacy communication, addressing issues such as mining impacts on environment and human health and legislation (natural resources and environmental management).

PROGRAMME MANAGER: BUILDING RESILIENT COMMUNITIES IN REGIONS 1 AND 7, GUYANA RED CROSS SOCIETY. 2013-2017

Lead a team of 15 persons on the strengthening community resilience programme. Specifically to: Lead the process of adopting new ways of strategically engaging key stakeholders and build alliances at grass root levels. Transformed the involvement of the programme in addressing community vulnerabilities by transitioning from a position of ‘project experts’ to one of partners and facilitators of comprehensive and holistic approaches intended to: a. foster cohesiveness within communities; b. build capacity of local leadership to identify, analyze, and respond to challenges; c. increase dialogue for greater connectedness; d. provide technical expertise in specific areas of vulnerability in an integrated manner; e. train community members as resources in diverse sector specific disciplines; and f. build alliances

with local and external partners increasing the impact of the programme. The programme directly reached over ten thousand people and indirectly impacted many more.

OTHER ROLES

FACILITATOR: EXCHANGE MEETING ON COMMUNITY MONITORING REPORTING AND VERIFICATION – NORTH RUPUNUNI DISTRICT DEVELOPMENT BOARD AND KANUKU MOUNTAINS COMMUNITY REPRESENTATIVE GROUP --- REGION 9, WWF GUIANAS CONTRACTED. 2017

FACILITATOR (WWF GUIANAS): STAKEHOLDER MEETING "PROMOTING INTEGRATED AND PARTICIPATORY OCEAN GOVERNANCE IN GUYANA AND SURINAME: THE EASTERN GATE TO THE CARIBBEAN" - GEORGETOWN, GUYANA. 2017

EVALUATOR (THE CONSULTANCY GROUP - TCG): POST ASSIGNMENT EVALUATION OF CI-IDB BASELINE FARM SURVEY. 2015

NATIONAL PROGRAMME MANAGER: CARIBBEAN HIV AND AIDS PREVENTION PROJECT FOR 'AT-RISK' POPULATIONS - REGIONS 1 AND 7, GUYANA RED CROSS SOCIETY. 2010 – 2013

FIELD MANAGER (USAID/PEPFAR): HIV AND AIDS PROGRAMME INITIATION MANAGER - REGIONS 1, 4 AND 9, 2004-2010

PROJECT MANAGER (WORLD BANK): REGIONS 1, 4, AND 10. 2006 - 2010

FIRST AID (FA) COORDINATOR, NATIONAL, 2002-2004

EDUCATION

St. Ignatius Secondary School
Dip. Public Management, University of Guyana
BSc. Sociology, University of Guyana
Certificate – Youth Leadership, Commonwealth Youth Programme
Certificate – Programme Management in Development (PMD Pro), APMG International Certificate
Certificate - Community Engagement and Accountability (IFRC)
Certificate - Project/Programme Planning Process (Programme Development)

Amanda Sahai–Alli

Social Specialist

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PROFILE

Dynamic, hardworking and detail-oriented professional with over ten years' experience engaging members of diverse communities, government agencies and private sector organisations to effectively and efficiently build and maintain cross-functional relationships that contribute to capacity building, community development, and client health and wellness. Works independently with minimal oversight to prioritize tasks and meet tight deadlines in high-pressure environments. Adept in conducting research and synthesizing large volumes of information into concise and informative reports.

CORE COMPETENCIES

- ❖ Stakeholder Engagement
- ❖ Project Management
- ❖ Statistical Package for Social Sciences
- ❖ Research
- ❖ Logistics
- ❖ Monitoring & Evaluation
- ❖ Social Impact Assessment
- ❖ Mental Health

Computer Skills: Microsoft Office Suite

EDUCATION

- **Master of Science (Public Health),** University of Bedfordshire, London, England, 2019–2021
- **Bachelor of Science in Social Work**, University of Guyana, Turkeyen, Guyana, 2005–2007
- **Diploma in Social Work**, University of Guyana, Turkeyen, Guyana, 2003–2005

CERTIFICATION

- Corona Virus Workforce Preparedness Training, Corporate Health and Wellness Association, October 2020
- Certified Training in Statistical Package for Social Sciences (SPSS), Nations University, July 2020
- Certificate in Psychological First Aid for Children (A&B) and Worker Care Module 1, Guyana Red Cross Society, February 2008

PROFESSIONAL EXPERIENCE

March 2017 –Present **Social Work Consultant**
Panacea Consulting

Provide Employee Assistant Programme (EAP) services to organisations in the public and private sectors of Guyana to help employees manage life-stressors of various kinds. The services offered include:

- individual counseling through the practice of social work
- interactive group sessions on mental health awareness
- corporate wellness and pertinent social issues
- corporate social responsibility and
- social impact assessments for projects

February 2008–2011 **Project Manager**

Health Sector Development Unit, Ministry of Health

- Provided oversight of projects managed by the Health Sector Development Unit particularly budget preparation and addressing implementation issues for Human Resource Management Information System Project and other donor funded projects.
- Provided capacity building support for Civil Society Organizations in Project Management.
- Participated in the formulation of the National Mental Health Strategic Plan (2008-2012) including addressing gaps in the then Mental Health Legislation.

Monitoring & Evaluation Officer

Health Sector Development Unit, Ministry of Health

- Responsible for the monitoring of IDB, World Bank and Global Fund Projects including the Basic Nutrition Programme, Guyana HIV/AIDS Reduction Project, the Global Fund Malaria and Tuberculosis Projects.
- Assisted in the adaptation of M&E Tools by Civil Society Organizations and Line Ministries implementing HIV interventions in Guyana.

Assistance Mental Health Coordinator

Health Sector Development Unit, Ministry of Health

- Facilitated workshops under Programme including "Enhancing the Capacity of First Responders to Provide Therapeutic Psychosocial and Basic Mental Health Interventions to Children Affected by Trauma".
- Served on National Suicide Prevention Committee.
- Represented Ministry of Health on "Mental Health and Media Reporting" forum organized by the Ministry of Health in

collaboration with the IDB and the Pan American Health Organization.
- Participated in the preparation and planning of the Treatment and Rehabilitation Program for Substance Abusers in Guyana.
- Planned and executed several psychosocial interventions in the Lusignan Community, Bartica Community and Linden Region.

VOLUNTARY WORK

- Current Director of Public Relations, Rotary Club of Garden City Georgetown Guyana
- Volunteer Counselor with Guyana Foundation , 2012 - 2016
- Member and Social Worker for the Central Islamic Organization of Guyana (CIOG) Medical Outreach Committee, 2008 – 2010
- "Humanitarian Assistance Program" (HAP); which included workshops and seminars [US Embassy Office – Georgetown, Guyana], July 2007
- Community Service Work with the Transfiguration Church, August 2005

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APPENDIX C

Water Quality Modeling Report

Submitted with changes

March 2022

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Esso Exploration and Production Guyana Limited

Water Quality Modeling Report

Yellowtail Development Project

March 2022

Project No.: 0600620

The business of sustainability

ERM

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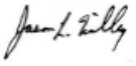
Signature Page

March 2022

Water Quality Modeling Report

Yellowtail Development Project

Shwet Prakash
Partner



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Acronyms and Abbreviations

Name	Description
ºC	degree Celsius
°F	degree Fahrenheit
2-D	two-dimensional
3-D	three-dimensional
bbl	barrel
BOD_5	5-day biochemical oxygen demand
BPD	barrels per day
CFU	colony-forming units
cm	centimeter
cm/s	centimeter per second

Name	Description
CORMIX	Cornell Mixing Zone Expert System
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
FPSO	Floating Production, Storage, and Offloading (vessel)
g/m²	gram per square meter
GEMSS®	Generalized Environmental Modelling System for Surfacewaters
GIFT	Generalized Integrated Fate and Transport
GLLVHT	Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport
HYCOM	HYbrid Coordinate Ocean Model
kBPD	thousand barrels per day
kg/L	kilogram per liter
km^2	square kilometer
m	meter
m^2	square meter
m^3	cubic meter
m^3/d	cubic meter per day
m/s	meter per second
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
mg/L	milligram per liter
mi^2	square mile
m^3	cubic meter
mL	milliliter
mm	millimeter
NA	not applicable
NABF	non-aqueous base fluid
NADF	non-aqueous drilling fluid
ppg	pounds per gallon
ppm	parts per million
SRU	Sulfate Removal Unit
SURF	subsea, umbilicals, risers, and flowlines
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
UTM	Universal Transverse Mercator
WBM	water-based mud

1. INTRODUCTION

1.1 Purpose

In support of an Environmental Impact Assessment (EIA) for the proposed Yellowtail Development Project (Project), Esso Exploration and Production Guyana Limited (EEPGL) commissioned Environmental Resources Management (ERM) to perform modeling of discharges into the marine environment related to planned drilling and oil production in the Stabroek Petroleum Prospecting License Area offshore Guyana (Stabroek Block; Figure 1-1). This modeling included simulations of drill cuttings and mud deposition; and discharges of cooling water; sulfate removal, ultrafiltration, and wash water processing brines; produced water; and hydrotest fluid. Additionally, modeling was performed for a potential unplanned event comprising the hypothetical release of untreated black water from the Project's proposed floating production, storage, and offloading (FPSO) vessel.

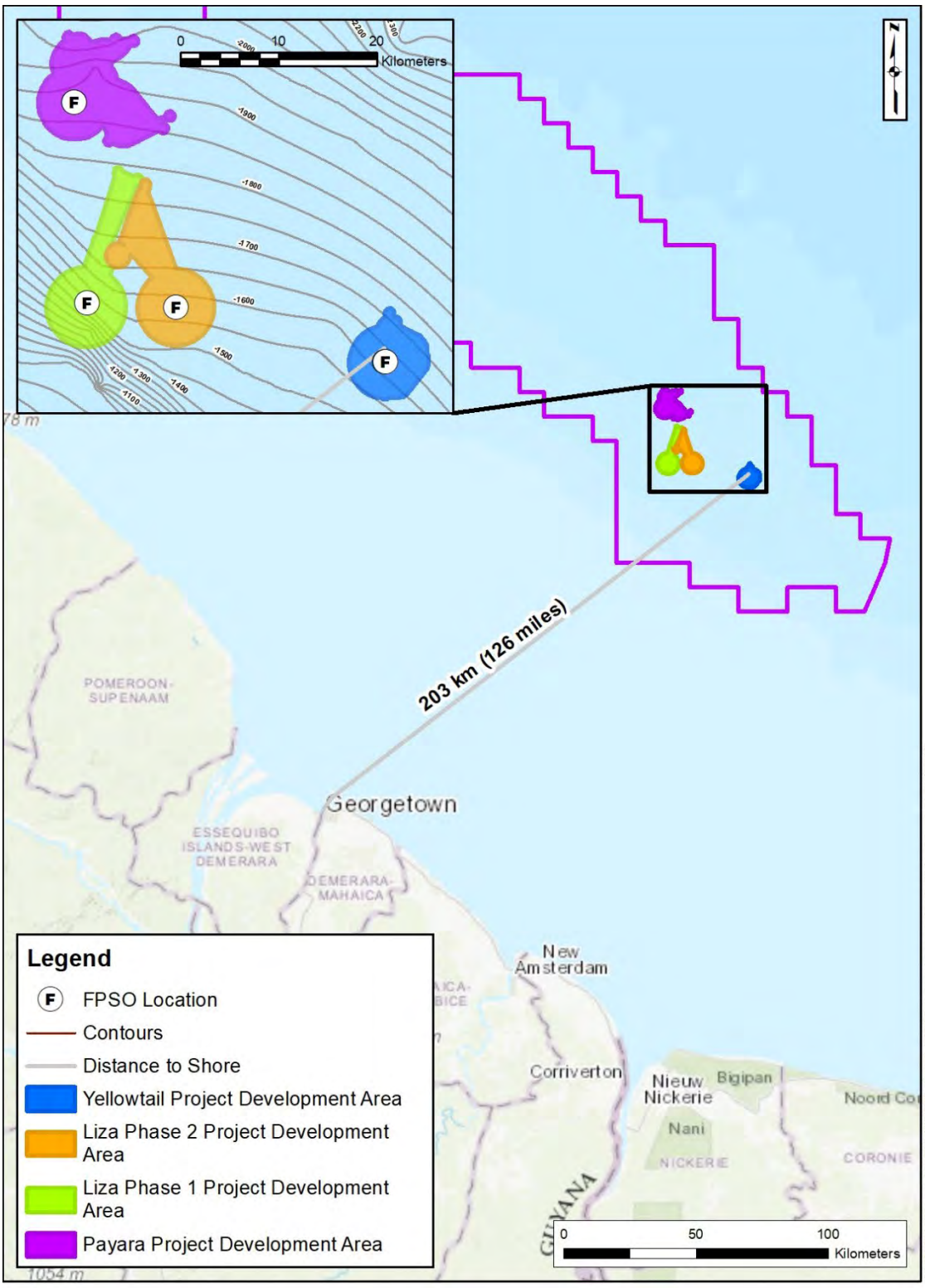
1.2 Scope of Work and Report Organization

This technical report describes the modeling study performed to facilitate assessment of the potential impacts from planned offshore releases and one unplanned offshore release. Section 2 describes modeling performed for planned discharges related to drilling operations; Section 3 describes modeling performed for planned discharges related to production operations, as well as modeling performed for an unplanned release of untreated wastewater (black water) from the Project FPSO. Because the planned activities of the Project will overlap with the planned activities of other EEPGL projects in the Stabroek Block, Sections 4 and 5 describe modeling performed for the combined (cumulative) activities of the Project along with those of the Liza Phase 1, Liza Phase 2, and Payara Development Projects.

Computational models were used to estimate the fate and transport of Project-related discharges. Input data for the modeling were selected based on review of available Project design information, review of oceanographic data from the Project Development Area vicinity, and use of conservative assumptions where data were not available.

Results from modeling conducted for unplanned oil spill scenarios are provided under separate cover in an Oil Spill Response Plan prepared in support of EEPGL's offshore activities in Guyana.

Figure 1-1: Location of the Yellowtail Project Development Area within the Stabroek Block



km = kilometer

2. DRILL CUTTINGS AND MUD DEPOSITION MODELING

2.1 Approach

In this section, the planned discharge of drill cuttings is evaluated. It is assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the riserless open-hole section at each well and, for all other well sections, a discharge near the sea surface of cuttings from material removed in the lower well sections plus a small fraction of adhered residual non-aqueous drilling fluid (NADF) after treatment on the FPSO.

Modeling was performed to predict the following as a result of cuttings discharge:

- The total suspended solids (TSS) concentrations in the water column;
- The accumulation (thickness) of the adhered muds and drill cuttings on the seafloor; and
- The mass of hydrocarbons settled upon the seafloor.

2.1.1 Scenario Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional (3-D) phenomenon requiring 3-D hydrodynamic fate and transport modeling.

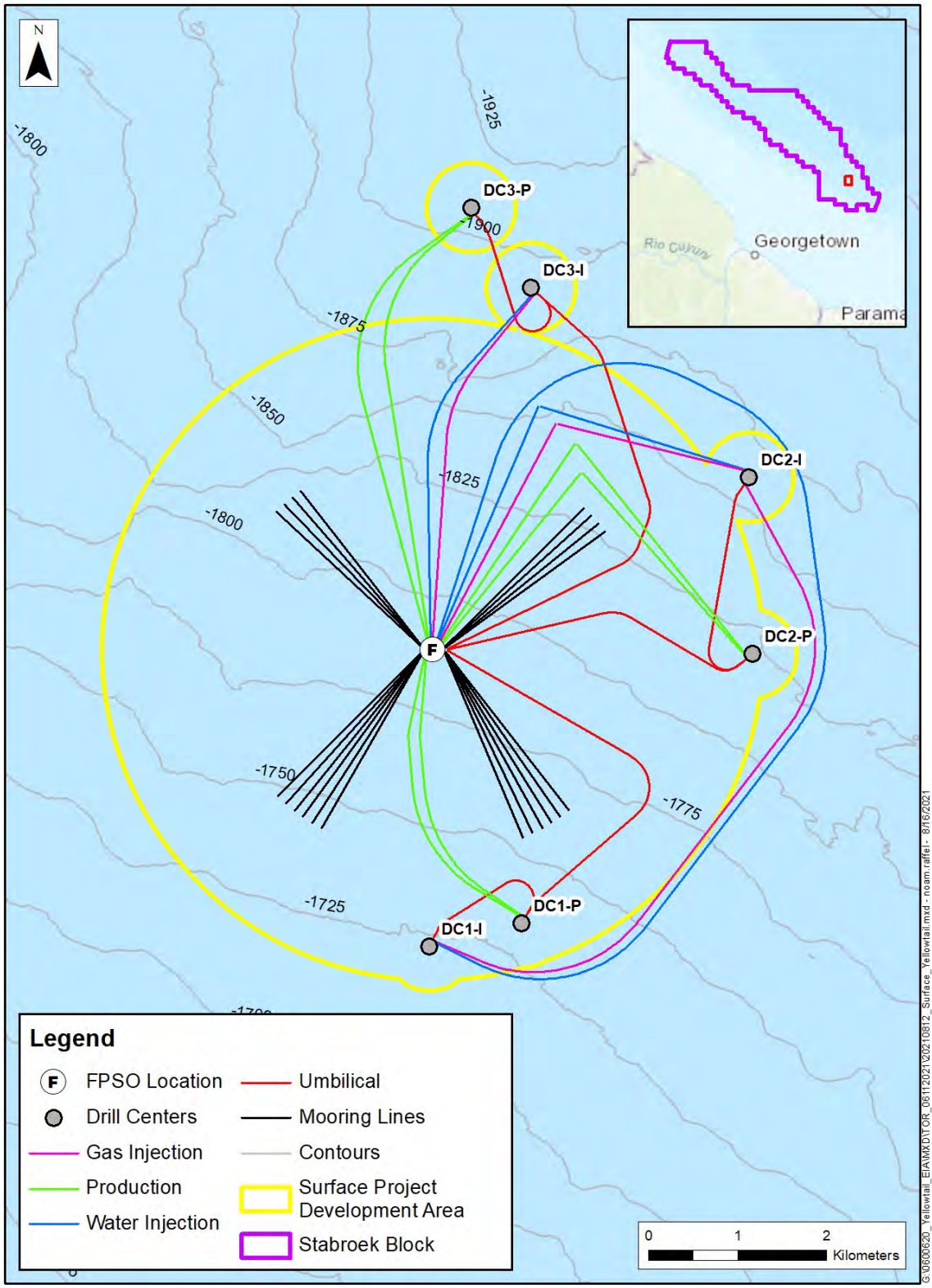
For modeling purposes, two drill center locations were selected at extreme ends of the range of water depths across the Project drill centers (see Figure 2-1). Location DC1-I represents an injection well cluster at drill center DC1-I, and location DC3-P represents a production well cluster at drill center DC3-P. Coordinates of the drill centers and the approximate depths of water at these locations are presented in Table 2-1.

Table 2-1: Modeled Drill Center Locations and Water Depths

Drill Center Location	Longitude	Latitude	X Coordinate in UTM 21N (meters)	Y Coordinate in UTM 21N (meters)	Water Depth (meters)
DC1-I	-56.7168	7.9272	531,218.4	876,268.4	1,723
DC3-P	-56.7122	8.0019	531,720.6	884,520.0	1,910

UTM = Universal Transverse Mercator

Figure 2-1: Locations of Planned Drill Centers in the Yellowtail Project Development Area



2.1.1.1 Location DC1-I

For modeling purposes, it is assumed that a cluster of four wells will be drilled within <20 meters (65.6 feet) of the drill center at DC1-I. Each well will consist of five sections. At each of these well locations, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with water-based muds (WBM) to a depth of 1,540 meters (5,052.5 feet) below the mud line. The subsequent three sections—with hole diameters of 44.5 centimeters (17.5 inches), 31.1 centimeters (12.25 inches), and 24.1 centimeters (9.5 inches)—will be drilled with NADF until a total depth of approximately 6,090 meters (19,980 feet) below the mud line is reached. Details of these sections are presented in Table 2-2. The discharge pipe from the drill ship is assumed to release treated cuttings from Sections 3 through 5 at a depth of 11 meters (36 feet) below mean sea level.

Table 2-2: Well Profile at Location DC1-I

Section	Diameter, millimeters (inches)	Section Length, meters (feet)	Modeled Cuttings Discharge Duration (days)
Section 1—Structural (Top Hole, Jet)	914.4 (36)	120 (393.7)	0.5
Section 2—Conductor	711.2 (28)	1,420 (4,658.8)	1.6
Section 3—Surface	444.5 (17 ½)	950 (3,116.8)	3.5
Section 4—Production	311.2 (12 ¼)	2,550 (8,366.1)	8.1
Section 5—Open	241.3 (9 ½)	1,050 (3,444.9)	6.8

2.1.1.2 Location DC3-P

For modeling purposes, it is assumed that a cluster of four wells will be drilled within <20 meters (65.6 feet) of the drill center at DC3-P. Each well will consist of five sections. At each of these well locations, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with WBM to a depth of 1,430 meters (4,691.6 feet) below the mud line. The subsequent three sections—with hole diameters of 44.5 centimeters (17.5 inches), 31.1 centimeters (12.25 inches), and 24.1 centimeters (9.5 inches)—will be drilled with NADF until a total depth of approximately 6,070 meters (19,914.7 feet) below the mud line is reached. Details of these sections are presented in Table 2-3. The discharge pipe from the drill platform is assumed to release treated cuttings from Section 3 through 5 at a depth of 11 meters (36.1 feet) below mean sea level.

Table 2-3: Well Profile at Location DC3-P

Section	Diameter millimeters (inches)	Section Length, meters (feet)	Modeled Cuttings Discharge Duration (days)
Section 1—Structural (Top Hole, Jet)	914.4 (36)	130 (426.5)	0.5
Section 2—Conductor	711.2 (28)	1,300 (4,265.1)	1.6
Section 3—Surface	444.5 (17 ½)	930 (3,051.2)	3.5
Section 4—Production	311.2 (12 ¼)	2,670 (8,759.8)	8.1
Section 5—Open	241.3 (9 ½)	1,040 (3,412.1)	6.8

2.1.1.3 Model Scenarios

The model simulations for drill cuttings discharges included three scenarios at each drill center location. These are described below.

Scenario 1

Scenario 1 evaluated the impacts from sequentially jetting and drilling two top-hole sections (Sections 1 and 2) at each of the four well locations at DC1-I and DC3-P. This represents the most likely maximum number of top holes (eight; four wells with two top-hole sections each) that could be drilled sequentially at any time from a drill center (DC1-I or DC3-P) within a 30-day time period (the time period relevant for the 5 centimeters (2 inches) per month deposition threshold used). Table 2-2 and Table 2-3 show that the predicted drilling durations based on continuous drilling are 0.5 day and 1.6 days for Section 1 and Section 2, respectively. However, from an operational standpoint, the total duration of the jetting/drilling of these top-hole sections (Sections 1 and 2) will each take approximately 1 week, considering breaks and labor shifts. In addition, jetting/drilling of any top-hole section (Sections 1 and 2) will be followed by at least a 4-day rest period prior to starting the jetting/drilling of the next top-hole. Considering these breaks and rest periods, in addition to the actual drilling/jetting period, this results in a total operational period of 40 days for all four locations, with two top-hole sections at each location.

The resting/break period of 4 days between the sections and wells will allow releases to settle without initiation of a new release from a subsequent well. For conservativeness in the model, the model simulations assumed only a 1-day resting/break period, while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of 40 days to a total of 19 days. The modeled drilling schedule is shown in Table 2-4.

Table 2-4: Scenario 1 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 1	0.5
Break	1
Well 1—Section 2	1.6
Break	1
Well 2—Section 1	0.5
Break	1
Well 2—Section 2	1.6
Break	1
Well 3—Section 1	0.5
Break	1
Well 3—Section 2	1.6
Break	1
Well 4—Section 1	0.5
Break	1
Well 4—Section 2	1.6
Additional Modeled Period for Particle Settling	3.6
Total Simulation Days	**19**

Scenario 2

Scenario 2 evaluated the sequential jetting and drilling of two top-hole sections (Sections 1 and 2) at two of the drill center locations (DC1-I and DC3-P) followed by the change-out of the drill ship to NADF drilling and the drilling of Sections 3 and 4 at the second drill center location for which top-hole sections were drilled. This represents the most likely maximum number of top holes (two wells with two top-hole sections each) and bottom holes (one well with two bottom-hole sections) that could be drilled sequentially at any time from a drill center (DC1-I or DC3-P) within a 30-day time period (the time period relevant for the 5 centimeters (2 inches) per month deposition threshold used). Table 2-2 and Table 2-3

show that the actual predicted drilling durations based on continuous drilling are 0.5 days and 1.6 days for Section 1 and Section 2, respectively. Actual predicted drilling duration based on continuous drilling is 3.5 days for Section 3 and 8.1 days for Section 4. However, from an operational standpoint, the total duration of the jetting/drilling operation of these top-hole sections (Sections 1 or 2) will take approximately 1 week, considering breaks and labor shifts. Once the top-hole sections of the second well have been drilled (approximately 7 days), WBM drilling equipment will be changed to NADF equipment over a rest period of approximately 7 days. Following this change out, Sections 3 and 4 of the second well will be drilled over a period of approximately 15 days. Considering these breaks and rest periods, in addition to actual drilling/jetting period, this results in a total operation period of approximately 40 days.

The resting/break period of 4 to 7 days between the sections and wells will allow releases to settle without any new release starting from the subsequent section. For conservativeness in the model, the model simulations only assumed a 1-day resting/break period, while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of 40 days to a total of 21.5 days. The modeled drilling schedule is shown in Table 2-5.

Table 2-5: Scenario 2 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 1	0.5
Break	1
Well 1—Section 2	1.6
Break	1
Well 2—Section 1	0.5
Break	1
Well 2—Section 2	1.6
Break	1
Well 2—Section 3	3.5
Break	1
Well 2—Section 4	8.1
Additional Modeled Period for Particle Settling	0.7
Total Simulation Days	**21.5**

Scenario 3

Scenario 3 assesses hydrocarbon deposition from topside discharges of treated drill cuttings with adhered NADF from sequentially drilling three bottom-hole sections (Sections 3, 4, and 5) at each of four well locations at a drill center. Table 2-2 and Table 2-3 show that the actual drilling durations based on continuous drilling are 3.5 days, 8.1 days, and 6.8 days for Section 3, 4, and 5, respectively. However, from an operational standpoint, the drilling of Sections 3 through 5 of a well would likely extend over a period of approximately 25 days, followed by a period of approximately 14 days before beginning drilling of Sections 3 through 5 of a subsequent well. The drilling of Sections 3 through 5 of the subsequent well will require another approximately 25 days to complete, followed by a period of approximately 14 days before drilling the next well's bottom-hole sections. Drilling of the third and fourth wells will take another approximately 64 days. In total, it is estimated that this drilling operation would take approximately 140 days.

The resting/break period ranging from 4 to 7 days to multiple weeks between the sections and wells will allow releases to settle without any new release initiating. For conservativeness in the model, the model simulations only assume a 1-day resting/break period while preserving the actual continuous drilling

duration. This conservative assumption significantly compresses the overall drilling schedule from a total of more than 140 days to a total of 87 days. The modeled drilling schedule is shown in Table 2-6.

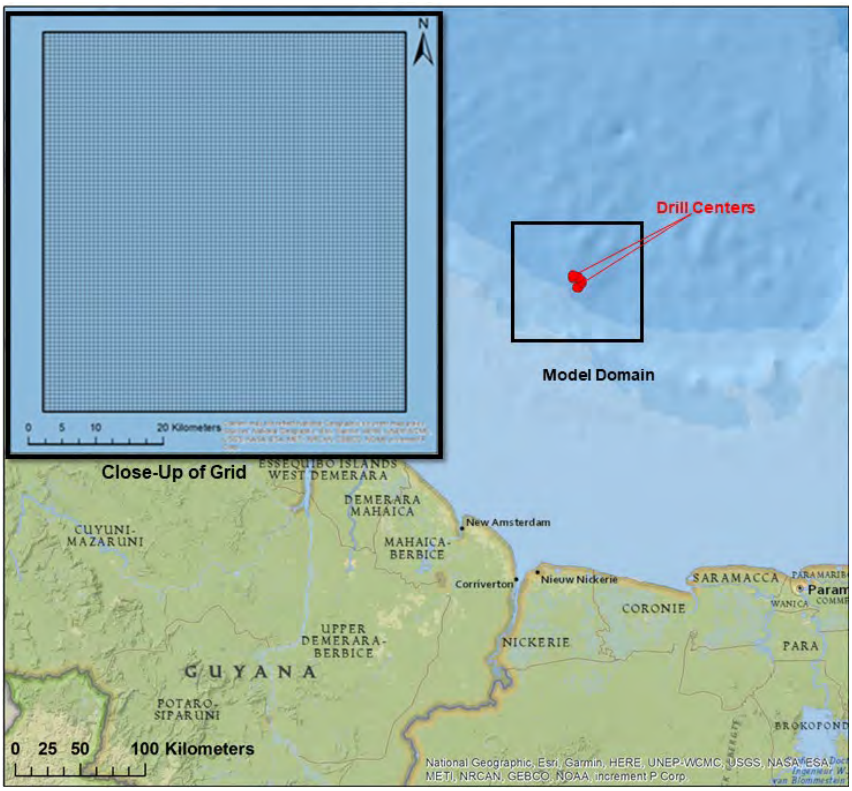
Table 2-6: Scenario 3 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 3	3.5
Break	1
Well 1—Section 4	8.1
Break	1
Well 1—Section 5	6.8
Break	1
Well 2—Section 3	3.5
Break	1
Well 2—Section 4	8.1
Break	1
Well 2—Section 5	6.8
Break	1
Well 3—Section 3	3.5
Break	1
Well 3—Section 4	8.1
Break	1
Well 3—Section 5	6.8
Break	1
Well 4—Section 3	3.5
Break	1
Well 4—Section 4	8.1
Break	1
Well 4—Section 5	6.8
Additional Modeled Period for Particle Settling	2.4
Total Simulation Days	**87**

2.1.1.4 Particle Grids

Three model grids were used: a particle grid, a depositional grid, and a concentration grid. The movement of the discharged cuttings and muds using Lagrangian particles was computed within the particle grid (Figure 2-2). This particle grid is a square approximately 50 kilometers (31 miles) on each side, with each cell approximately 50 meters (164 feet) by 50 meters (164 feet). Each grid cell contains an interpolated depth value derived from the bathymetry data described in Section 2.1.3.1, Bathymetry. Particles are free to move horizontally and vertically within this grid's domain, independently of the grid, except for movement past the grid boundaries representing the seafloor (as defined by the bathymetry) and any shorelines.

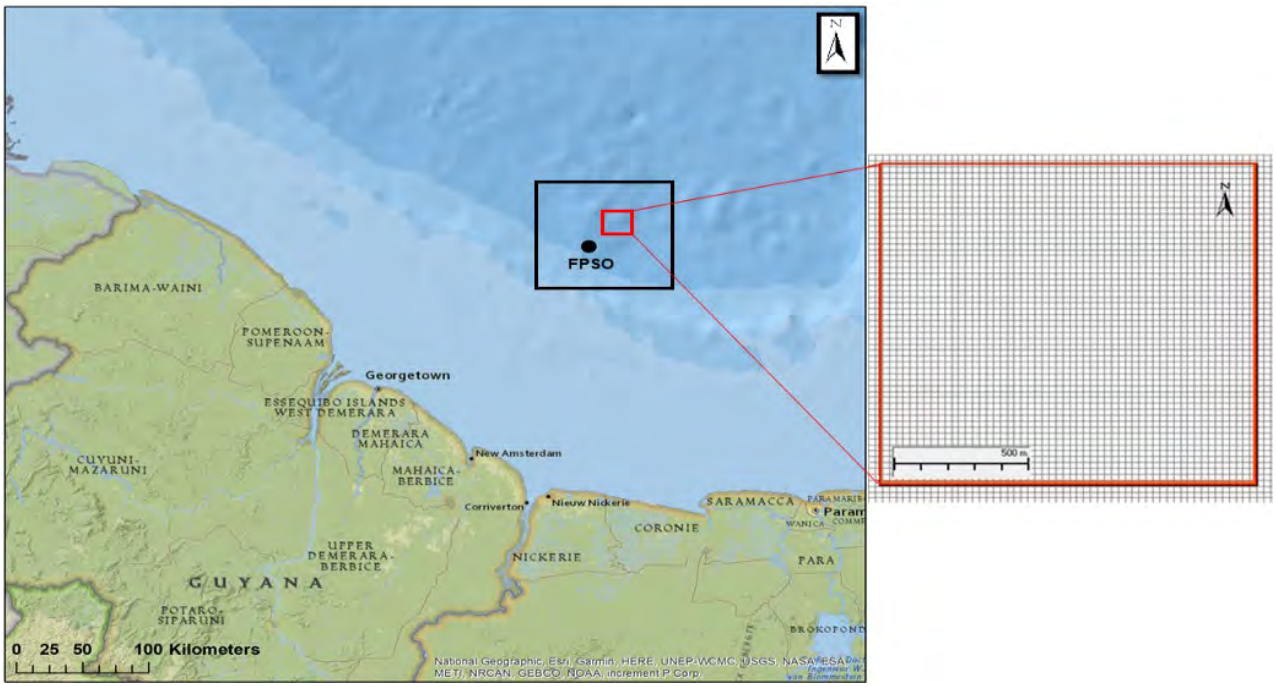
Figure 2-2: Particle Grid



For computation of the deposition on the seafloor, the model used a smaller, more finely spaced two-dimensional (2-D) depositional grid, with each grid centered on a drill center. The depositional grid is a square approximately 20 kilometers (12.4 miles) on each side. Cell sizes vary in size from 10 meters (32.8 feet) by 10 meters (32.8 feet) near the center to 100 meters (328 feet) by 100 meters (328 feet) at the edge of the grid. Figure 2-3 shows a closer look at the depositional grid in the vicinity of the FPSO.

The concentration grid, used for computation of TSS concentrations in the water column, is 3-D, with the same horizontal dimensions as the depositional grid. Vertically, the cells are 10 meters (32.8 feet) thick at the surface and bottom of the water column, where the maximum TSS concentrations are predicted to occur. The cell thicknesses expand in size toward the middle of the water column.

Figure 2-3: Depositional and Concentration Grid



m = meter

A summary of the dimensions of these grids is presented in Table 2-7.

Table 2-7: Grid Dimensions

Grid	Horizontal Dimensions (meters)	Vertical Dimensions
Particle grid	50 x 50	NA
Depositional grid	Variable—smallest 10 x 10 at center	NA
Concentration grid	Variable—smallest 10 x 10 at center	Variable—smallest 5 meters at top and bottom of water column

NA = not applicable

2.1.2 Drill Cuttings and Mud Deposition Software

The modeling was performed using the software package Generalized Environmental Modelling System for Surfacewaters (GEMSS®) and its drill cuttings and muds discharge module, Generalized Integrated Fate and Transport (GIFT) (Kolluru and Spaulding 1993; Kolluru, et al. 1998; Fichera and Kolluru 2007; Fichera et al. 2013; Prakash and Kolluru 2014). GIFT can simulate the fate of dissolved and particulate material discharged from a range of sources, including drill cuttings and muds and produced water. This 3-D particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values. The modeling methodology is based on a deterministic mode of simulation. In deterministic, single-event simulations, the starting date and current speed and direction at each time step are chosen from a database of properties in the selected periods.

Drill cuttings and muds were modeled as particles. Movement in the vertical direction resulted in the settling and deposition of cuttings on the seabed. The deposition, based on particle size distribution and the intensity of release, results in the predicted accumulation of drill cuttings on the seabed.

Modeling data inputs included:

- Drill section sizes and schedule;
- Drilling mud types;
- Cuttings and mud grain size distribution;
- Mud and cuttings densities; and
- Mud and cuttings release rates, durations, and discharge depths.

2.1.3 Environmental Data

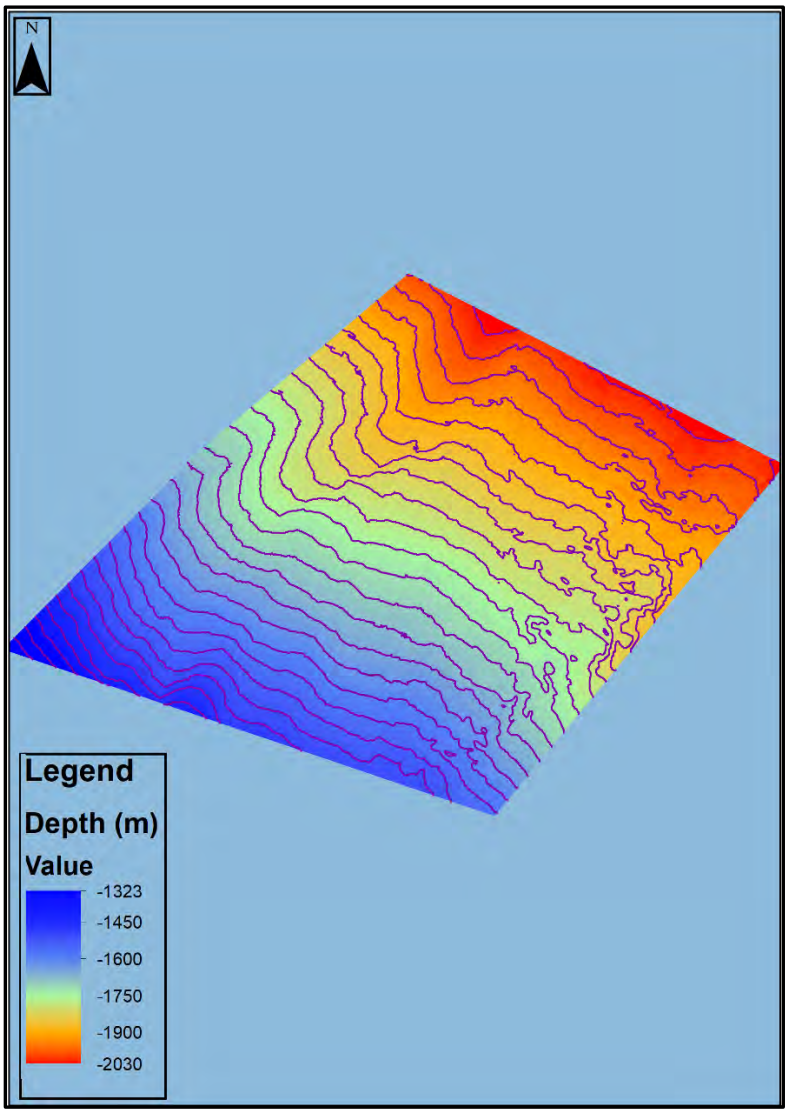
Model inputs were assembled and formatted for use with GIFT. The environmental data used by the model included bathymetry, ocean current, water temperature, and salinity data. Spatially and temporally varying oceanic data were collected to characterize the area in which the discharges will occur and to determine appropriate simulation periods to represent the range of potential results (see Yellowtail EIA Section 6.4.2, Existing Conditions—Marine Water Quality).

2.1.3.1 Bathymetry

The primary spatial dataset is bathymetric data, used to describe the depth and shape of the seafloor. Bathymetric data are used to develop the lower boundary of the modeling grids. EEPGL supplied bathymetry contour data at the study site with contour intervals of 25 meters (82 feet). The bathymetric contours are shown on Figure 2-4.

A polyline shapefile of the Guyana coastline was used as a boundary in the model domain between land and water. The coastline boundary was obtained from Esri's World Boundaries and Places Alternate product.

Figure 2-4: EEPGL Bathymetry Data Offshore Guyana



m = meters

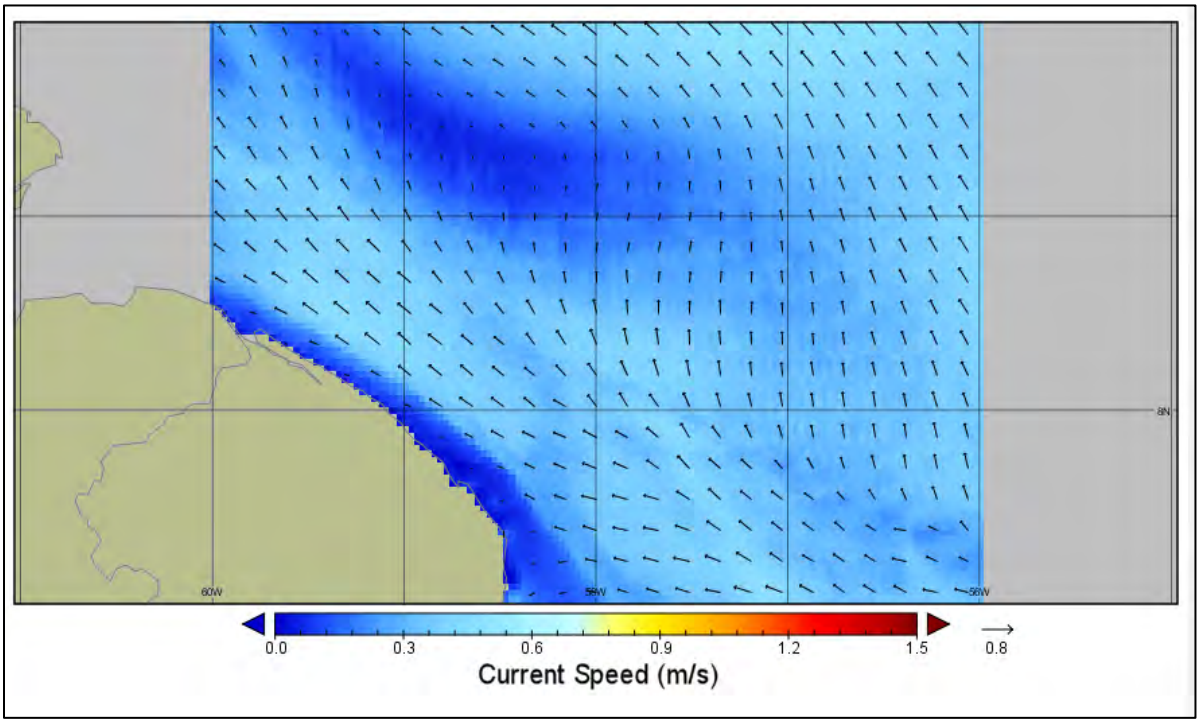
2.1.3.2 Time Varying Data: Ocean Current, Temperature, and Salinity Data

The time-varying data used for the drill cuttings deposition modeling included ocean current speed and direction, water temperature, and salinity. Deposition modeling requires time-varying currents on a 3-D grid. Hourly depth-varying and spatially varying currents were obtained from ExxonMobil Upstream Research Company using the SAT-OCEAN model combined with currents from the HYbrid Coordinate Ocean Model (HYCOM) global ocean circulation hindcast model. Currents were obtained every 3 hours from 2005 through 2014. The model extended from 56ºW to 58ºW longitude and 7ºN to 11ºN latitude over 128 by 128 grid cells and 22 depth bins at 0-, 5-, 10-, 20-, 30-, 40-, 50-, 75-, 100-, 125-, 150-, 200-, 300-, 400-, 500-, 1,000-, 1,500-, 2,000-, 2,500-, 3,000-, 3,500-, and 4,000-meter (0-, 16.4-, 32.8-, 65.6-, 98.4-, 131.2-, 164-, 246.1-, 328.1-, 410.1-, 492.1-, 656.2-, 984.3-, 1,312.3-, 1,640.4-, 3,280.8-, 4,921.3-, 6,561.7-, 8,202.1-, 9,842.5-, 11,482.9-, and 13,123.4-foot) depths. Depth-varying temperature and salinity values were obtained directly from HYCOM model output.

Monthly averaged, depth-averaged current speeds were computed across the 2005 to 2014 period of record. Through a statistical analysis of these current speeds at the well locations, the months with the minimum and maximum average current speeds were determined. Modeling was performed assuming drill cuttings deposition occurs starting on the first day of these 2 months: March 2006 (maximum speed) and August 2013 (minimum speed). Simulations performed during these 2 months will provide the extremes of the full range of depositional patterns (i.e., from a larger and thinner footprint when the current speeds are highest to a smaller and thicker footprint when the current speeds are lowest).

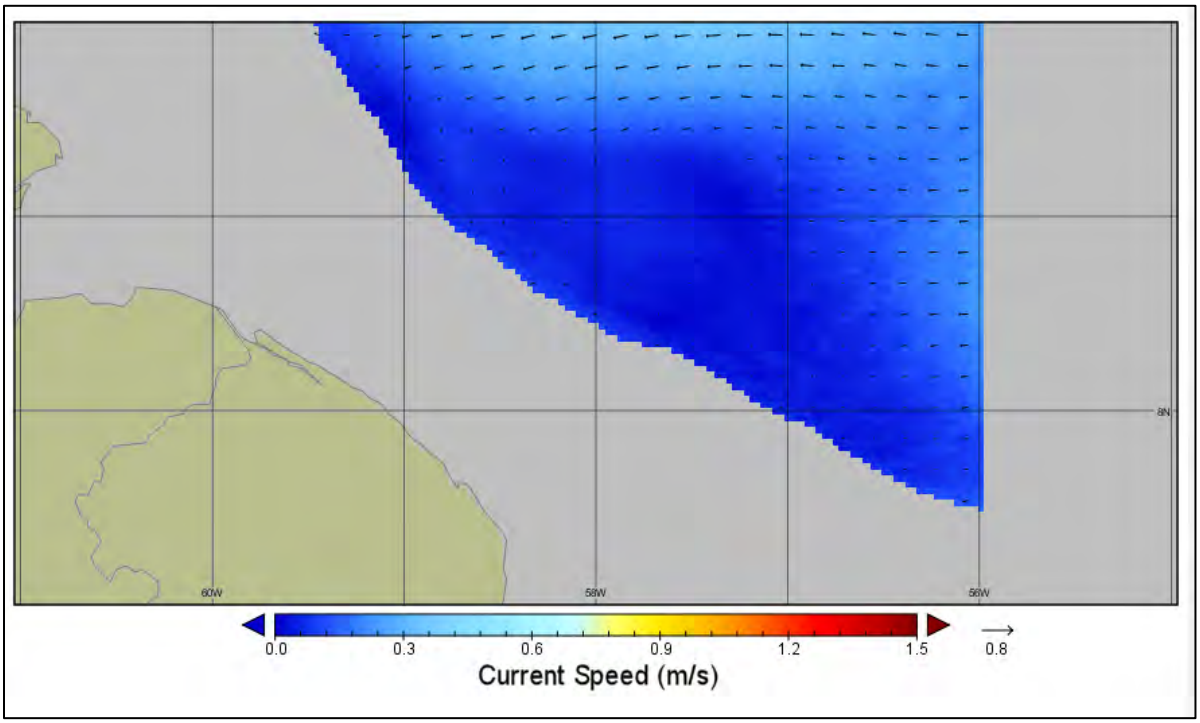
Example current vector plots for March 2006 and August 2013 are shown below on Figure 2-5 and Figure 2-7 (showing current speeds and directions at the sea surface) and on Figure 2-6 and Figure 2-8 (showing current speeds and directions at a depth of 1,000 meters [3,280.8 feet]).

Figure 2-5: Example Current Vector Diagram, 1 March 2006 (Surface)



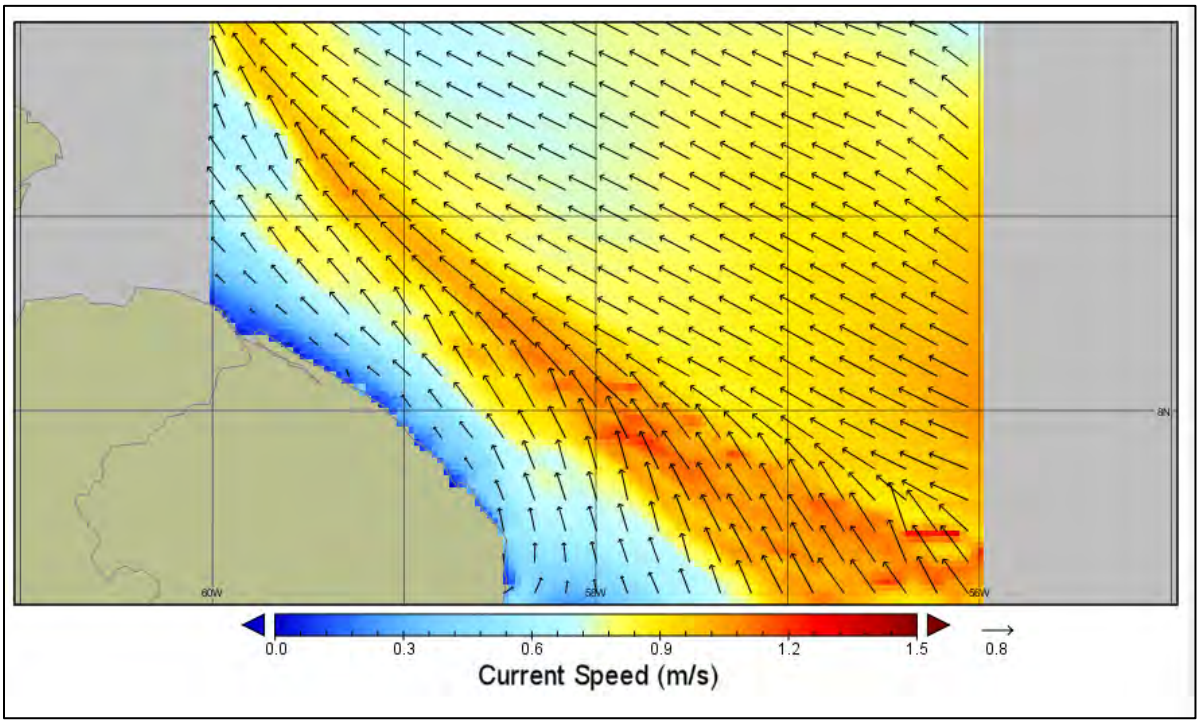
m/s = meter per second

Figure 2-6: Example Current Vector Diagram, 1 March 2006 (1,000-meter Depth)



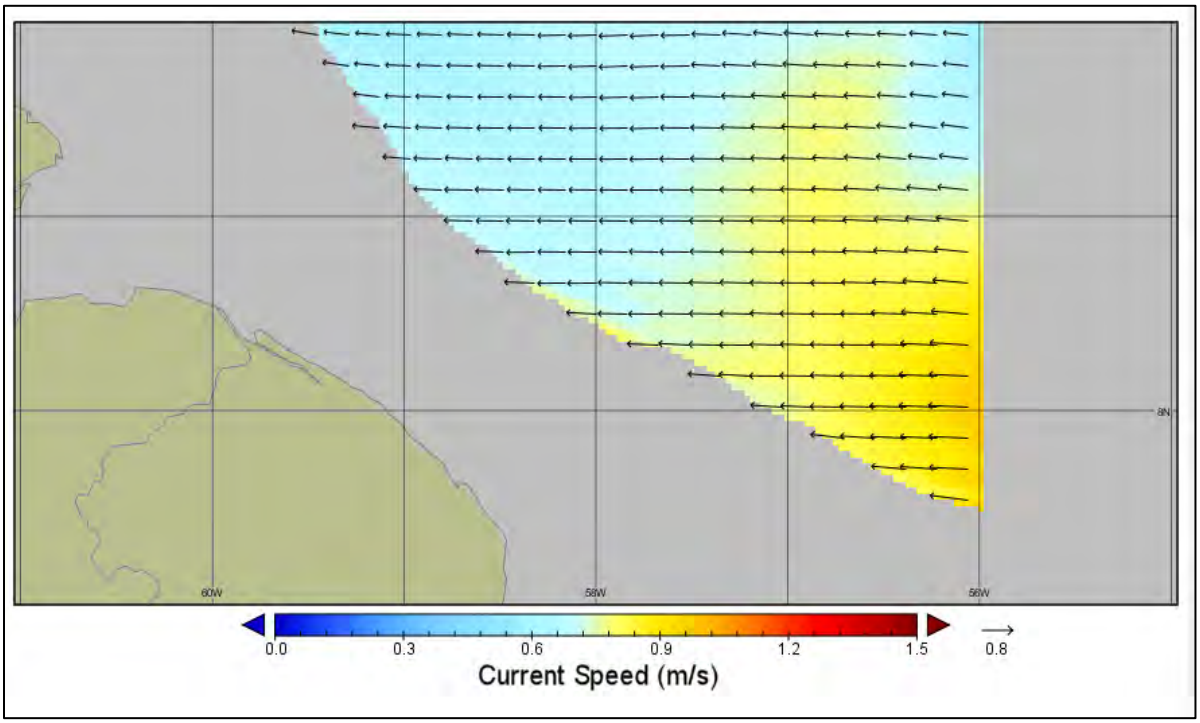
m/s = meter per second

Figure 2-7: Example Current Vector Diagram, 1 August 2013 (Surface)



m/s = meter per second

Figure 2-8: Example Current Vector Diagram, 1 August 2013 (1,000-meter Depth)



m/s = meter per second

2.1.3.3 Drill Cuttings and Mud Volumes and Properties

Estimated quantities of drill cuttings and fluids to be discharged during drilling are provided for locations DC1-I and DC3-P in Table 2-8 and Table 2-9, respectively. The estimated times to drill each section were provided by EEPGL (as discussed above). For the top-hole sections (Sections 1 and 2), only WBM is expected to be used and cuttings will be discharged at the seafloor. For Sections 3 through 5, the cuttings with a small percentage of adhered non-aqueous muds will be discharged at a depth of 11 meters (36.1 feet) below sea level. No non-aqueous drilling muds will be directly discharged. Solids control and cuttings drying equipment will be installed on the drill ships to process and reduce the percentage of NADF retained on cuttings, such that non-aqueous base fluid (NABF) retained on discharged cuttings will not exceed 6.9 percent (by mass) on average. Accordingly, the modeling assumed an NABF content of 6.9 percent by mass for all discharged cuttings.

Table 2-8: Discharge Description for Location DC1-I

Hole Diameter, millimeters (inches)	Volume of Cuttings to be Discharged, bbl (m^3)	Volume of Drilling Fluid to be Discharged, bbl (m^3)	Type of Drilling Fluid	Modeled Cuttings Discharge Duration (days)
914.4 (36)	545.32 (87.3)	683.96 (109.4)	WBM	0.5
711.2 (28)	3,781.93 (605.1)	9,910.34(1,585.7)	WBM	1.6
444.5 (17 ½)	879 (141)	140.60 (22.5)	NADF	3.5
311.2 (12 ¼)	1,310 (210)	210.96 (33.7)	NADF	8.1
241.3 (9 ½)	306 (49)	49.80 (8.0)	NADF	6.8
TOTAL	**6,822 (1,092)**	**10,995.66 (1,759.3)**	**—**	**20.5**

bbl = barrel; m^3 = cubic meter

Table 2-9: Discharge Description for Location DC3-P

Hole Diameter, millimeter (inches)	Volume of Cuttings Discharged, bbl (m^3)	Volume of Drilling Fluid to be Discharged, bbl (m^3)	Type of Drilling Fluid	Modeled Cuttings Discharge Duration (days)
914.4 (36)	495.66 (79.3)	668.3 (106.9)	WBM	0.5
711.2 (28)	4,086.1 (653.8)	9,749.1 (1,559.9)	WBM	1.6
444.5 (17 ½)	905.4 (144.9)	144.82 (23.2)	NADF	3.5
311.2 (12 ¼)	1,250.11 (200.0)	199.96 (32.0)	NADF	8.1
241.3 (9 ½)	314.36 (50.3)	50.3 (8.0)	NADF	6.8
TOTAL	**7,051.61 (1,128.3)**	**10,812.44 (1,730.0)**	**—**	**20.5**

bbl = barrel; m^3 = cubic meter

2.1.3.4 Cuttings and Mud Properties

The grain size properties of the drill cuttings and muds were provided by EEPGL. The distribution of particle sizes and associated fall velocities used in this study are listed in Table 2-10 for cuttings discharged from Section 1 and 2, in Table 2-11 for WBM, and in Table 2-12 for treated cuttings with NADF discharged from Sections 3 through 5. Cuttings density was assumed to be 2.6 kilograms per liter. The WBM density was assumed to be 11 pounds per gallon (ppg) (1.3 kilograms per liter [kg/L]). The density of NADF was reported by EEPGL to range between 9 and 13.2 ppg (1.1 to 1.6 kg/L); 9 ppg (1.1 kg/L) was used as a conservative assumption since it would result in slower settling and a larger footprint of deposition.

Table 2-10: Properties of Cuttings for Well Sections 1 and 2 (Water-Based Fluid)

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.00005	2	0.00003
0.0001	3	0.0001
0.0002	5	0.0003
0.0006	10	0.0046
0.0007	10	0.0695
0.0059	20	0.4460
0.0363	20	1.8300
0.1350	10	6.9300
0.3730	10	14.3000
0.6680	5	19.8000
0.9510	3	23.4000
1.2200	2	26.1000

cm = centimeter; cm/s = centimeters per second; wt% = weight percent

Table 2-11: WBM Grain-Size Distribution

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.0005	7	0.0027
0.0007	8	0.0061
0.0011	5	0.0148
0.0015	10	0.0300
0.0018	13.3	0.0434
0.0020	13.3	0.0511
0.0007	19.2	0.0640

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.0008	19.2	0.0823
0.0058	4	0.4270
0.0250	1	1.1200

cm = centimeter; cm/s = centimeters per second; wt% = weight percent

Table 2-12: Properties of Treated Cuttings for Well Sections 3 through 5 (with Adhered NADF)

Estimated Diameter (cm)	Mass Fraction (wt%)	Fall Velocity (cm/s)
0.001	43	0.02
0.01	1.01	0.20
0.04	4.99	2.00
0.16	5.55	8.00
0.36	7.99	14.00
0.62	10.99	19.00
0.83	13.01	21.99
1.00	6.81	23.99
1.32	3.69	26.99
1.89	2.47	30.97
Note a	0.49	124.97

cm = centimeter; cm/s = centimeters per second; wt% = weight percent
[a] Fall velocity outside the range of available correlations; size computed internally by GIFT model. Fall velocities were based on experiments. These velocities were directly used in the GIFT model to estimate settlement. Estimated diameter sizes are only for reference and do not affect GIFT computations.

2.2 Simulations

Modeling was performed for 12 simulations: for each of three scenarios at each of the two modeled locations (DC1-I and DC3-P), at each of the minimum and maximum ambient current scenarios determined by the monthly averaged, depth-averaged currents analysis (see Table 2-13).

Table 2-13: Drill Cuttings and Fluid Deposition Simulations

Drill Center	Scenario	Parameter(s) Evaluated	Ambient Current Scenario
DC1-I	1	Depositional Thickness Bottom TSS	Minimum Monthly Average
			Maximum Monthly Average
	2	Depositional Thickness Bottom TSS Surface TSS	Minimum Monthly Average
			Maximum Monthly Average
	3	Hydrocarbon Mass Deposition	Minimum Monthly Average
			Maximum Monthly Average
DC3-P	1	Depositional Thickness Bottom TSS	Minimum Monthly Average
			Maximum Monthly Average
	2	Depositional Thickness Bottom TSS Surface TSS	Minimum Monthly Average
			Maximum Monthly Average
	3	Hydrocarbon Mass Deposition	Minimum Monthly Average
			Maximum Monthly Average

Because Scenario 1 results in only bottom discharges from the sequential jetting/drilling of the top-hole sections of four wells, the simulations include predicted cuttings depositional thickness on the seabed on a 2-D basis and TSS concentrations in the water column on a 3-D basis. Scenario 2 drilling results in both bottom and surface discharges. Consequently, depositional thickness as well as surface and bottom TSS concentrations were evaluated. Scenario 3 evaluated the sequential drilling of bottom holes (Sections 3 through 5) for four wells, which represents the worst case for hydrocarbon deposition (from the perspective of temporal overlap) resulting from surface discharges of treated drill cuttings. For this scenario, the mass of deposited hydrocarbons on a 2-D basis was evaluated.

2.2.1 Cuttings Depositional Thickness

Burial by drilling mud and cuttings may cause physical impacts on benthic communities on the seabed. The potential severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material, and the duration of the burial. Thickness thresholds vary by species and sediment impermeability. A suggested threshold deposition rate of 5 centimeters (2 inches) per month is recommended based on Ellis and Heim (1985) and MarLIN (2019). Smaller threshold values as low as 1 millimeter (0.04 inch) have been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering effects. Accordingly, for the purpose of modeling, results are presented in terms of the lateral extent of deposition exceeding 5 centimeters (2 inches) in thickness over a 30-day period. Simulations were designed with consideration to the temporal aspect of the threshold.

2.2.2 Total Suspended Solids

Increases in TSS concentrations in the water column will occur due to discharges of drill cuttings and mud. The highest concentration increases will occur at the point of discharge (i.e., at the seafloor for top sections of the well and near the sea surface for subsequent sections of the well), and will decrease over time and distance as the TSS plume dissipates and settles. Larger particles will settle out more quickly than finer particles, such that smaller particles may stay suspended longer and travel laterally further than larger particles. As such, elevated TSS concentrations may form in regions where tiny suspended particles linger in a cloud and mix with particles from subsequent discharges.

Impacts on marine organisms related to elevated TSS may occur if light penetration in the photic zone (typically the top 200 meters [656.2 feet]) is impeded significantly for long periods of time (reducing the ability of plants and phytoplankton to photosynthesize). Increases in TSS may also decrease water clarity and clog fish gills. A commonly used guidance value for TSS from effluent discharges in the marine environment recommended by MARPOL 73/78[1] is 35 milligrams per liter (mg/L) (IMO 2006). Accordingly, for the purpose of modeling, results are presented in terms of the lateral area with TSS concentrations exceeding 35 mg/L. The likelihood of impacts related to elevated TSS concentrations will tend to decrease in deeper waters below the photic zone, where photosynthesis does not occur. However, elevated TSS concentrations at deeper depths can still impact fish gills. In the absence of a depth-varying guidance value, the same value is applied throughout the water column, but delineation of potential impacts related to elevated TSS concentrations at water depths below the photic zone should be considered a more conservative estimate than near the surface.

2.3 Mass of Oil Deposition

Cuttings containing NADF will be treated through the drilling rig onboard systems (shakers and dryers). The NABF portion of the NADF that remains will be reduced to no more than 6.9 percent base fluid retention on cuttings (average, by mass). These base oils made of hydrocarbons, once settled to the

[1] International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978

seafloor, degrade over time, and may enter the pore water within the sediments or become dissolved in the water column, depending on each specific hydrocarbon's tendency to remain partitioned to the solids.

2.4 Results

The results of the modeling are illustrated in the following sections as contour plots. The plots presented indicate the location of the drill cuttings release point. Results are presented for each of the following parameters for the appropriate scenarios:

- Cuttings deposition thickness on the seafloor at the end of the simulation;
- Maximum TSS concentration in the water column at any time in the simulation (at the surface and at the bottom, representing the surface and seabed discharges, respectively); and
- Mass of hydrocarbons per unit area deposited on the seafloor.

As discussed above, the following threshold criteria were applied for the purpose of reporting results:

- Criterion 1—Cuttings deposition rate less than 5 centimeters (2 inches) per month; and
- Criterion 2—Recommended TSS concentrations no greater than 35 mg/L.

There are no available criteria applicable for the mass of hydrocarbons deposited on the seafloor.

2.4.1 Cuttings Depositional Thickness

2.4.1.1 Scenario 1

When the first two (top-hole) sections of a well are jetted and drilled (prior to the installation of a riser), cuttings and WBMs are discharged directly to the seabed, resulting in a mound of material deposited closely around the well. The material discharged at the seabed is mostly deposited in the area directly adjacent to each wellhead.

Figure 2-9 through Figure 2-12 present the depositional thickness for Scenario 1 for drill centers DC1-I and DC3-P. Higher thicknesses are concentrated around the drill center at the well clusters, but some discrete patches of depositional thicknesses greater than 1 millimeter (0.04 inch) are also present at some distance from these wells.

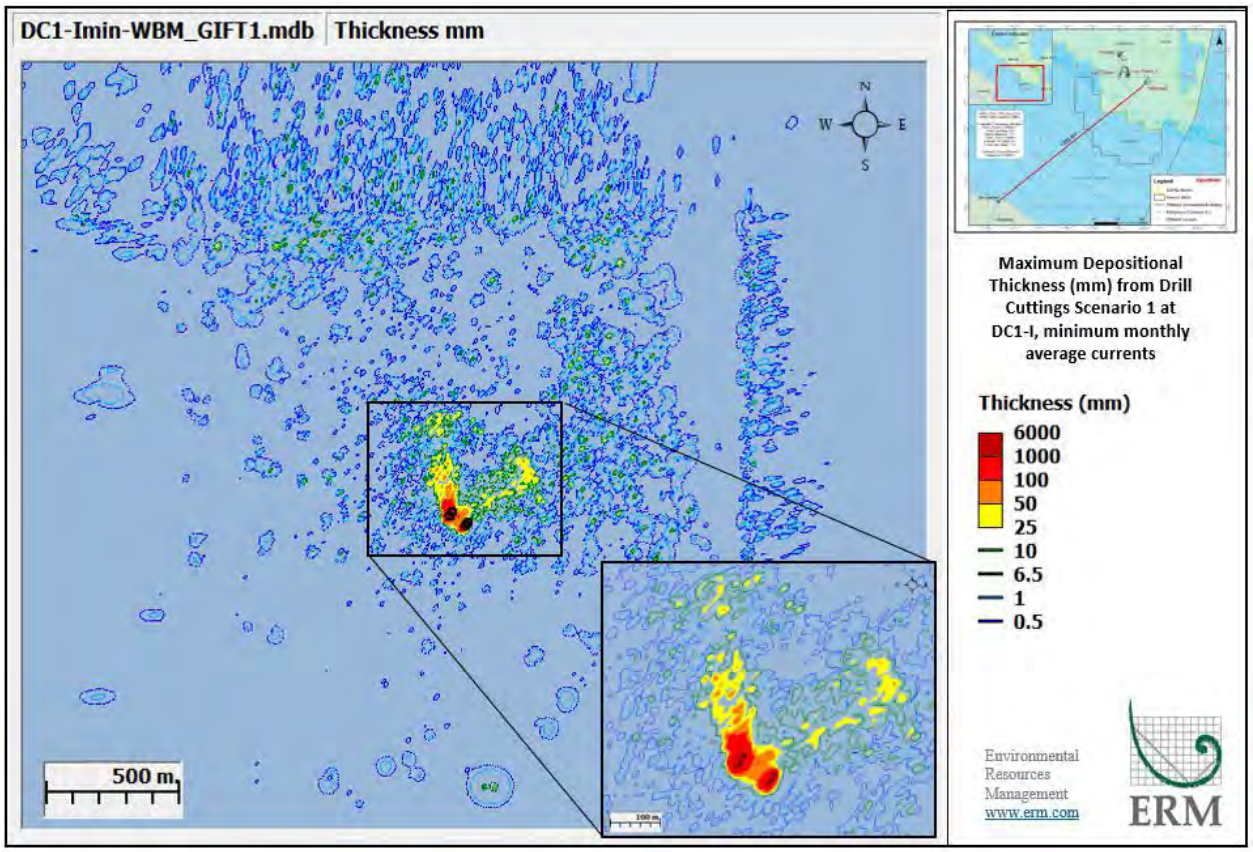
In all simulations, a small region surrounding the well clusters at the drill centers exceeds the depositional thickness threshold value of 5 centimeters (2 inches). For DC3-P, there are two deposition mounds with an approximate lateral extent of 50 meters (164 feet) where the thicknesses exceed this threshold. For DC1-I, the thicknesses exceed this threshold primarily within a 0.4-kilometer (0.23-mile) radius of the drill center. The maximum depositional thicknesses and areas exceeding the threshold value of 5 centimeters (2 inches) for Scenario 1 are presented in Table 2-14. For drill center DC1-I, the maximum depositional thickness is approximately 561 centimeters (220.9 inches) under the minimum currents simulation. For drill center DC3-P, the maximum depositional thickness is approximately 200 centimeters (78.7 inches) under the maximum currents simulation. It is noted that these are conservatively high estimates, as slope failures (i.e., collapse of the depositional mound) and resuspension of the particles by ocean currents are likely to reduce the height of the deposited materials over time.

Table 2-14: Summary of Results—Cuttings Depositional Thickness: Scenario 1

Simulation	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm threshold
DC1-I Scenario 1 Minimum Currents	560.8	8,381
DC1-I Scenario 1 Maximum Currents	443.1	7,234
DC3-P Scenario 1 Minimum Currents	190.3	3,969
DC3-P Scenario 1 Maximum Currents	200.2	3,436

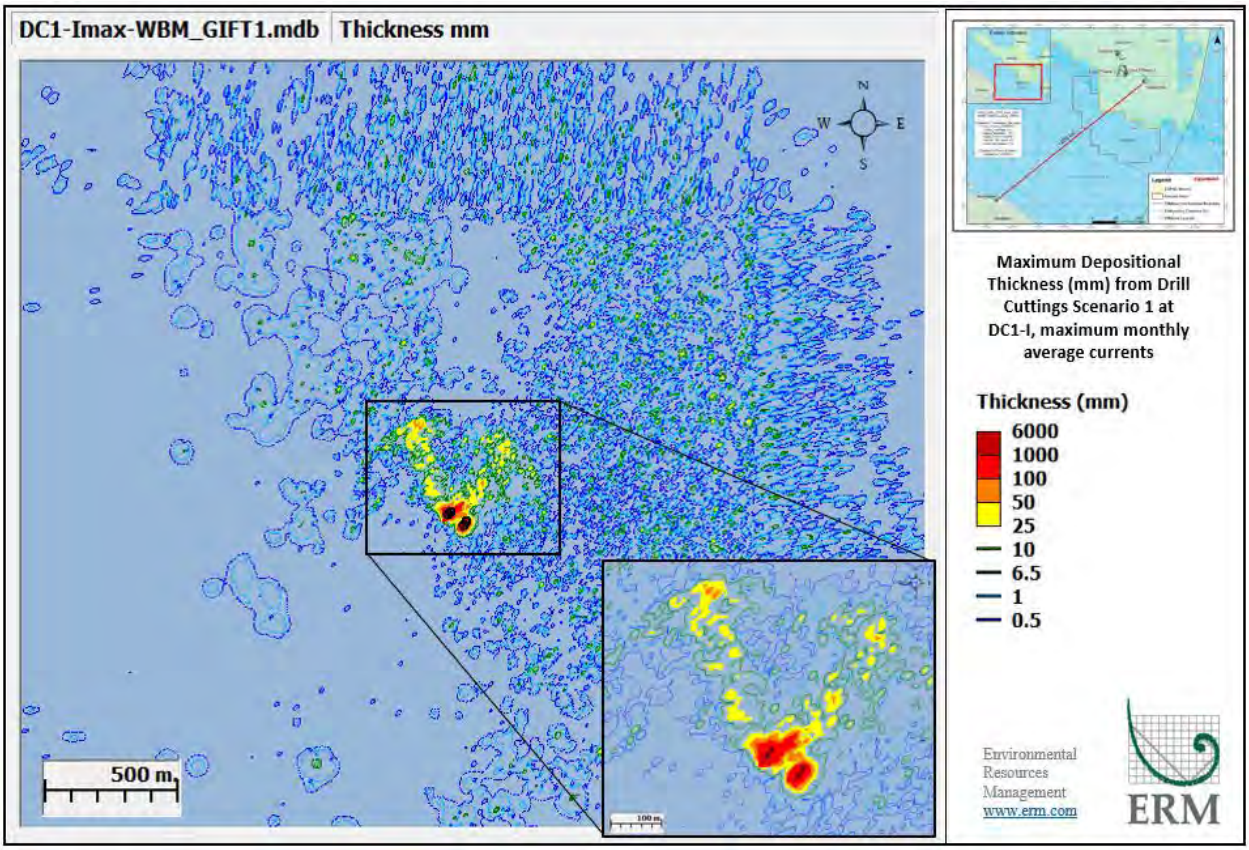
cm = centimeter; m^2 = square meter

Figure 2-9: Maximum Depositional Thickness—Scenario 1 DC1-I: Minimum Currents



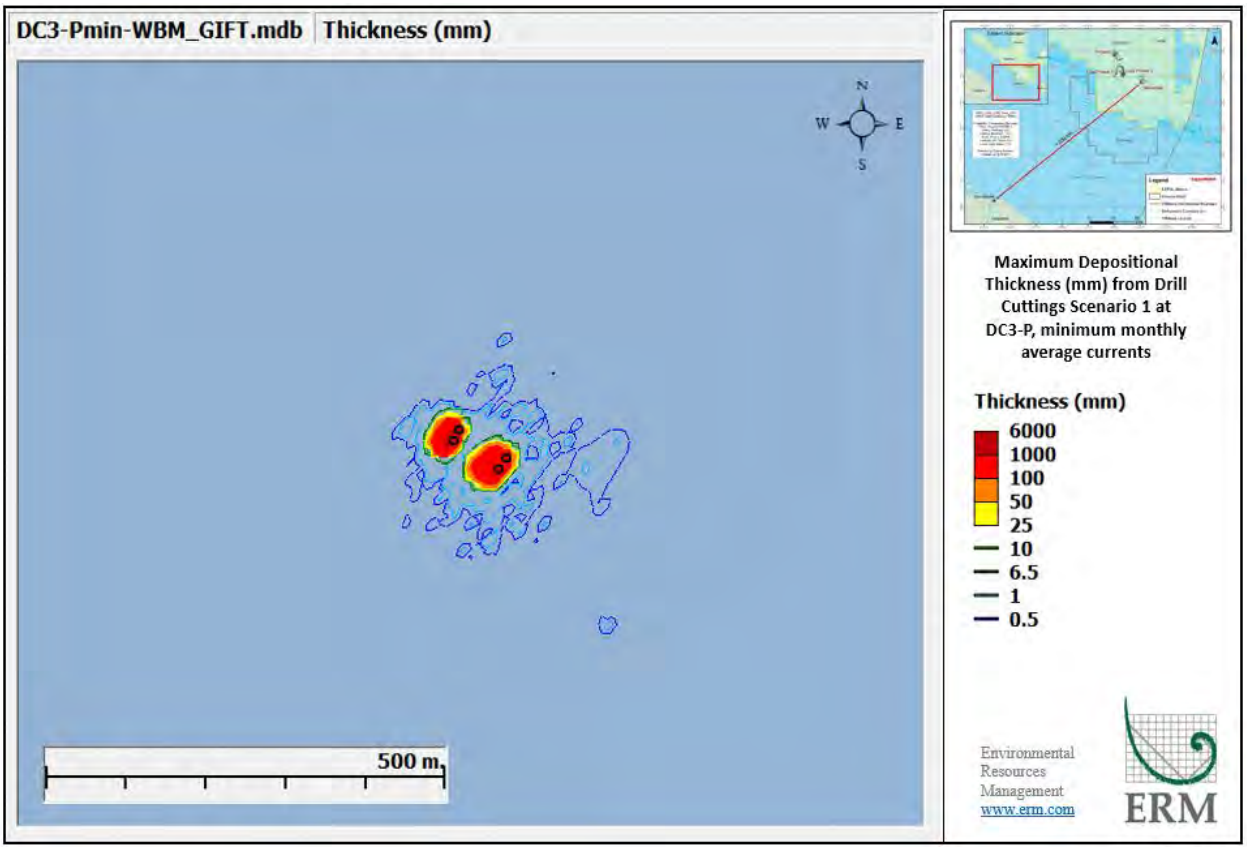
m = meter; mm = millimeter

Figure 2-10: Maximum Depositional Thickness—Scenario 1 DC1-I: Maximum Currents



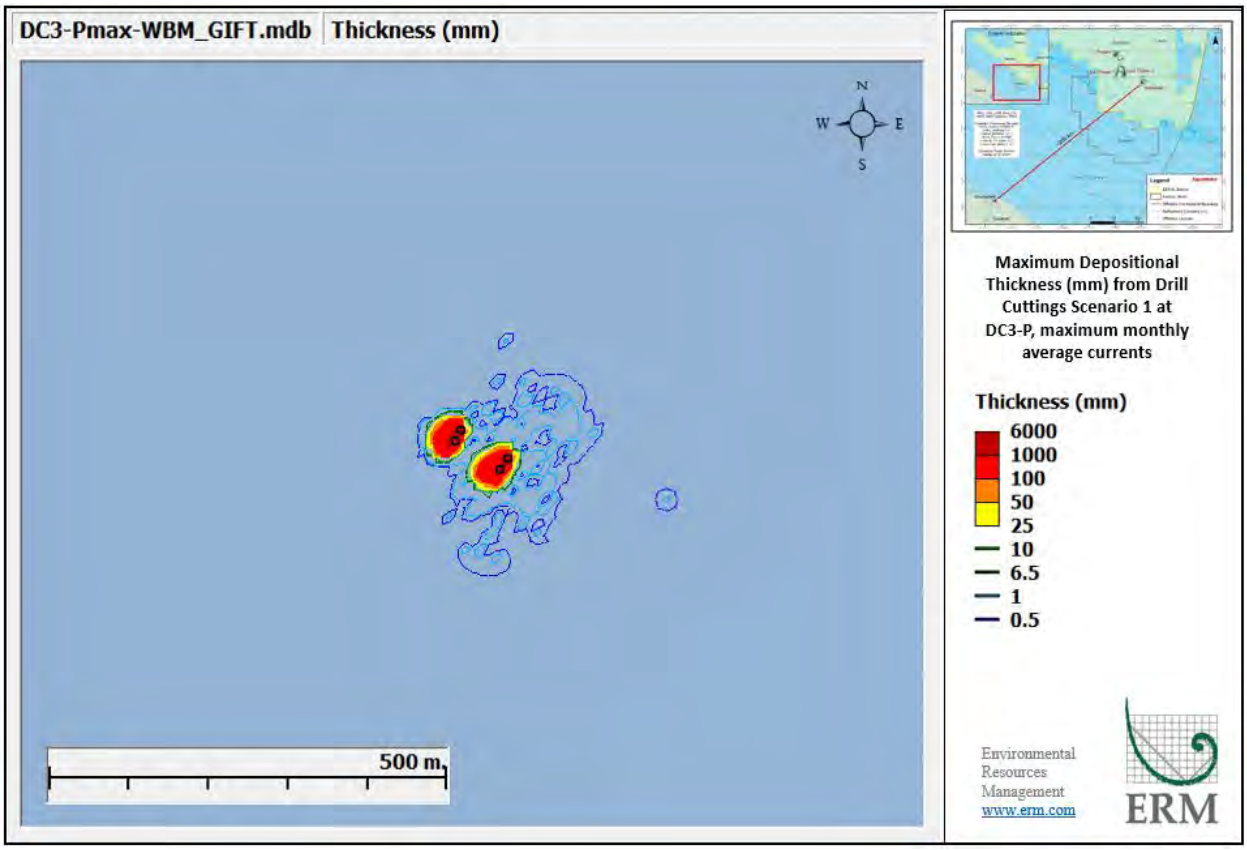
m = meter; mm = millimeter

Figure 2-11: Maximum Depositional Thickness—Scenario 1 DC3-P: Minimum Currents



m = meter; mm = millimeter

Figure 2-12: Maximum Depositional Thickness—Scenario 1 DC3-P: Maximum Currents



m = meter; mm = millimeter

2.4.1.2 Scenario 2

Figure 2-13 through Figure 2-16 present the depositional thickness for Scenario 2 for drill centers DC1-I and DC3-P. For both DC1-I and DC3-P, higher thicknesses are concentrated around the well cluster associated with the drill center, but discrete patches of depositional thicknesses greater than 1 millimeter (0.04 inch) thickness are also present. In all simulations, a small region close to the drill centers exceeds the depositional thickness threshold value of 5 centimeters (2 inches). There is one deposition mound with an approximate lateral extent of 50 meters (164 feet) where the thicknesses exceed this threshold.

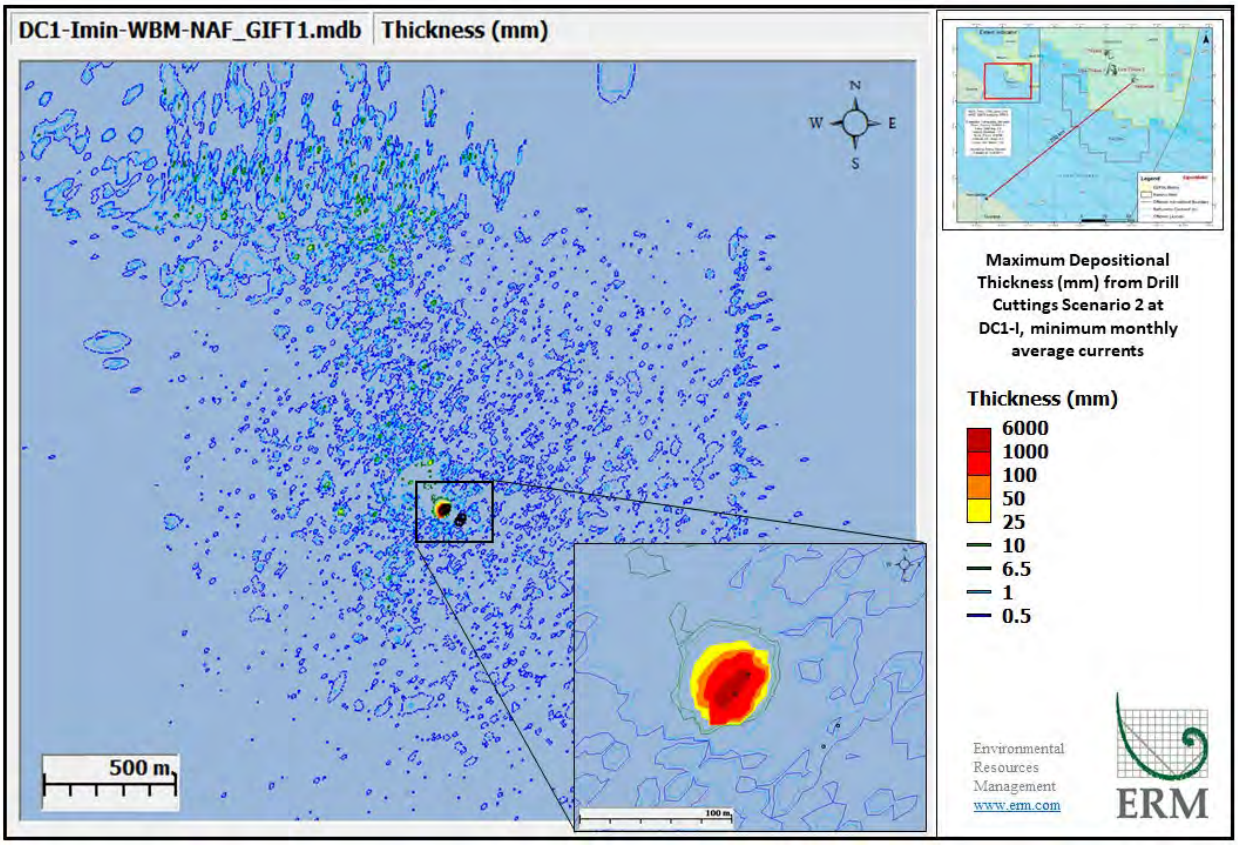
The maximum depositional thicknesses and areas exceeding the threshold value of 5 centimeters (2 inches) for Scenario 2 are presented in Table 2-15. For drill center DC1-I, the maximum depositional thickness is approximately 258 centimeters (101.6 inches) under the maximum current simulation. For drill center DC3-P, the maximum depositional thickness is approximately 170 centimeters (70 inches) under the maximum current simulation. It is noted that these are conservatively high estimates, as slope failures (i.e., collapse of the depositional mound) and resuspension of the particles by ocean currents are likely to reduce the height of the deposited materials over time.

Table 2-15: Summary of Results—Cuttings Depositional Thickness: Scenario 2

Simulation	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm threshold
DC1-I Scenario 2 Minimum Currents	247.1	1,632
DC1-I Scenario 2 Maximum Currents	258.4	1,939
DC3-P Scenario 2 Minimum Currents	126.7	2,135
DC3-P Scenario 2 Maximum Currents	169.8	1,814

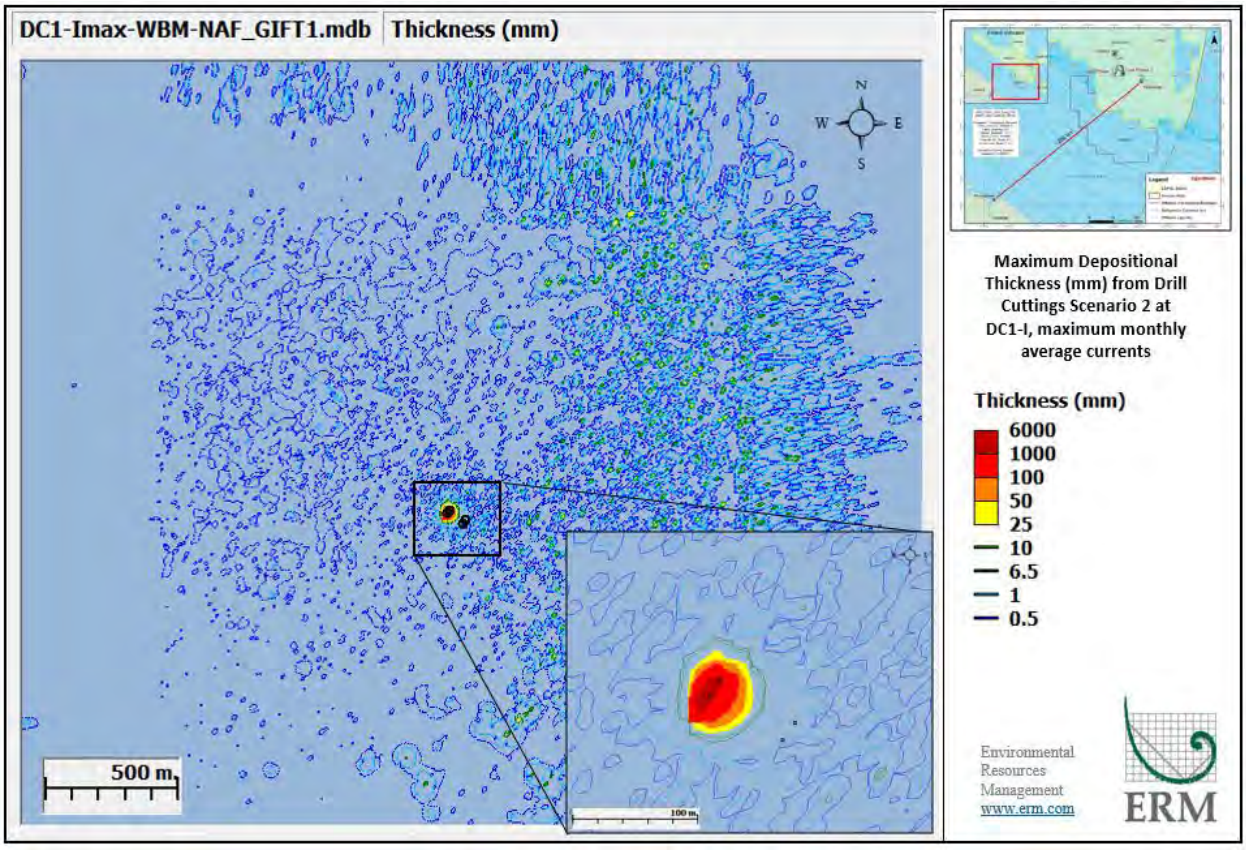
cm = centimeter; m^2 = square meter

Figure 2-13: Maximum Depositional Thickness—Scenario 2 DC1-I: Minimum Currents



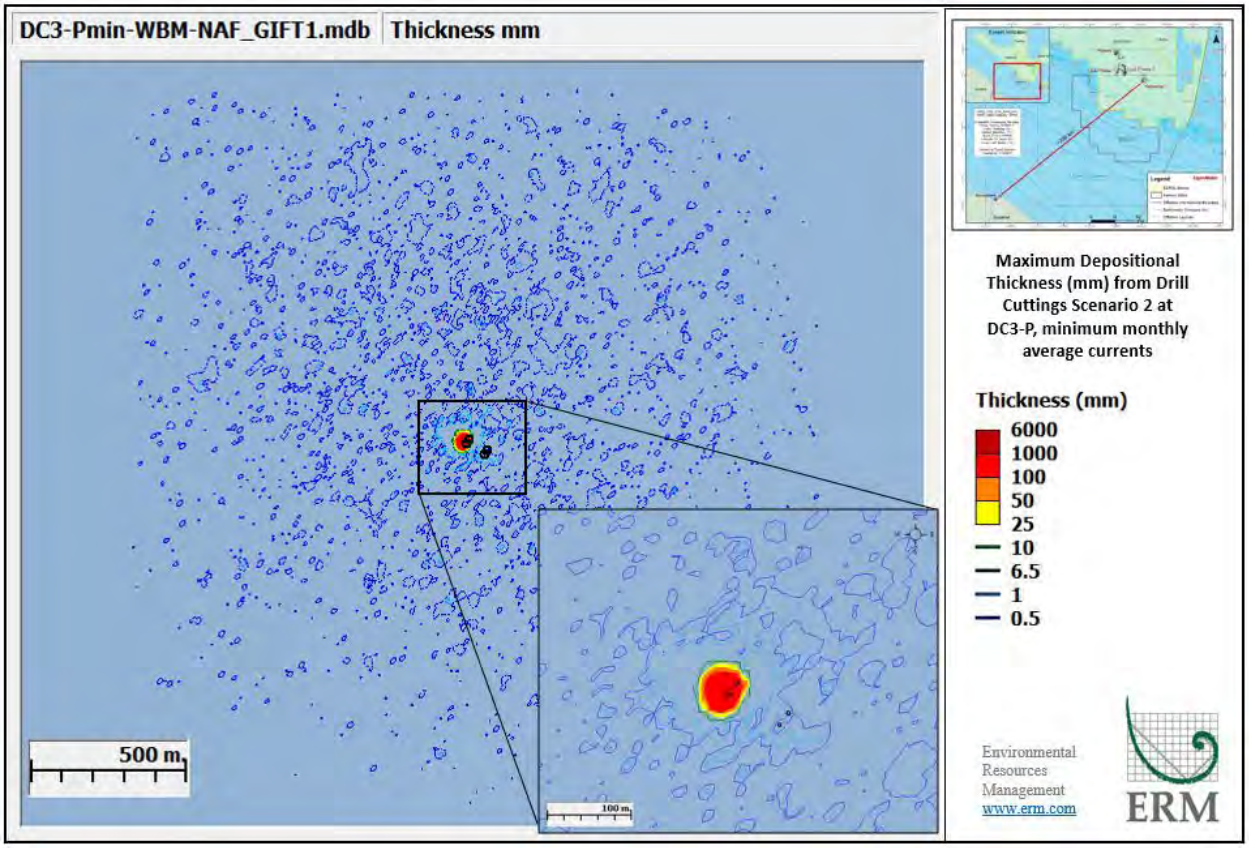
m = meter; mm = millimeter

Figure 2-14: Maximum Depositional Thickness—Scenario 2 DC1-I: Maximum Currents



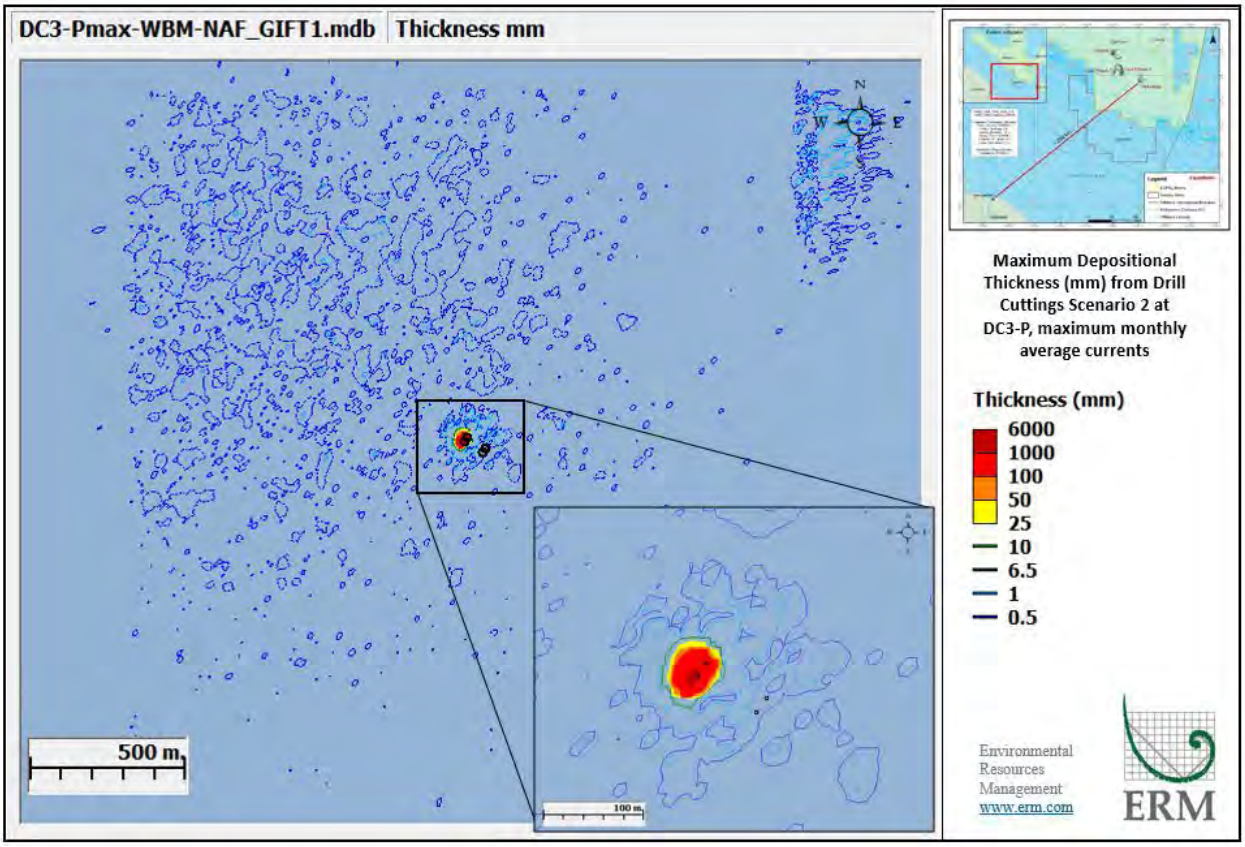
m = meter; mm = millimeter

Figure 2-15: Maximum Depositional Thickness—Scenario 2 DC3-P: Minimum Currents



m = meter; mm = millimeter

Figure 2-16: Maximum Depositional Thickness—Scenario 2 DC3-P: Maximum Currents



m = meter; mm = millimeter

2.4.2 Total Suspended Solids

2.4.2.1 Scenario 1

Figure 2-17 through Figure 2-20 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated area exceeding the above-referenced TSS concentration guideline value[2] occurs near the seabed. A separate “maximum” event was captured for near-seabed concentrations (correlating with direct discharge at the seabed).

Table 2-16 summarizes the maximum predicted surface and bottom TSS concentrations modeled and the maximum areas with TSS concentrations exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center.

[2] As noted above, the likelihood of impacts related to elevated TSS concentrations will tend to decrease in deeper waters below the photic zone, where photosynthesis does not occur. However, elevated TSS concentrations at deeper depths can still impact fish gills. In the absence of a depth-varying guidance value, the same value is applied in the EIA throughout the water column, but delineation of potential impacts related to elevated TSS concentrations at water depths below the photic zone (as in the case of Scenario 1) should be considered a conservative estimate of potential impact.

Table 2-16: Total Suspended Solids Summary—Scenario 1

Simulation	Maximum TSS (mg/L)		Maximum Area (m^2) with TSS >35 mg/L Threshold	
	Surface	Bottom	Surface	Bottom
Scenario 1: DC1-I Minimum Currents	NA	52,248	NA	400,000
Scenario 1: DC1-I Maximum Currents	NA	43,854	NA	991,000
Scenario 1: DC3-P Minimum Currents	NA	55,939	NA	81,100
Scenario 1: DC3-P Maximum Currents	NA	33,152	NA	60,800

km^2 = square kilometer; NA = not applicable

At the DC1-I drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 43,854 mg/L under maximum monthly averaged currents to 52,248 mg/L under minimum monthly averaged currents. The maximum area with TSS exceeding the 35 mg/L threshold was 400,000 square meters (m^2) (0.2 square mile [mi^2]) under minimum currents and 991,000 m^2 (0.4 mi^2) under maximum currents.

At the DC3-P drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 33,152 mg/L under maximum currents to 55,939 mg/L under minimum currents. The maximum area with TSS exceeding the 35 mg/L threshold was 81,100 m^2 (0.03 mi^2) under minimum currents and 60,800 m^2 (0.02 mi^2) under maximum currents.

Figure 2-17: Maximum Area of TSS Exceedance near the Bottom—Scenario 1 DC1-I: Minimum Currents

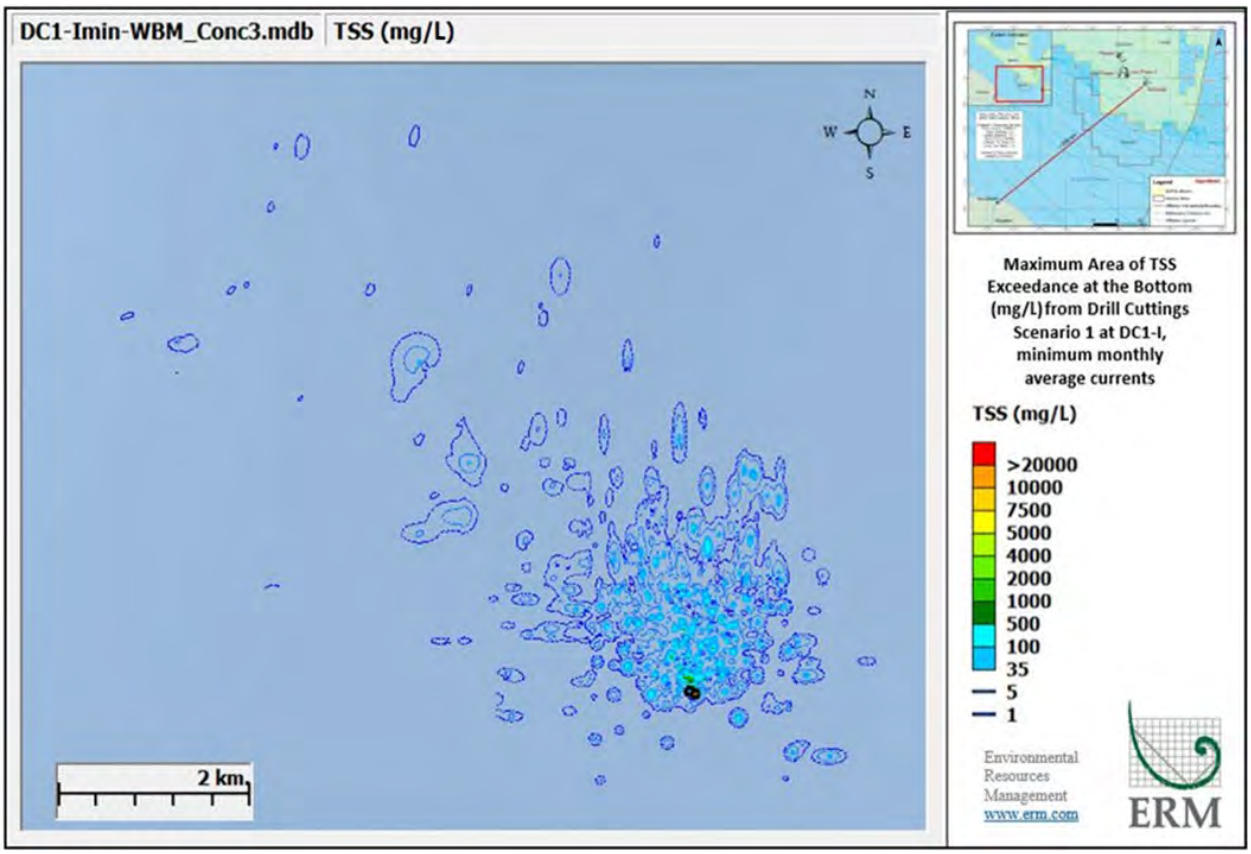


Figure 2-18: Maximum Area of TSS Exceedance near the Bottom—Scenario 1 DC1-I: Maximum Currents

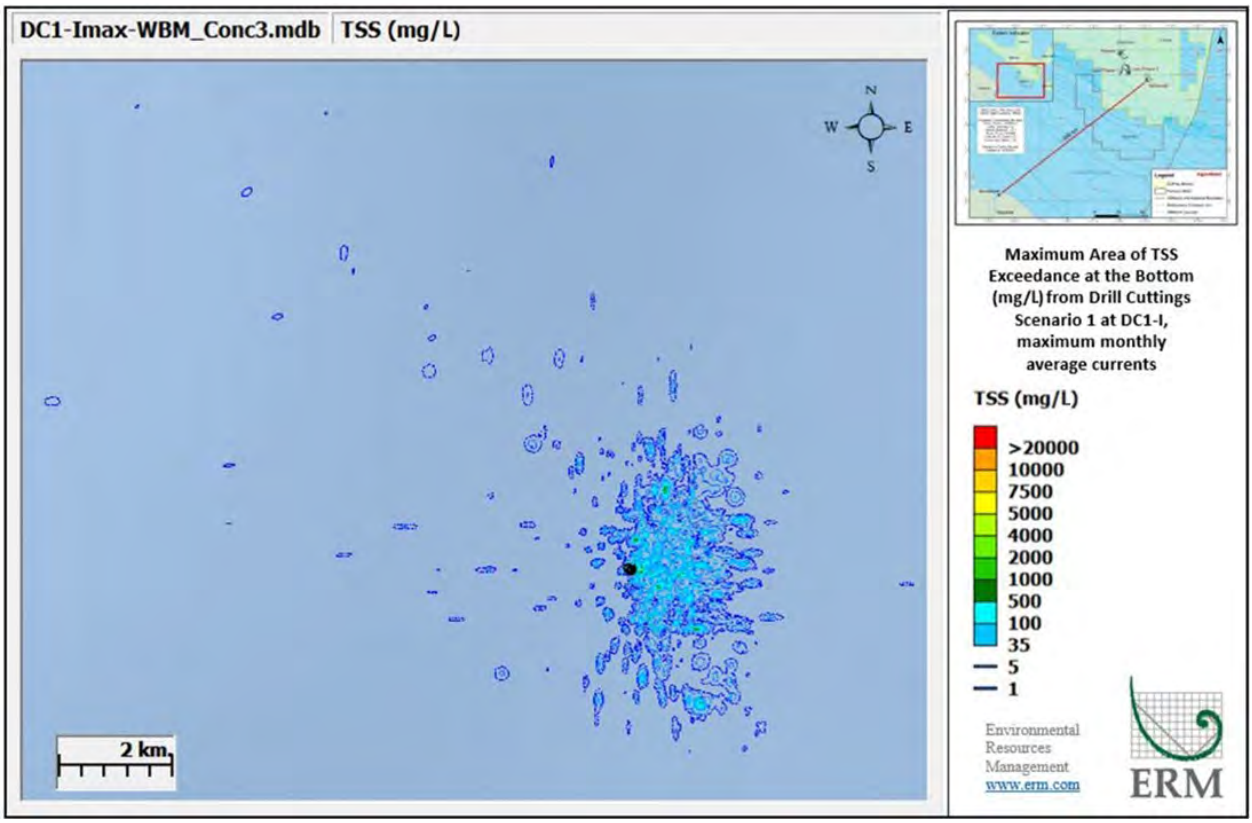


Figure 2-19: Maximum Area of TSS Exceedance near the Bottom—Scenario 1 DC3-P: Minimum Currents

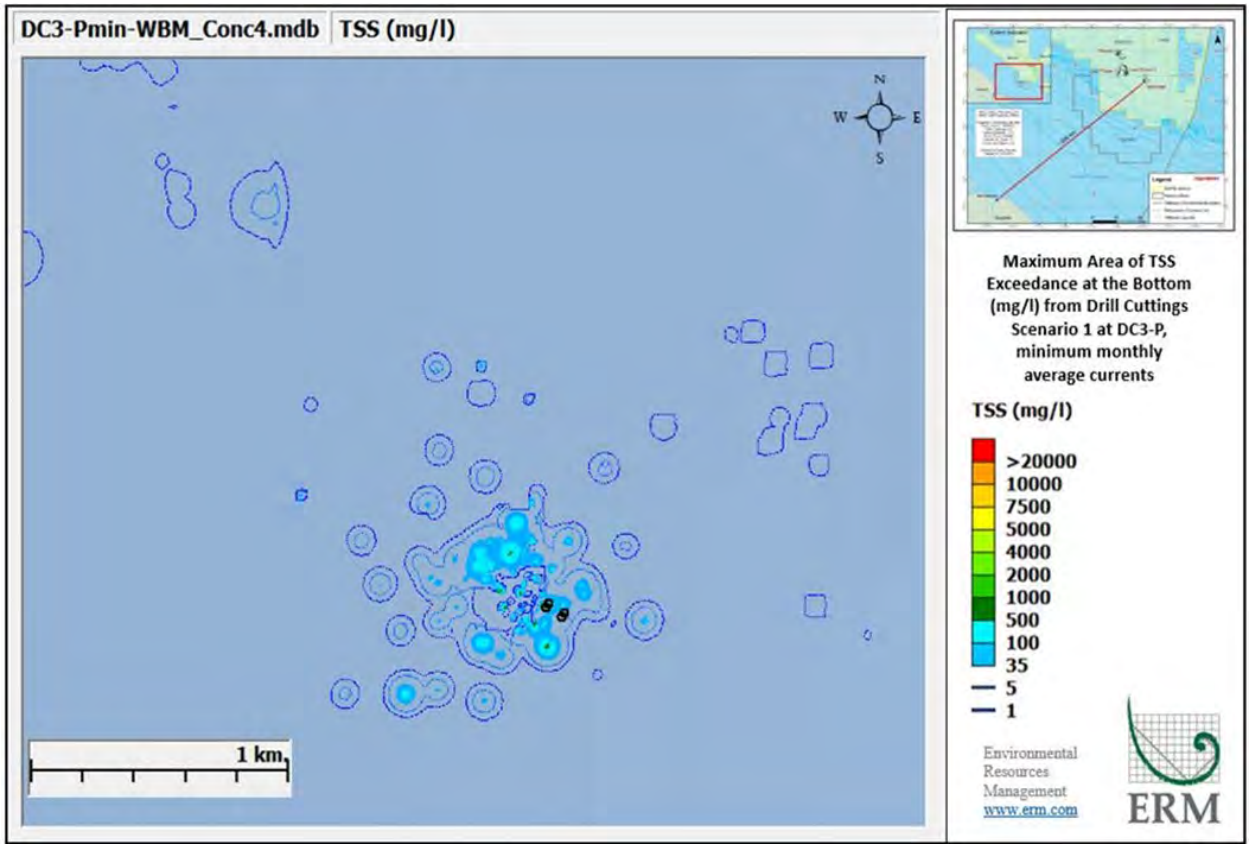
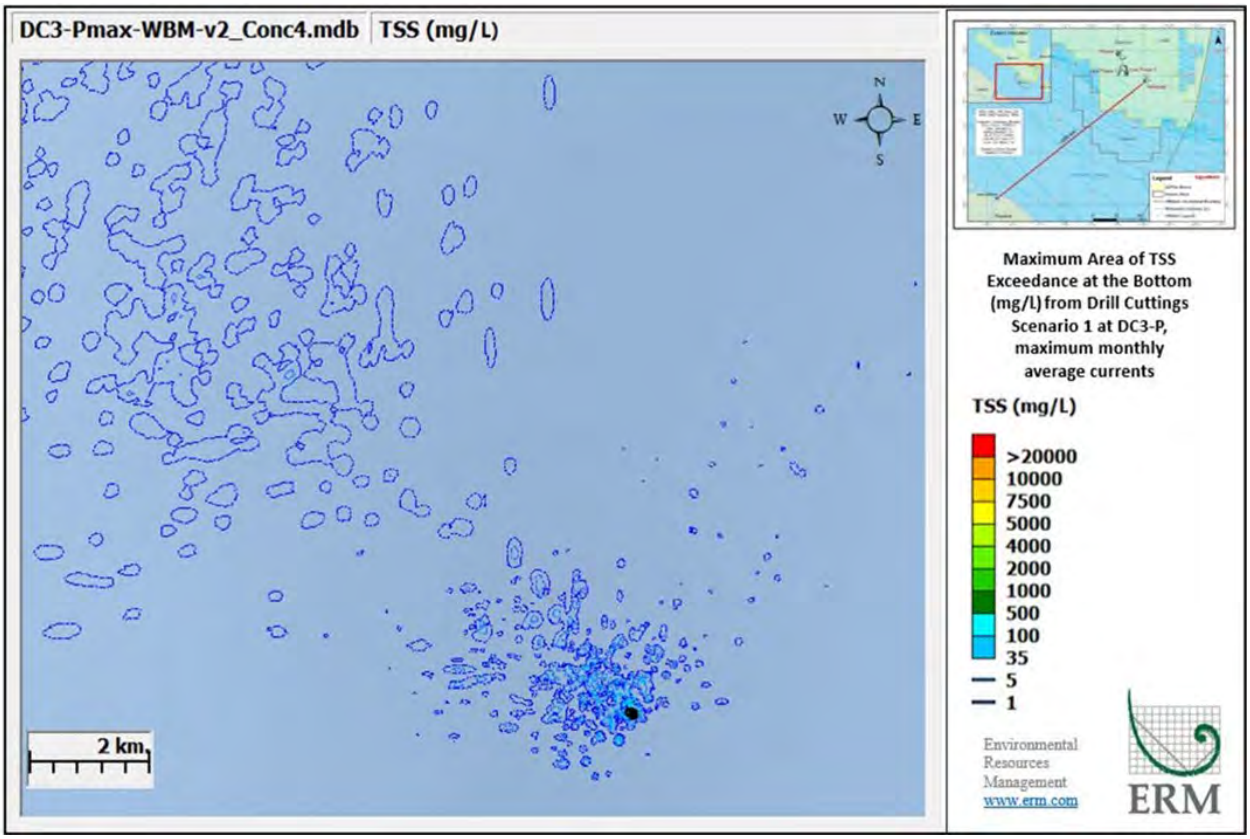


Figure 2-20: Maximum Area of TSS Exceedance near the Bottom—Scenario 1 DC3-P: Maximum Currents



2.4.2.2 Scenario 2

Figure 2-21 through Figure 2-24 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated area of TSS exceedance occurs near the seabed. Figure 2-25 through Figure 2-28 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated area of TSS exceedance occurs from surface discharges, when applicable.

At the DC1-I drill center, the maximum instantaneous TSS concentration added above ambient as a result of seabed discharges ranges from 18,717 mg/L under minimum currents to 33,323 mg/L under maximum monthly averaged currents. The maximum area with TSS exceeding the 35 mg/L threshold is 366,000 m^2 (0.1 mi^2) under maximum currents and 240,000 m^2 (0.1 mi^2) under minimum currents. For surface discharges, the maximum instantaneous TSS concentration added above ambient ranges from 87.7 mg/L under maximum currents to 951.9 mg/L under minimum currents. The maximum area of TSS exceeding the 35 mg/L threshold is 23,200 m^2 (0.009 mi^2) under maximum currents and 12,000 m^2 (0.005 mi^2) under the minimum currents.

At the DC3-P drill center, the maximum instantaneous TSS concentration added above ambient as a result of seabed discharges ranges from 8,412 mg/L under maximum currents to 14,711 mg/L under minimum currents. The maximum area with TSS exceeding the 35 mg/L threshold is 187,000 m^2 (0.1 mi^2) under maximum currents and 207,000 m^2 (0.1 mi^2) under minimum currents. For surface discharges, the maximum instantaneous TSS concentration added above ambient ranges from 21.3 mg/L under maximum currents to 1,013 mg/L under minimum currents. The maximum area of TSS exceeding the

35 mg/L threshold is 13,400 m^2 (0.005 mi^2) under minimum currents. The threshold is not exceeded under maximum currents.

Note that on the following figures, the estimated maximum instantaneous TSS concentrations may be slightly offset from the discharge location as the simulation's floating small particles suspended in the water column may concentrate together at various locations. Larger particles do not remain suspended but quickly settle to the seafloor.

Table 2-17 summarizes the maximum instantaneous predicted surface and bottom TSS concentrations modeled and the lateral areas with TSS concentrations exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center.

Table 2-17: Total Suspended Solids Summary—Scenario 2

Simulation	Maximum TSS (mg/L)		Area (m^2) with TSS >35 mg/L Threshold	
	Surface	Bottom	Surface	Bottom
Scenario 2: DC1-I Minimum Currents	951.9	18,717	12,000	240,000
Scenario 2: DC1-I Maximum Currents	87.7	33,323	23,200	366,000
Scenario 2: DC3-P Minimum Currents	1,013	14,711	13,400	207,000
Scenario 2: DC3-P Maximum Currents	21.30	8,412	0	187,000

Figure 2-21: Maximum Area of TSS Exceedance at the Bottom—Scenario 2 DC1-I: Minimum Currents

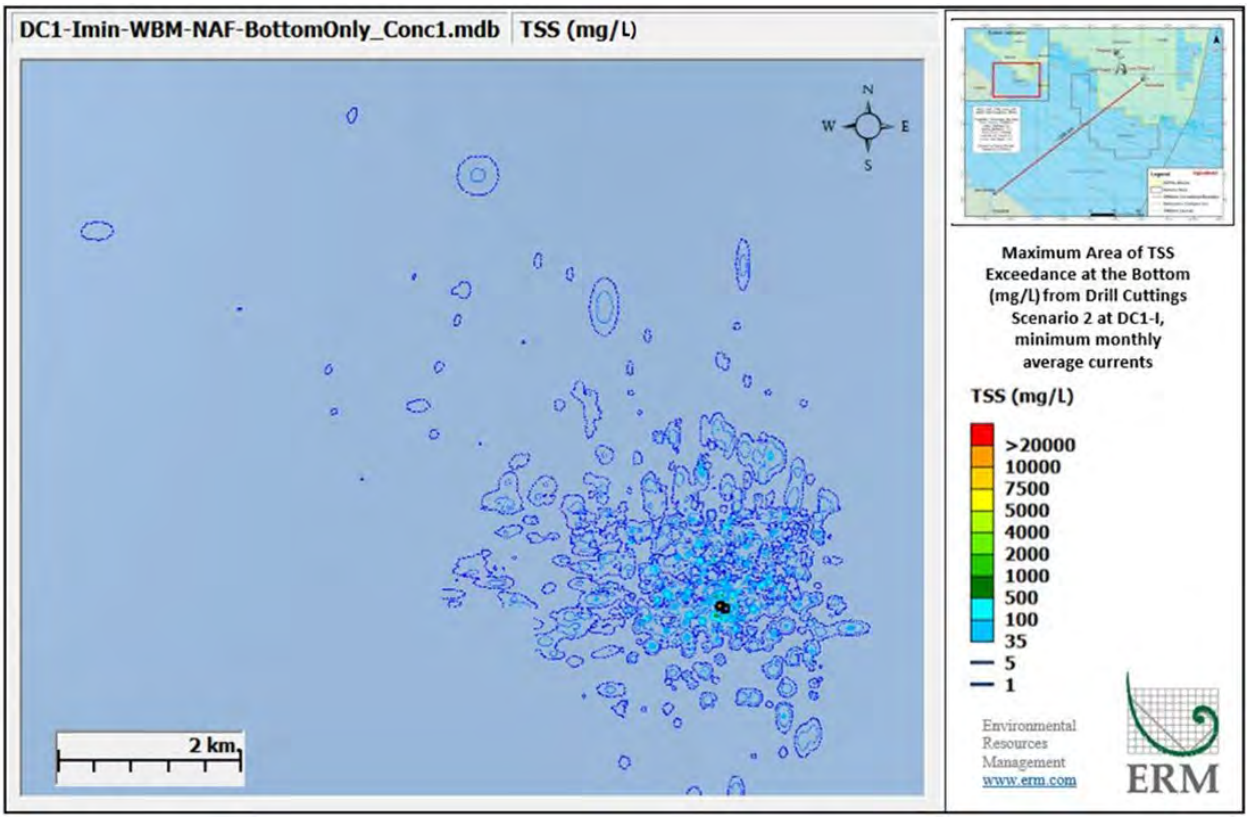


Figure 2-22: Maximum Area of TSS Exceedance at the Bottom—Scenario 2 DC1-I: Maximum Currents

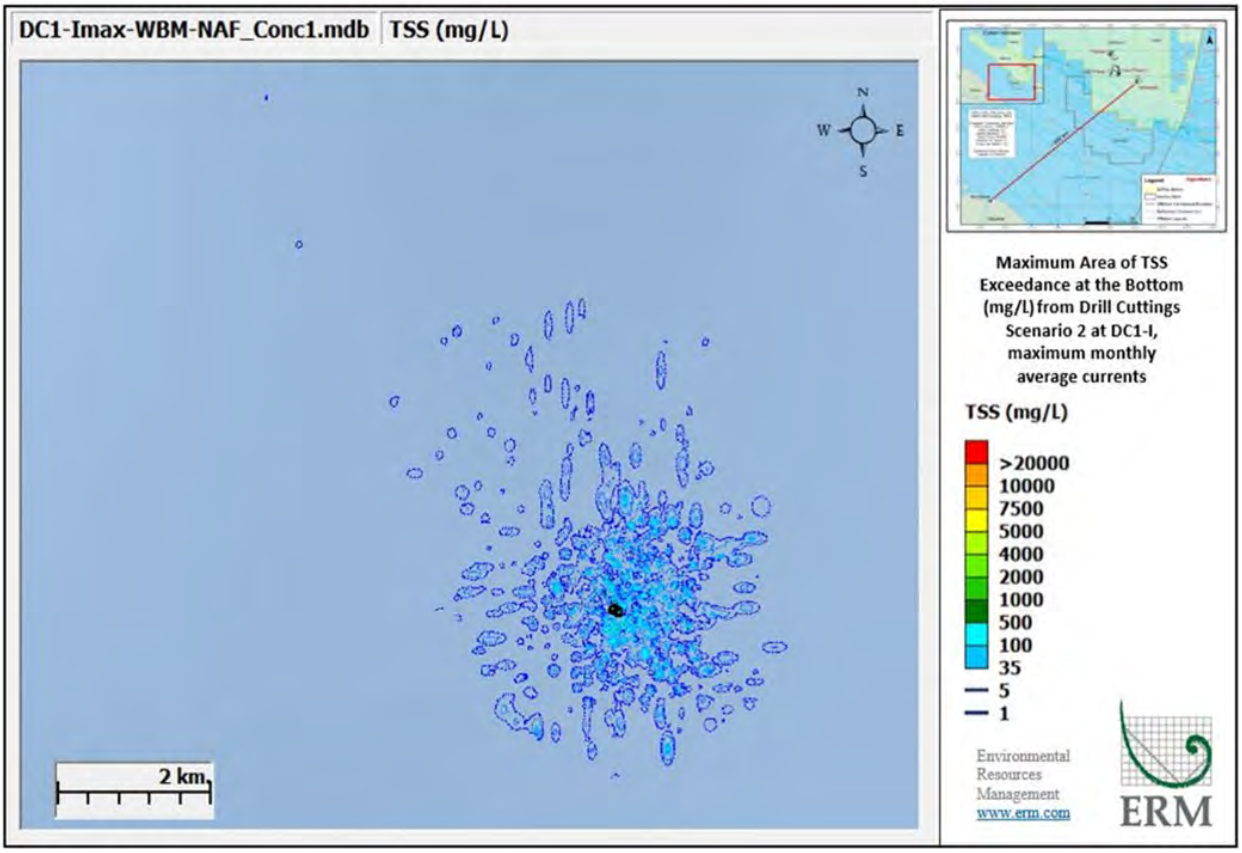


Figure 2-23: Maximum Area of TSS Exceedance at the Bottom —Scenario 2 DC3-P: Minimum Currents

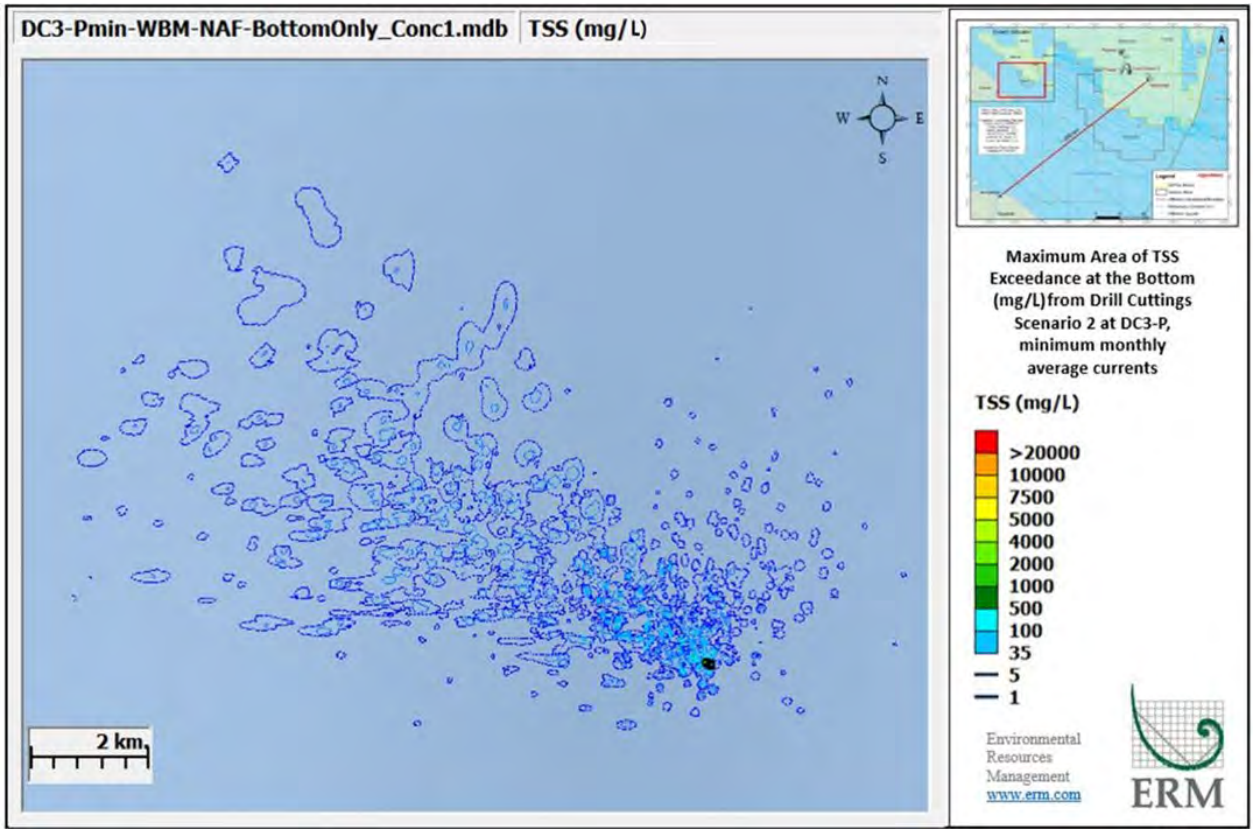


Figure 2-24: Maximum Area of TSS Exceedance at the Bottom—Scenario 2 DC3-P: Maximum Currents

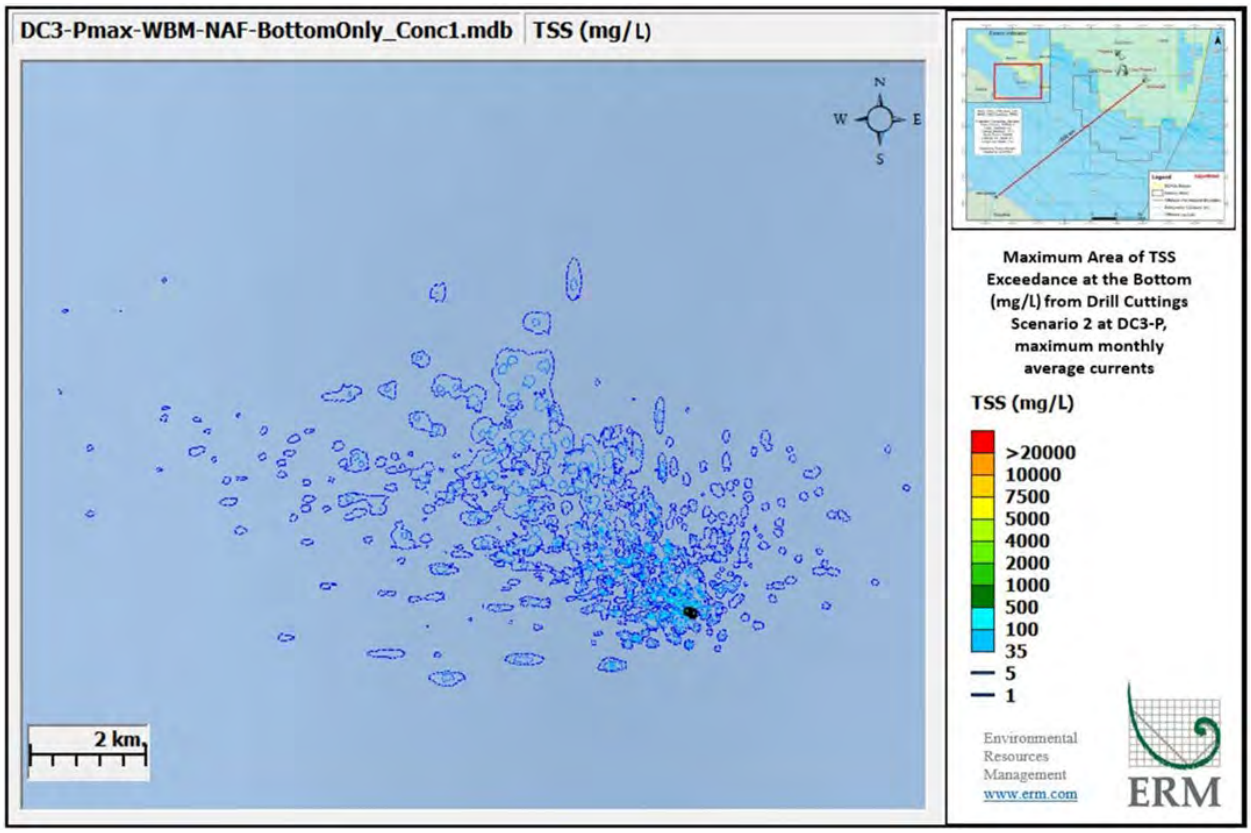


Figure 2-25: Maximum Area of TSS Exceedance at the Surface—Scenario 2 DC1-I: Minimum Currents

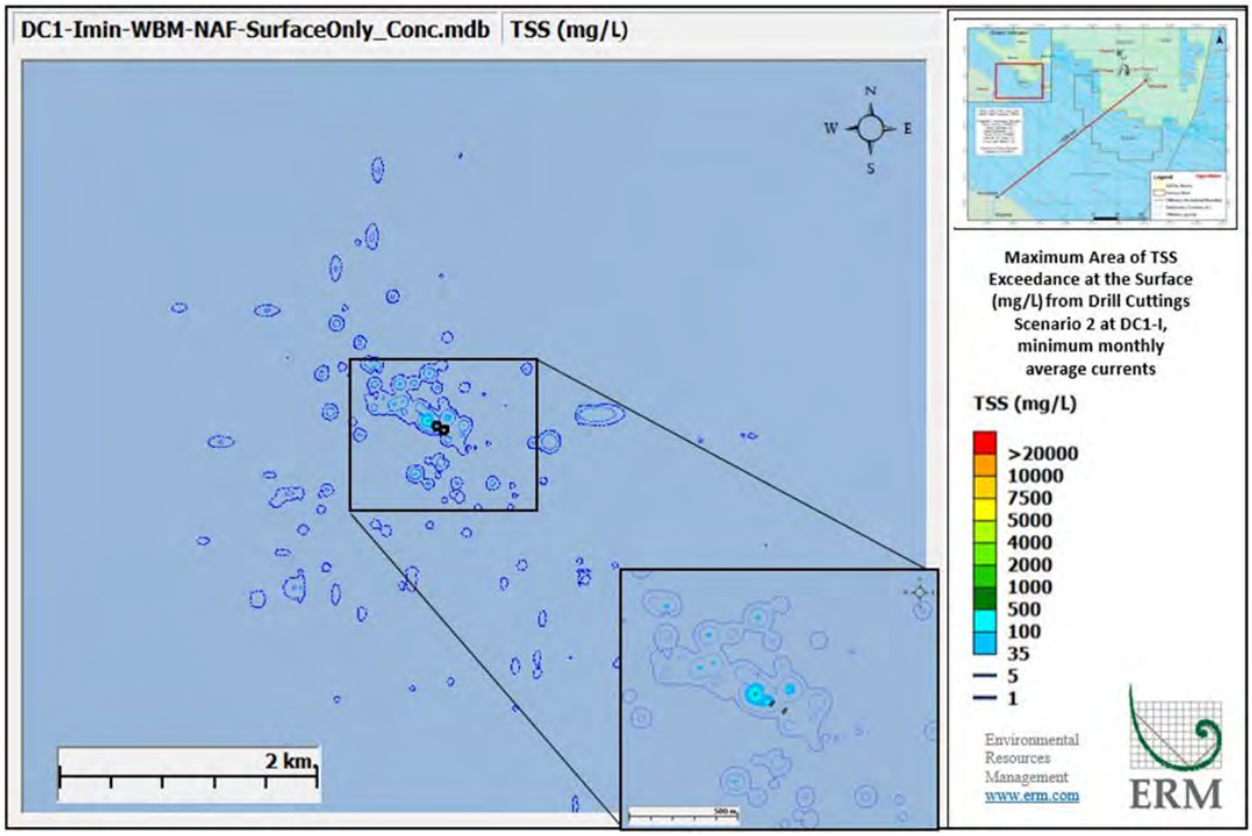


Figure 2-26: Maximum Area of TSS Exceedance at the Surface—Scenario 2 DC1-I: Maximum Currents

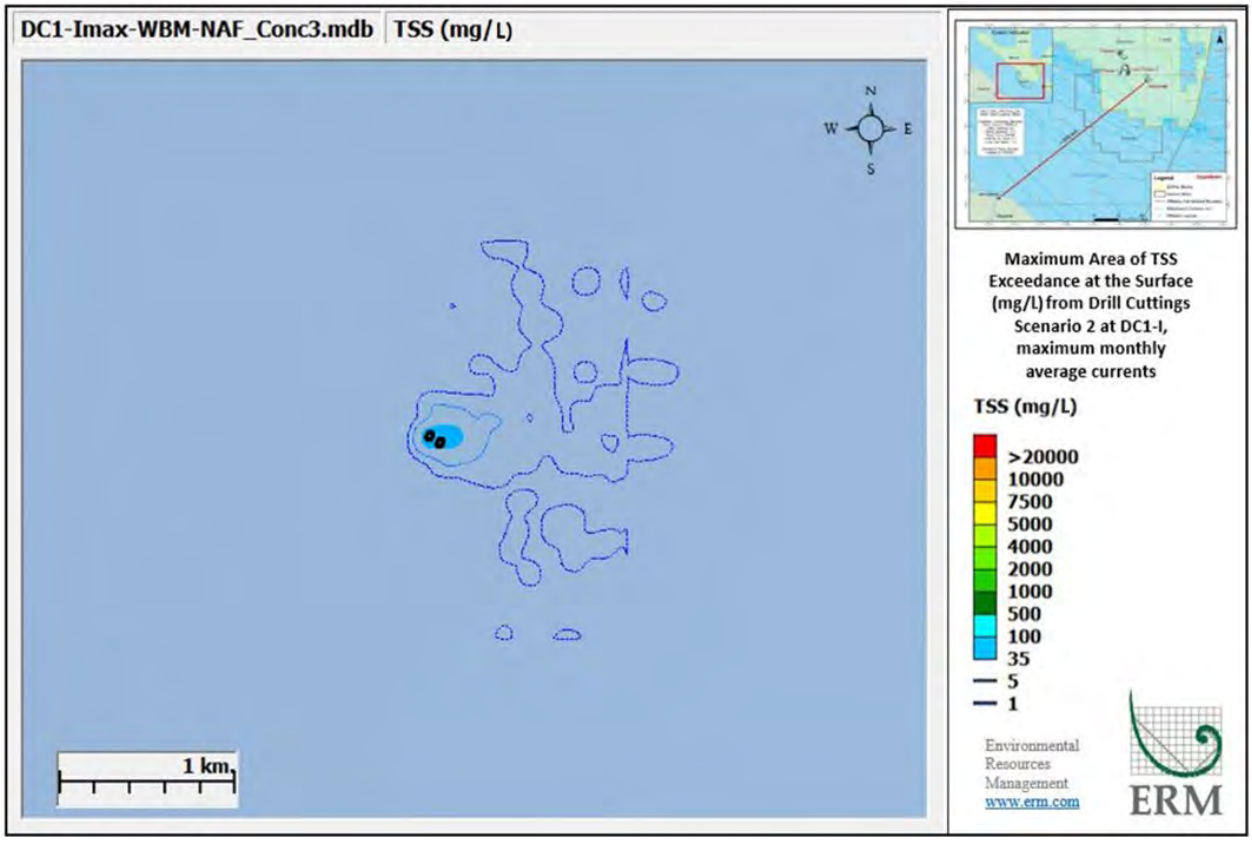


Figure 2-27: Maximum Area of TSS Exceedance at the Surface—Scenario 2 DC3-P: Minimum Currents

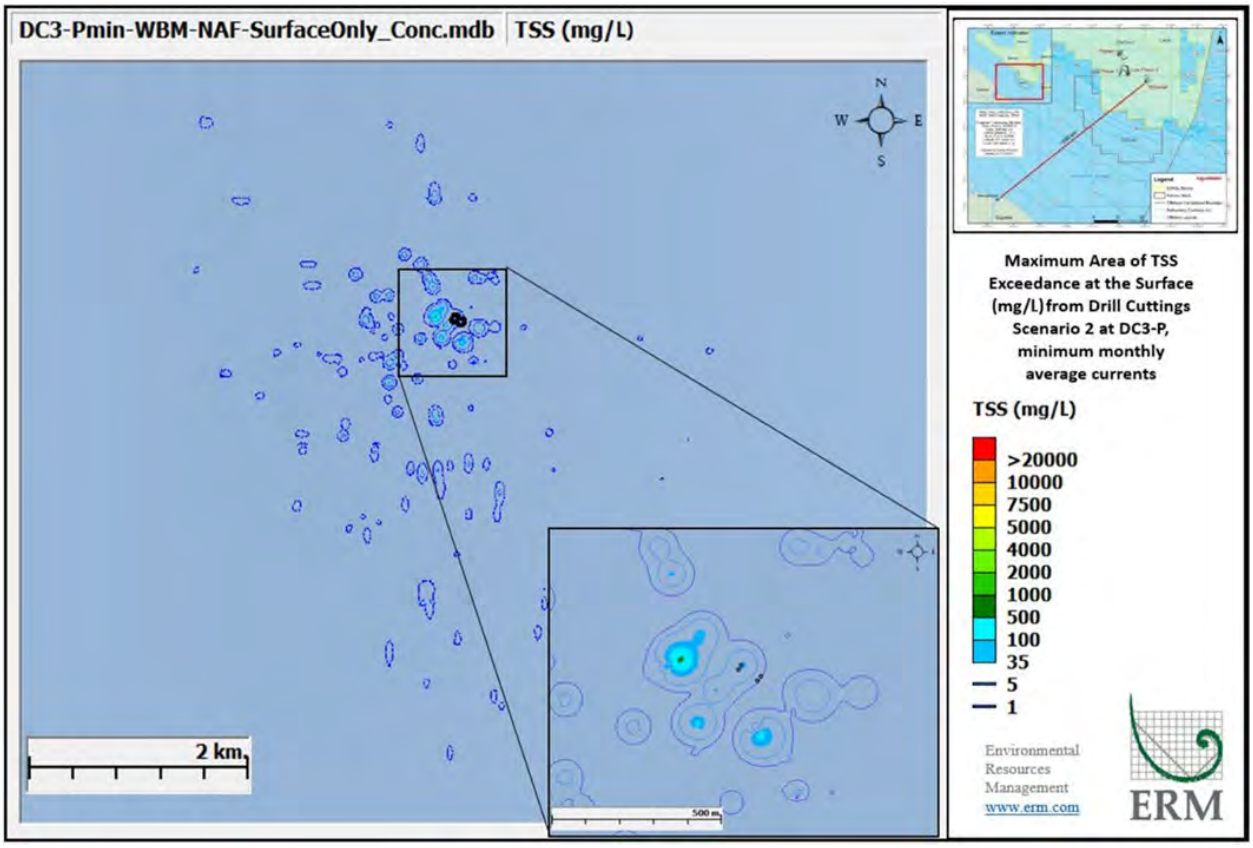
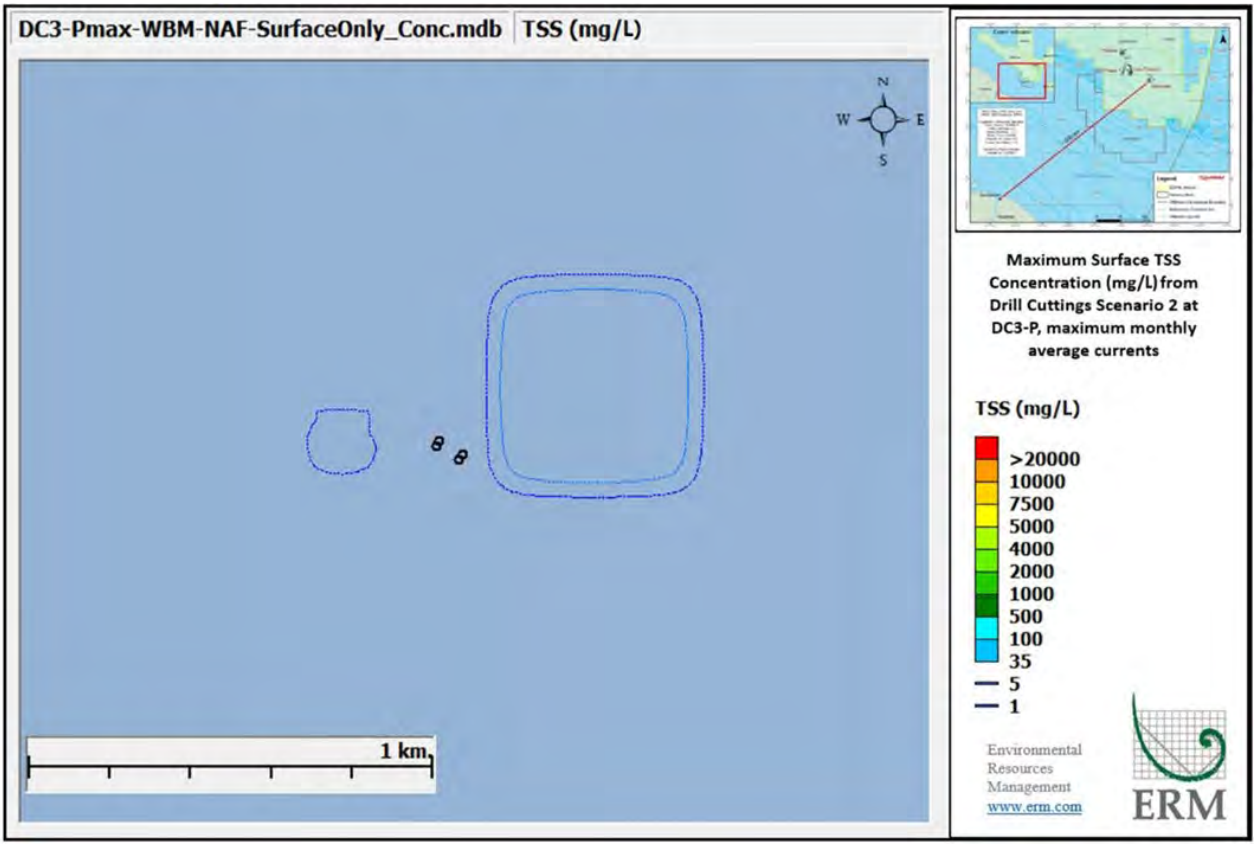


Figure 2-28: Maximum TSS Concentrations at the Surface—Scenario 2 DC3-P: Maximum Currents[3]



2.4.3 Mass of Oil Deposited on the Seabed

Figure 2-29 through Figure 2-32 present the predicted hydrocarbon deposition on the seabed based on the statistical summary identifying the maximum hydrocarbon deposition occurring on the ocean floor during the entire simulation period. At the end of the simulation period (87 days), NABF adhered to the cuttings settles primarily within an approximately 2.5-kilometer (1.6-mile) radius of the drill center for all four simulations.

For drill center DC1-I, the maximum hydrocarbon deposition under the minimum monthly averaged current scenario is 256.9 grams per square meter (g/m²) and is 237.2 g/m² under the maximum monthly averaged current scenario.

For drill center DC3-P, the maximum hydrocarbon deposition under the minimum monthly averaged current scenario is 200.5 g/m² and is 186.6 g/m² under the maximum monthly averaged current scenario.

[3] TSS concentrations in this scenario appear smaller than in the other scenarios. The fast currents, generally directing the particles toward the northwest, quickly spread and dilute the released mass. The square shape of the plume is a modeling artifact from depicting radially decreasing concentrations around a discrete location with high TSS.

Figure 2-29: Total Deposited Adhered Oil—Scenario 3 DC1-I: Minimum Currents

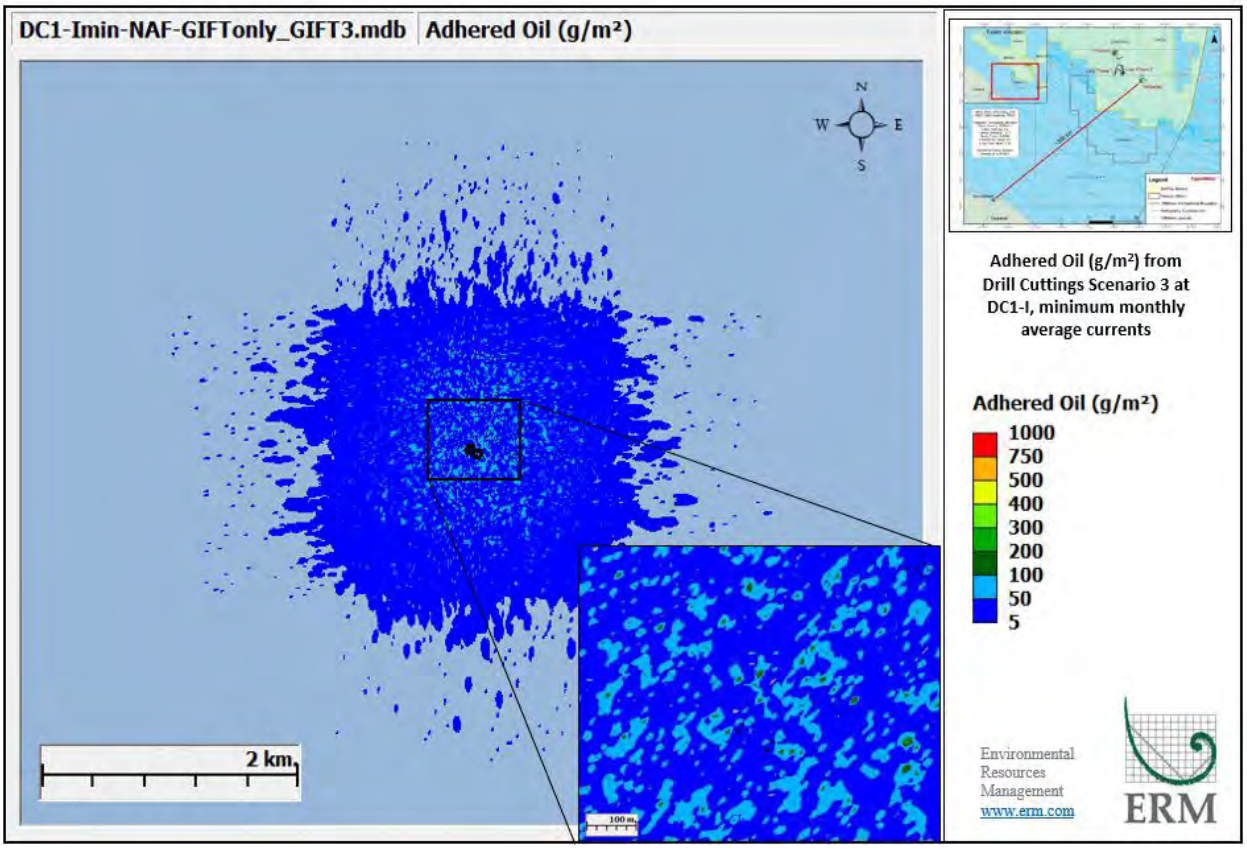


Figure 2-30: Total Deposited Adhered Oil—Scenario 3 DC1-I: Maximum Currents

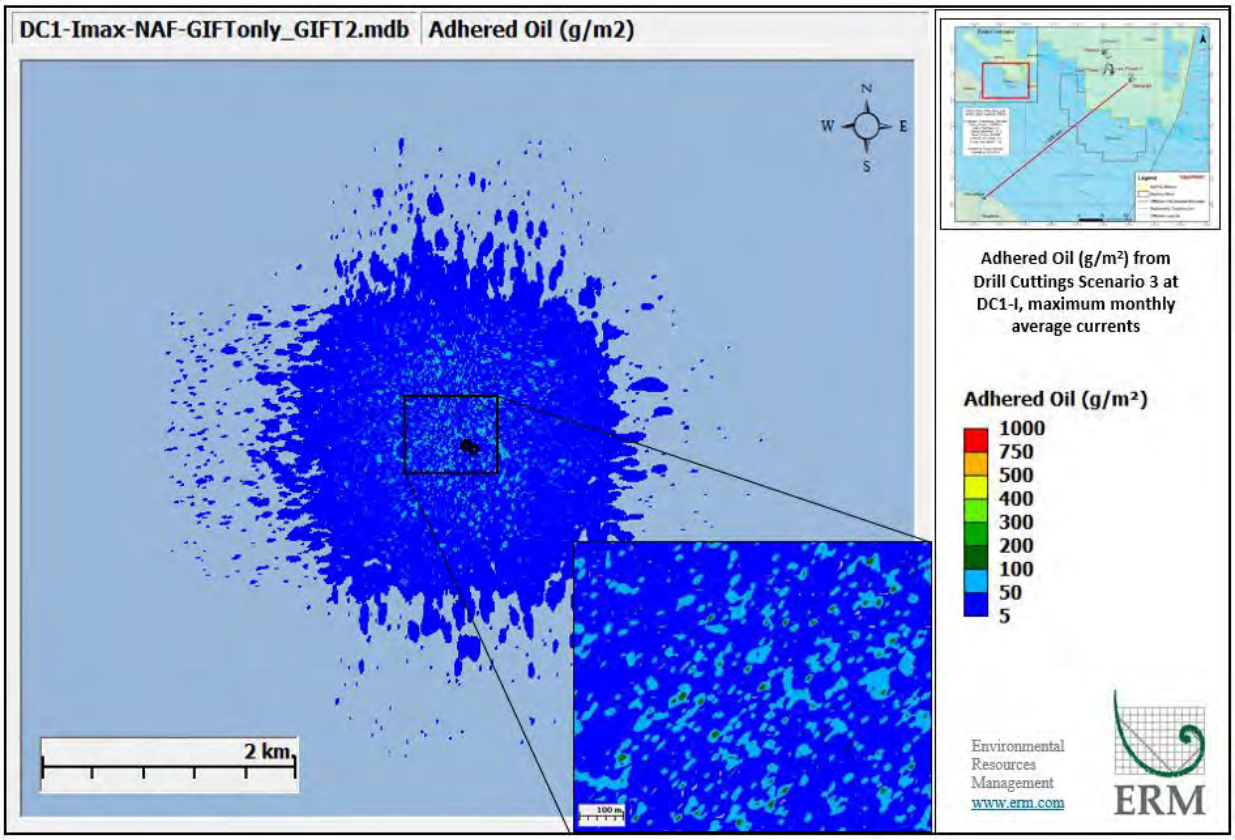


Figure 2-31: Total Deposited Adhered Oil—Scenario 3 DC3-P: Minimum Currents

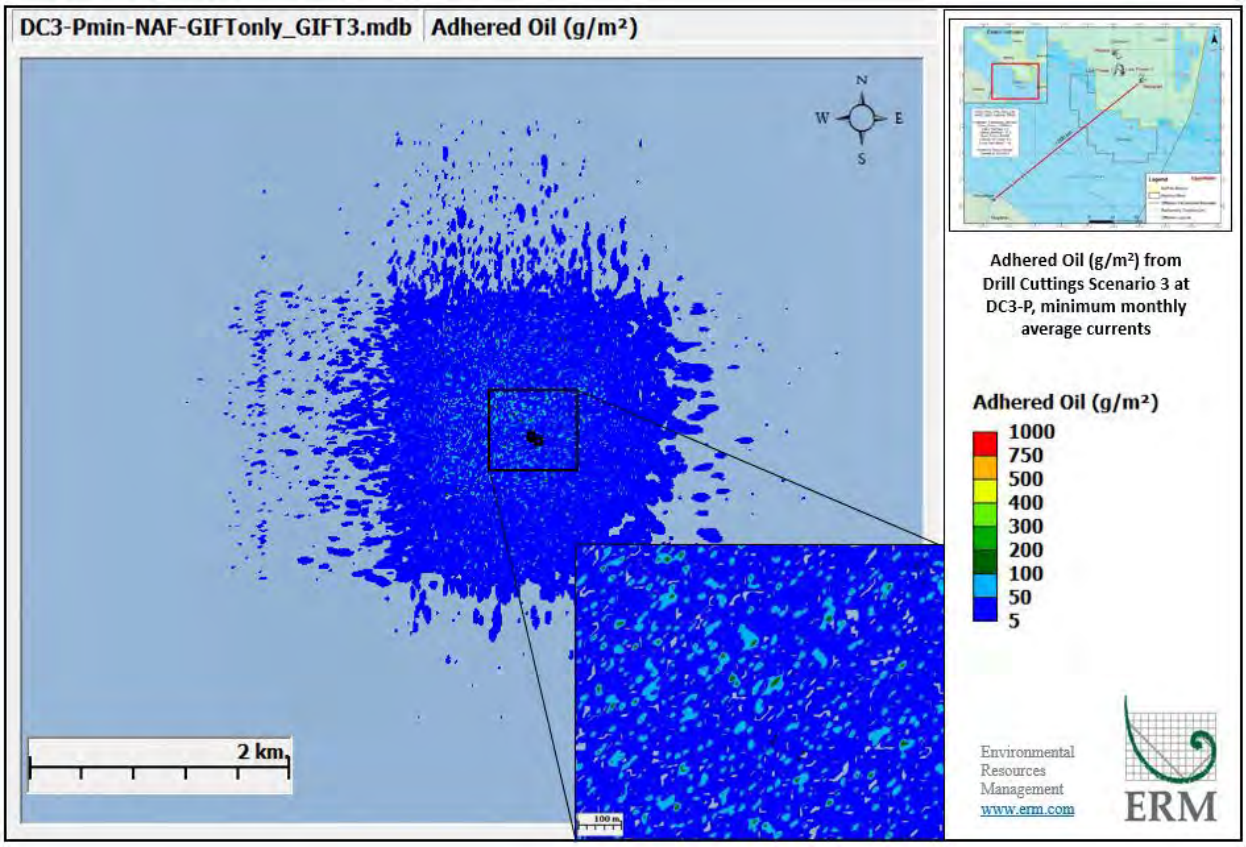


Figure 2-32: Total Deposited Adhered Oil—Scenario 3 DC3-P: Maximum Currents

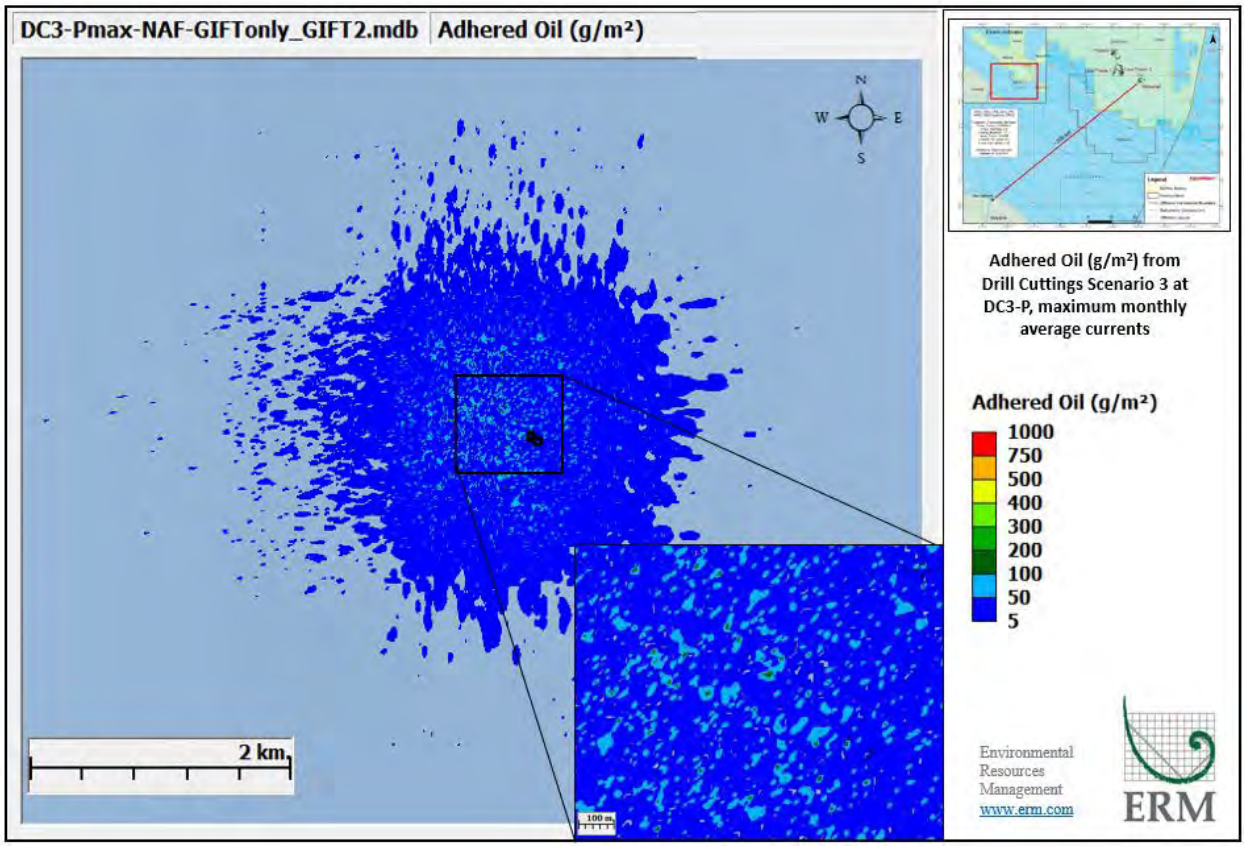


Table 2-18 summarizes the maximum hydrocarbon deposition modeled at any point under minimum and maximum current conditions at each drill center.

Table 2-18: Hydrocarbon Deposition Summary

Simulation	Maximum Hydrocarbon Deposition (g/m²)
Scenario 3: DC1-I Minimum Currents	256.9
Scenario 3: DC1-I Maximum Currents	237.2
Scenario 3: DC3-P Minimum Currents	200.5
Scenario 3: DC3-P Maximum Currents	186.6

2.5 Conclusions

Drill cuttings deposition modeling was performed using GEMSS® and its drill cuttings and muds deposition module, GIFT. Twelve simulations were modeled, representing two drill centers (DC1-I and DC3-P) and three drilling scenarios under two ambient current conditions (minimum and maximum monthly averaged, depth-averaged current speeds over a 10-year period of record).

Output from the drill cutting deposition modeling included estimations of the distribution of deposited cuttings thickness on the seafloor, the maximum instantaneous increase in TSS concentrations above ambient conditions, and the distribution of mass of hydrocarbons adhered to cuttings deposited on the seafloor. The results of the modeling are shown below in Table 2-19.

Table 2-19: Model Results Summary

Simulation	Maximum Depositional Thickness (cm)	Area (m²) with Thickness >5 cm Threshold	Maximum TSS (mg/L)— Bottom/ Surface	Area (m²) with TSS >35 mg/L Threshold— Bottom/ Surface	Maximum Adhered Oil Deposition (g/m²)
Scenario 1—DC1-I Minimum Currents	560.8	8,381	52,248	400,000	NA
Scenario 1—DC1-I Maximum Currents	443.1	7,234	43,854	991,000	NA
Scenario 1—DC3-P Minimum Currents	190.3	3,969	55,939	81,100	NA
Scenario 1—DC3-P Maximum Currents	200.2	3,436	33,152	60,800	NA
Scenario 2—DC1-I Minimum Currents	247.1	1,632	18,717/ 951.9	240,000 / 12,000	NA
Scenario 2—DC1-I Maximum Currents	258.4	1,939	33,323/ 87.7	366,000 / 23,200	NA
Scenario 2—DC3-P Minimum Currents	126.7	2,135	14,711/ 1,013	207,000 / 13,400	NA
Scenario 2—DC3-P Maximum Currents	169.8	1,814	8,412/ 21.3	187,000/ 0	NA
Scenario 3—DC1-I Minimum Currents	NA	NA	NA	NA	256.9
Scenario 3—DC1-I Maximum Currents	NA	NA	NA	NA	237.2
Scenario 3—DC3-P Minimum Currents	NA	NA	NA	NA	200.5
Scenario 3—DC3-P Maximum Currents	NA	NA	NA	NA	186.6

cm = centimeter; NA = not applicable

In all simulations, a small region close to the drill centers exceeded the depositional thickness threshold value of 5 centimeters (2 inches). For DC1-I, the region of exceedance was within 370 meters (1,214 feet) of the drill center. For DC3-P, the lateral extent of the deposition mound where thicknesses exceed this threshold was approximately 50 meters (164 feet). The bulk of the depositional mound results from the cuttings and muds discharged during the jetting and drilling of the two top-hole sections. The maximum increase in TSS concentration above ambient conditions in the bottom of the water column is predicted to be as much as 55,939 mg/L at the point of release; however, these concentrations will occur at water depths below the photic zone, in areas where photosynthesis inhibition is not a concern. For minimum current conditions, the maximum instantaneous TSS concentration increases above ambient in the shallow water column is 1,013 mg/L. For maximum current conditions, the maximum instantaneous TSS concentration increases above ambient in the shallow water column is 87.7 mg/L. Hydrocarbon deposition on the seafloor had a maximum predicted value of 256.9 g/m².

Variations in the current speeds are the primary cause for the variations in the model results provided. In general, scenarios with minimum currents have higher areas of deposition greater than the 5-centimeter (2-inch) threshold and higher bottom TSS concentrations compared to the scenarios with maximum currents. Slower currents allow for a less dispersed settling and therefore a more laterally concentrated deposition and more concentrated TSS.

Similar to the depositional thickness, scenarios with minimum currents have higher hydrocarbon deposition per unit area compared to scenarios with maximum currents. Slower currents allow for a more concentrated deposition of hydrocarbon-containing cuttings.

3. OFFSHORE DISCHARGES MODELING

3.1 Approach

The Project will have several planned discharges to water associated with subsea, umbilicals, risers, and flowlines (SURF) and FPSO commissioning activities, as well as FPSO production operations. These discharges, based on the preliminary Project design information, are listed in Table 3-1.

Table 3-1: Summary of Planned Commissioning- and Production-Related Discharges

Type of Discharge and Estimated Effluent Characteristics [a]	Estimated Discharge Volume/Rate [a]
Ballast Water (FPSO initial deballasting)	≤550,000 bbl (≤ 87,500 m^3) total
Hydrostatic Test Water ■ Biocide / oxygen scavenger / corrosion inhibitor: 1,500 ppm	65,000 bbl (10,400 m^3) (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)
Gas Re-injection Line Commissioning Fluids ■ Hydrate inhibitor (e.g., methanol or ethylene glycol)	1,400 bbl (223 m^3) total
Produced Water ■ Oil and grease ■ Temperature (55°C/131°F at point of discharge) ■ Residual production and water treatment chemicals – Scale Inhibitor ≤100 ppm – Corrosion Inhibitor ≤200 ppm ■ Hydrate inhibitor (e.g., methanol) [b]	≤300,000 BPD (≤ 47,700 m^3/d)
Cooling Water ■ Hypochlorite: ≤5 ppm ■ Temperature (50°C/122°F at point of discharge)	≤1,900,000 BPD (≤ 302,100 m^3/d)
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines ■ Hypochlorite: ≤1 ppm ■ Electrolyte: ≤1 ppm ■ Biocide: ≤5 ppm ■ Oxygen Scavenger: ≤10 ppm ■ Scale Inhibitor: ≤5 ppm	≤315,000 BPD (≤ 50,100 m^3/d)
Subsea Hydraulic Fluid Discharge ■ Water soluble, low-toxicity	≤5 BPD (≤ 0.8 m^3/d)
FPSO Bilge Water	1,800 BPD (287 m^3/d)
Inert Gas Generator Cooling Water	Negligible
FPSO Slop Tank Water (includes off-specification oil from process and deck drainage)	Negligible
Miscellaneous Discharges including Desalinization Blowdown and Lab Sink Drainage	<10 BPD (<1.6 m^3/d)
Tanker Ballast Water	Maximum 629,000 bbl (100,000 m^3) total (at each tanker crude loading)
Blowout Preventer (BOP) System Testing Water-Soluble, Low-Toxicity Hydraulic Fluid	30 bbl (4.8 m^3) every 2 weeks
Grey Water	250 BPD (40 m^3/d)
Black Water (sewage)	85 BPD (13.6 m^3/d)
Food Preparation Wastes	<40 BPD (<6.4 m^3/d)
Firefighting Foam Monitor Testing Discharge	<6 bbl (<0.95 m^3) per year (at annual fire monitor testing event)

°C = degrees Celsius; °F = degrees Fahrenheit; bbl = barrel; BPD = barrels per day; ppm = parts per million; m^3/d = cubic meters per day; m^3 = cubic meters

[a] Effluent characteristics and volumes/rates are based on the preliminary Project design information available at the time of the EIA.

[b] During production line commissioning and planned and unplanned shutdowns

Cooling water, produced water, and brines from the Sulfate Removal Unit (SRU), ultrafiltration, and wash water reverse osmosis system (all associated with the production operations stage) are the main operational discharges that are significant enough to require an assessment of the extent of the discharge plume. Although the discharge of hydrotest water and commissioning fluids will occur over only a short time period during the SURF installation and commissioning stage, they were also included in the offshore discharge modeling as a conservative measure. Additionally, a scenario simulating a failure in the sewage treatment plant requiring all black water to bypass the macerator (and assuming it also bypasses the holding tank) and be discharged directly overboard via an emergency outfall was considered. The constituents considered from these discharges are listed in Table 3-2.

Table 3-2: Offshore Discharges and their Constituents Modeled

Discharge	Modeled Constituents
Cooling Water	■ Temperature ■ Residual chlorine
Produced Water	■ Temperature ■ Oil and grease ■ Residual production and water treatment chemicals (e.g., scale and corrosion inhibitors)
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines	■ Hypochlorite ■ Electrolyte ■ Biocide ■ Oxygen scavenger ■ Scale inhibitor
Hydrotest Water	■ Biocides ■ Oxygen scavenger ■ Corrosion inhibitor
Gas Injection Line Commissioning Fluid	■ Hydrate inhibitor (e.g., methanol or ethylene glycol)
Black Water	■ TSS ■ BOD_5 ■ Coliform bacteria

BOD_5 = 5-day biochemical oxygen demand

The model used is the U.S. Environmental Protection Agency's (USEPA) Cornell Mixing Zone Expert System (CORMIX) dilution model. CORMIX is a design tool routinely used by regulatory agencies to estimate the size and configuration of proposed and existing mixing zones resulting from wastewater discharges. CORMIX is primarily a near-field model (i.e., it applies to the region adjacent to the discharge structure in which the wastewater plume is recognizable as separate from the ambient water and its trajectory is dominated by the discharge rate, effluent density, and geometry of the discharge structure).

The CORMIX calculation is based on defining the various hydraulic zones the effluent plume traverses in the receiving waterbody, then applying an analytical solution or empirical relationship to compute the plume trajectory and dilution rate in each zone. Each of these analytical solutions and empirical relationships has been validated by the developers and other researchers against laboratory and field studies. CORMIX has been applied to many cases (http://www.cormix.info) and is recognized by the USEPA and other national regulatory agencies as an appropriate model for computing trajectories, dilution rates, and mixing zone dimensions.

To represent the short-term nature of the discharge for the untreated black water discharge scenario, the 3-D hydrodynamic and water quality model GEMSS® was used. Unlike CORMIX, the GEMSS model is capable of simulating temporally and spatially varying conditions.

3.2 Scenario Selection

Understanding the mixing characteristics of the various discharges and assessing compliance with applicable regulatory standards requires an understanding of the properties of the receiving (ambient) water. The properties of the ambient water, in combination with the discharge port configuration (pipe or diffuser), control the near-field mixing and dilution of the discharge. Properties of the ambient water relevant to the current analysis include current velocity, temperature, and salinity. While the ambient current velocity (and its strength relative to the discharge/exit velocity) determines the level of initial mixing, temperature and salinity influence the behavior of the discharge plume and its relative configuration due to density differences (i.e., buoyancy effects). Significant density differences between the discharge and ambient water will impede mixing. Balancing that effect, significant differences between discharge velocity and ambient current increase entrainment of the ambient water into the discharge plume, resulting in rapid mixing.

3.2.1 Discharge Velocity

Discharge velocity is directly related to the pipe diameter used for the various effluent streams. Smaller pipe diameters result in higher exit velocities, facilitating increased mixing. However, engineering constraints may require a minimum pipe diameter. As is typically the case for an EIA, details are not yet available for all aspects of the Project discharge design. However, detailed design information is available for the Destiny and Unity FPSOs; accordingly, where appropriate, design values from these projects were used for the analysis for the Yellowtail Project. If smaller discharge pipe diameters are used for the Yellowtail Project, the discharge will result in increased mixing and smaller plumes. A larger pipe diameter was also evaluated for some scenarios to confirm that the plume under a larger pipe will continue to meet the targeted environmental guidelines. The pipe configurations considered for the discharge streams modeled are listed in Table 3-3.

Table 3-3: Pipe Diameters Considered for Offshore Discharges

Type of Discharge	Pipe Diameter (inches/millimeters)	Vertical Location Relative to Sea Level
Produced Water	23 / 584.2	1 meter (3.2 feet) above water surface
Cooling Water	22.6 and 45.2 / 574 and 1,148.1	1 meter (3.2 feet) above water surface
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines	23 / 584.2	1 meter (3.2 feet) above water surface
Hydrostatic Test Water	2 and 6 / 50.8 and 152.4	Seafloor
Hydrate Control Fluid	2 and 6 / 50.8 and 152.4	Seafloor
Black Water	8 / 203.2	1 meter (3.2) feet below water surface

3.2.2 Discharge Properties

Discharge rates for the various operational discharges were based on the preliminary design (see Table 3-1). For modeling of hydrotesting discharges, SURF volumes were also based on preliminary design information. The discharge rates and SURF volumes reflect conservative (high) estimates. Anticipated constituent concentrations and temperatures in discharge streams were also based on preliminary design. The selected discharge rates and constituent concentrations are shown in Table 3-4.

Table 3-4: Modeled Discharge Properties

Type of Discharge	Modeled Discharge Rate	Modeled Parameter Values
Produced Water	300,000 BPD (48,000 m^3/d) (conservative)	■ Temperature: 55°C (131°F) ■ Oil and Grease: 42 mg/L (daily maximum) ■ Residual production and water treatment chemicals (100 ppm scale inhibitor and 200 ppm corrosion inhibitor used as examples)
Cooling Water	1,900,000 BPD (≤ 304,000 m^3/d)	■ Temperature: 50°C (122°F) ■ Hypochlorite: ≤5 ppm
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines	315,000 BPD (≤ 50,400 m^3/d)	■ Hypochlorite: ≤1 ppm ■ Electrolyte: ≤1 ppm ■ Biocide: ≤5 ppm ■ Oxygen scavenger: ≤10 ppm ■ Scale inhibitor: ≤5 ppm
Hydrostatic Test Water	65,000 bbl (10,400 m^3) (total volume for all flowlines and risers, occurring across approximately 1 year)	■ Biocide: 500 ppm ■ Oxygen scavenger: 100 ppm ■ Corrosion inhibitor: 200 ppm
Hydrate Control Fluid	2,500 bbl (400 m^3) (may be as low as 1,400 bbl [224 m^3])	■ Concentrated methanol or ethylene glycol
Black Water	3,960 gallons (15 m^3) per day [a]	■ TSS: 650 mg/L ■ BOD_5: 350 mg/L ■ Coliform: 10,000,000 CFU/100 ml

°C = degrees Celsius; °F = degrees Fahrenheit; bbl = barrel; BOD_5 = 5-day biochemical oxygen demand; BPD = barrels per day; CFU = colony-forming units; ml = milliliter; ppm = parts per million; m^3 = cubic meter; m^3/d = cubic meters per day
[a] Based on design capacity for black water (85 BPD) with 180 persons on board; 10 percent contingency factor applied.

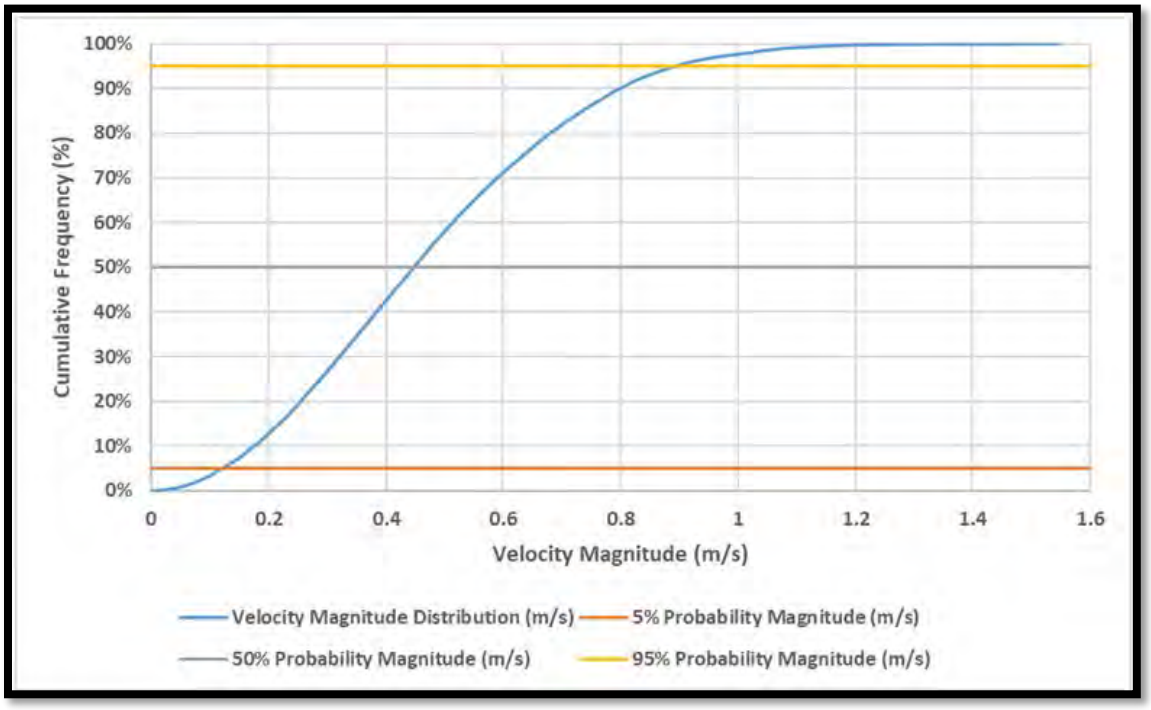
3.2.3 Ambient Currents

Ambient current velocities for the region were available from ExxonMobil Upstream Research Company using the SAT-OCEAN model and analyzed in order to select appropriate values for the specific locations for the discharges at the FPSO location. Although the operational discharges will occur near the surface, the hydrotesting and hydrate control fluid releases will occur near the seabed. Therefore, the ambient current velocities were analyzed to select appropriate values depending on the discharge being modeled.

Ambient current velocities were analyzed for the period of January 2005 to December 2014. A frequency distribution analysis was performed to evaluate the magnitude and exceedance percentages for current velocities. The ambient current velocities selected for modeling consisted of bounding cases (5 percent and 95 percent) and a typical case (50 percent). The frequency distributions for the two depths are shown on Figure 3-1 and Figure 3-2. The selected current velocities are shown in Table 3-5.

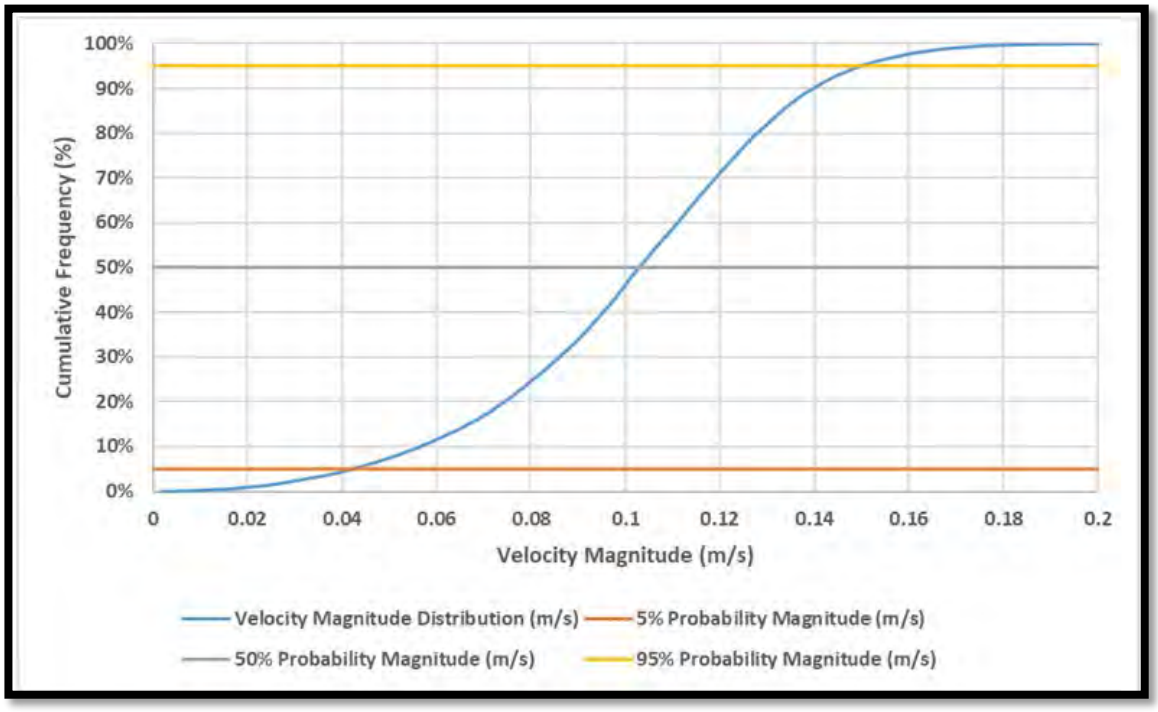
The use of a frequency distribution for selection of current velocities helps determine bounding cases for extreme ambient currents. The period of record is 10 years, which is sufficient to represent the variety in ambient conditions. Conditions outside of the ones observed during this 10-year period are expected to occur infrequently and, if they do occur, to not be sustained for long durations. Dynamics of the discharge plume under these unlikely conditions will therefore be rare and will quickly return to typical conditions due to the transitional nature of the currents. Furthermore, the model selected for analysis (CORMIX) has inherent conservativeness built in. It is thus reasonable to assume that the choice of bounding cases (5 percent and 95 percent) from the 10 years of record provides adequate representation of the likely discharge plumes that would predominate.

Figure 3-1: Cumulative Frequency Distribution for Current Velocities at FPSO Location (near surface)



m/s = meter per second

Figure 3-2: Cumulative Frequency Distribution for Current Velocities at FPSO Location (near seabed)



m/s = meter per second

Table 3-5: Selected Ambient Current Velocities (meters/second)

Cumulative Frequency	Surface	Seabed
Low (5%)	0.121	0.042
Typical (50%)	0.447	0.103
High (95%)	0.894	0.150

3.2.4 Ambient Temperatures

An analysis of ambient temperatures for the FPSO location was conducted based on data available from the HYCOM model. Since the ambient temperatures do not vary significantly within the Stabroek Block, only the FPSO location was considered. The temperature data are available for January 2013 to April 2018. A frequency distribution analysis was completed to evaluate the temperatures and exceedance percentages. Selected ambient temperatures consisted of two bounding cases (1 percent and 99 percent) and a typical case (50 percent). Only the cooling water discharge, whose plume is influenced by the ambient temperatures and whose flowrate is relatively high, was considered for the bounding cases and all remaining discharges were run for the typical case. The frequency distribution is shown on Figure 3-3 and the selected temperatures are shown in Table 3-6. For discharges released near the seafloor (hydrostatic test discharge), a single value of temperature at 4.5 degrees Celsius (ºC) (40.1°Fahrenheit [°F]) was used, as the temperature values near the seafloor do not vary considerably with time and space.

Figure 3-3: Cumulative Frequency Distribution for Temperatures at FPSO Location (near surface)

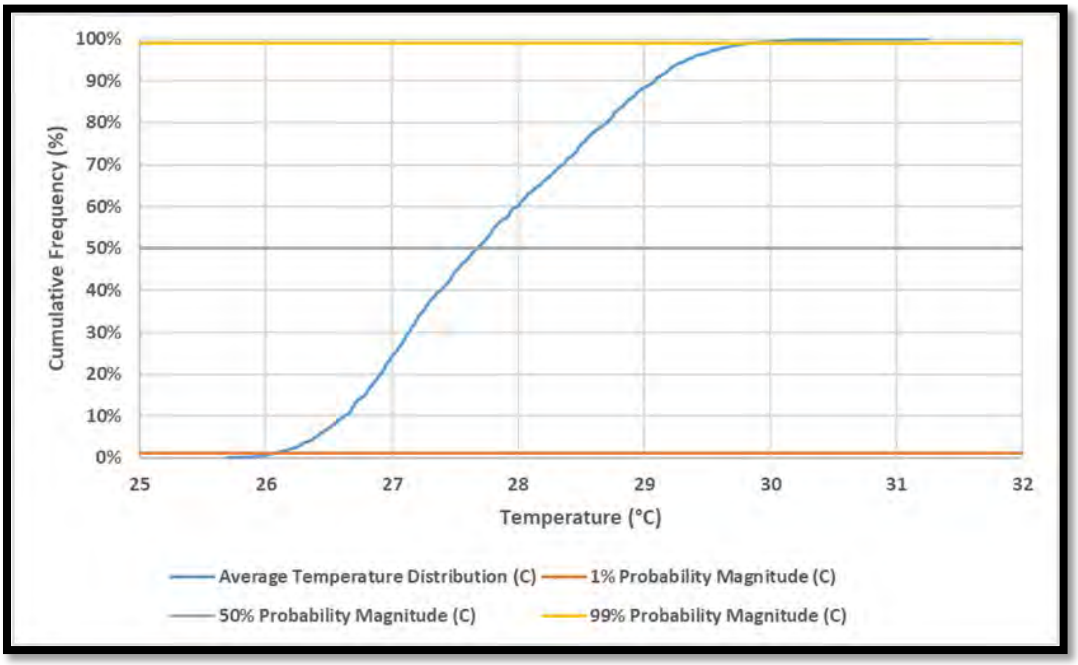


Table 3-6: Selected Ambient Near-Surface Temperatures (°C)

Cumulative Frequency	Temperature at FPSO Location
Low (1%)	26.07
Typical (50%)	27.68
High (99%)	29.89

3.2.5 Scenarios

A combination of the discharges, ambient properties (currents and temperatures), and discharge velocities (based on pipe diameters) were used to develop a comprehensive list of scenarios for simulation with CORMIX (Table 3-7). All potential pipe diameters listed in Table 3-3 were used to model these scenarios.

Table 3-7: List of Modeled Scenarios

No	Discharge	Scenario Name	Ambient Currents	Ambient Temperature	Location
1	Cooling Water—Thermal	T Sc. 01	Low (5%)	High (99%)	FPSO; 1 m above water surface
		T Sc. 02	Typical (50%)	High (99%)	FPSO; 1 m above water surface
		T Sc. 03	High (95%)	High (99%)	FPSO; 1 m above water surface
		T Sc. 04	Low (5%)	Low (1%)	FPSO; 1 m above water surface
		T Sc. 05	Typical (50%)	Low (1%)	FPSO; 1 m above water surface
		T Sc. 06	High (95%)	Low (1%)	FPSO; 1 m above water surface
2	Cooling Water—Hypochlorite	C Sc. 01	Low (5%)	High (99%)	FPSO; 1 m above water surface
		C Sc. 02	Typical (50%)	High (99%)	FPSO; 1 m above water surface
		C Sc. 03	High (95%)	High (99%)	FPSO; 1 m above water surface

No	Discharge	Scenario Name	Ambient Currents	Ambient Temperature	Location
		C Sc. 04	Low (5%)	Low (1%)	FPSO; 1 m above water surface
		C Sc. 05	Typical (50%)	Low (1%)	FPSO; 1 m above water surface
		C Sc. 06	High (95%)	Low (1%)	FPSO; 1 m above water surface
3	Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines	W Sc. 01	Low (5%)	Typical (50%)	FPSO; 1 m above water surface
		W Sc. 02	Typical (50%)	Typical (50%)	FPSO; 1 m above water surface
		W Sc. 03	High (95%)	Typical (50%)	FPSO; 1 m above water surface
4	Produced Water	P Sc. 01	Low (5%)	Typical (50%)	FPSO; 1 m above water surface
		P Sc. 02	Typical (50%)	Typical (50%)	FPSO; 1 m above water surface
		P Sc. 03	High (95%)	Typical (50%)	FPSO; 1 m above water surface
5	Hydrostatic Test Water	H Sc. 01	Low (5%)	4.5°C	FPSO; seafloor
		H Sc. 02	Typical (50%)	4.5°C	FPSO; seafloor
		H Sc. 03	High (95%)	4.5°C	FPSO; seafloor
6	Hydrate Control Fluid—Methanol	Methanol Sc01 2in	Low (5%)	4.5°C	FPSO; seafloor
		Methanol Sc03 2in	High (95%)	4.5°C	FPSO; seafloor
		Methanol Sc01 6in	Low (5%)	4.5°C	FPSO; seafloor
		Methanol Sc03 6in	High (95%)	4.5°C	FPSO; seafloor
7	Hydrate Control Fluid—Ethylene glycol	MEG Sc01 2in	Low (5%)	4.5°C	FPSO; seafloor
		MEG Sc03 2in	High (95%)	4.5°C	FPSO; seafloor
		MEG Sc01 6in	Low (5%)	4.5°C	FPSO; seafloor
		MEG Sc03 6in	High (95%)	4.5°C	FPSO; seafloor

m = meter

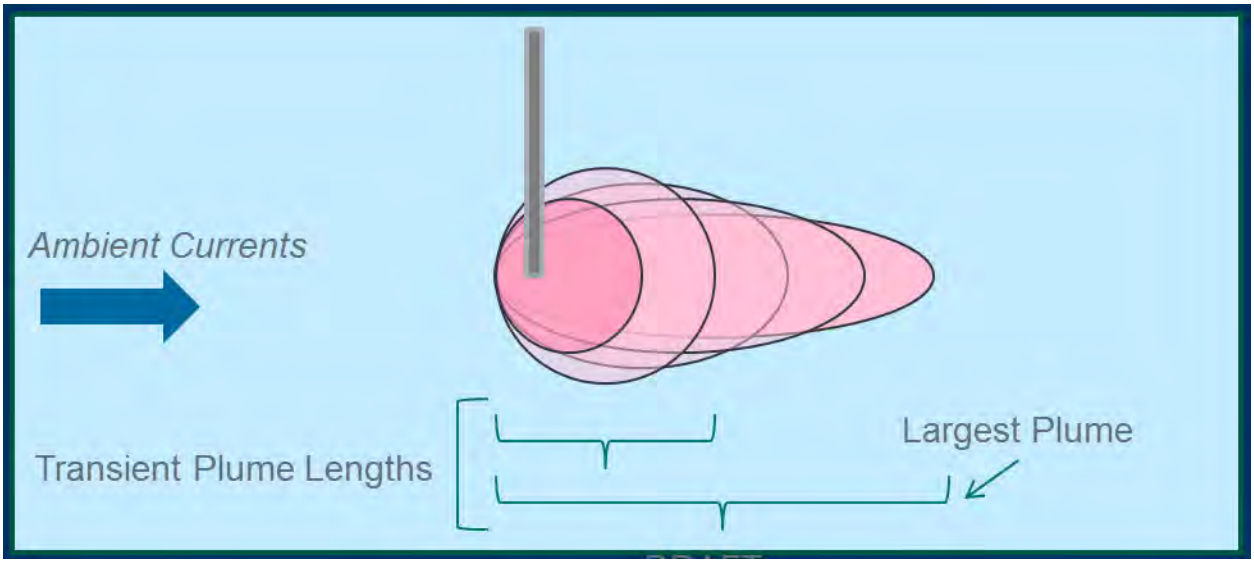
3.3 Standards and Thresholds

Cooling water discharges are typically regulated based on consideration of native aquatic species. These standards are more stringent in coastal and inland waters due to the presence of sensitive aquatic receptors and the limited area available for mixing. In offshore waters, such standards are usually absent. For this study, an internationally recognized thermal guidance of 3°C (5.4ºF) maximum temperature change at 100 meters (328.1 feet) from the point of discharge was used. Hypochlorite, added to cooling water to avoid biofouling, is either regulated as an end-of-pipe concentration or at the end of a mixing zone. However, due to the transient nature of the plume and absence of sustained exposure to residual chlorine, the hypochlorite is not expected to pose risk to biota. Although not technically applicable to a cooling water discharge, the assessment utilized the International Maritime Organization's *2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plant*s recommendation that when chlorine is used as a disinfectant, the best technical practice is to keep the disinfectant residual in the effluent below 0.5 mg/L (IMO 2012).

The scenarios designed in this study are highly conservative (i.e., they assume extended periods of time during which ambient conditions—primarily currents, salinity and temperature—persist). This approach assumes a static plume, which, in reality, will be transient in extent and configuration. For instance, the small ambient currents (5 percent bounding condition) will only exist for a short duration, as these currents only exist for 5 percent of the total time. In actuality, the currents will increase and decrease and the resulting plume will disperse more rapidly than the model predicts. Figure 3-4 shows a schematic of such a transient plume, where the extent and dilution continue to change as ambient currents decrease or increase. When modeling slower ambient current velocities (5 percent bounding condition), the analysis

will predict a more concentrated plume. However, this plume will exist for only a short duration, as velocities will change (increase), increasing dilution. Furthermore, the directionality of these currents will change the orientation of this transient plume, resulting in regions around the discharge that are only exposed to increased concentrations (or temperatures) for short durations.

Figure 3-4: Transient Discharge Plume from Various Offshore Releases



The end-of-pipe concentration of oil and grease in produced water is regulated by MARPOL73/78 standards at a maximum monthly average of 29 mg/L and a daily maximum of 42 mg/L. The USEPA compliance guidance document for the Gulf of Mexico (Final NPDES[4] General Permit for New and Existing Sources and New Discharges in the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico [GMG290000]) requires treatment chemicals such as biocides, corrosion inhibitors, or other chemicals used to prevent corrosion or fouling of piping or equipment to be limited by the following constraints (USEPA 2017):

- The maximum concentration and any other conditions specified in the USEPA product registration labeling; or
- The maximum manufacturer's recommended concentration; or
- 500 mg/L.

At the time of the study, no manufacturers' recommended limits are available for the SRU processing brines, produced water, or hydrotest water. It is noted that the maximum concentrations of any treatment chemicals in the discharge streams will be less than 500 mg/L.

With respect to the emergency black water discharge scenario, the International Maritime Organization's *2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* recommends the following standards for effluent discharge (IMO 2012):

- TSS should not exceed 35 mg/L.
- 5-day biochemical oxygen demand (BOD_5) should not exceed 25 mg/L.
- Thermotolerant coliforms should not exceed 100 colony-forming units (CFU) per 100 milliliters.

[4] National Pollutant Discharge Elimination System

Since no ambient water-quality standards are available for the various offshore discharge streams except for the guidance for temperature increase for the cooling water discharge, the assessment reports results in terms of percentage dilution at a reference distance of 100 meters (328.1 feet).

3.4 Results

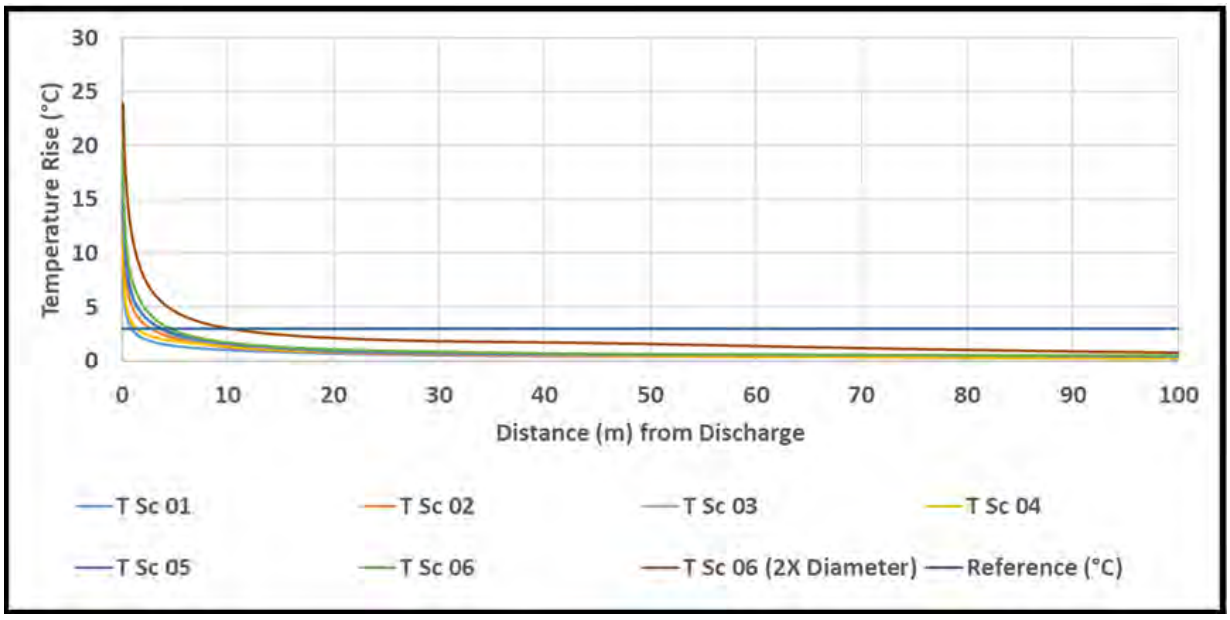
Each CORMIX simulation codes its results in a prediction (*.prd) file that consists of the plume centerline coordinates (0,0,0 at the discharge location), dilution (S) and concentrations. For thermal discharge (cooling water), concentration refers to the temperature rise above ambient and includes heat loss from the surface. For all other constituents, the dilution value does not include any decay and, therefore, represents a conservative (high) result. Inclusion of a decay term would result in a smaller plume. Since the concentrations are always the highest at the plume centerline, the results discussed here are shown as centerline concentrations at a particular distance directly down current from the discharge.

3.4.1 Cooling Water

The design of the cooling water discharge structure, at this early stage of the Project, is not finalized. However, information from the previous FPSOs (Destiny, Unity, and Prosperity) is available and was used as reference since these FPSOs will have similar overall design themes to that of the Yellowtail Project. The design will only consider pipe configurations that allow compliance with the thermal guideline of temperature rise within 100 meters (328.1 feet) of the discharge to be less than 3°C (5.4ºF). The previous FPSO designs were based on this guideline and, as such, provide a good basis for use in the Yellowtail Project, noting that the Yellowtail Project cooling water discharge rate is estimated to be 1,900,000 barrels per day (BPD), as compared to the Unity and Payara discharge rates (1,600,000 BPD). The discharge pipe diameter is currently expected to remain the same. This will tend to enhance the mixing of the discharge. Key to these design elements is the release of the discharge above the water surface, which results in significant gravitational acceleration and thus significant mixing at the point of entry into the ambient water. Two ambient temperatures (1 percent and 99 percent) were selected for simulation because different ambient temperatures will influence the plume behavior and the effluent temperature rise.

Based on the initial assessments, the scenario identified as T Sc. 06 (low ambient temperature and high ambient currents) was found to result in the longest distance for the plume to reach the temperature change threshold. This scenario was then re-run for a pipe diameter twice the size. Even with the diameter doubled (4 times the area), the thermal plume complied with the reference guideline of 3°C (5.4ºF) temperature change within 10 meters (32.8 feet) of the discharge. Figure 3-5 shows the temperature rise diminishing with distance from the discharge, showing compliance with the 3°C (5.4ºF) temperature change within 10 meters (32.8 feet) from the discharge for all scenarios.

Figure 3-5: Temperature Rise Above Ambient Versus Distance Downstream for All Scenarios



Compliance with the thermal discharge guideline requires sufficient mixing within the immediate vicinity of the discharge. The pipe configurations designed to ensure compliance for thermal guideline will therefore result in adequate mixing for the hypochlorite discharge as well. For the scenarios considered here, the worst case (lowest mixing) scenario (T Sc. 06 with 2X diameter) results in a dilution factor of 31.2 (23.93°C temperature rise / 0.768°C temperature rise) [43.1ºF temperature rise / 1.38ºF temperature rise]). This means that for this same scenario, for a hypochlorite dosing of 5 parts per million (ppm), hypochlorite concentrations will be 0.10 ppm at 100 meters (328.1 feet). As noted earlier, these concentrations represent conservative estimates (i.e., peak values) and will be transient in nature.

3.4.2 Produced Water

Produced water is characterized by an elevated temperature, and contains oil and grease and residual production and water treatment chemicals. Scale inhibitor and corrosion inhibitor were modeled at discharge concentrations of 100 ppm and 200 ppm, respectively, as examples of residual production chemicals that may exist in the produced water discharge. The pipe configuration (diameter and location) was assumed as 58.42 centimeters (23 inches) releasing at 1 meter (3.28 feet) above the water surface. Of the constituents of concern in produced water, only oil and grease end-of-pipe concentrations are regulated under MARPOL 73/78. The applicable standard is a maximum monthly average of 29 mg/L and a daily maximum of 42 mg/L, measured at the end of pipe. These standards are applied at the point of release of the produced water. The daily maximum value of 42 mg/L was therefore used as the discharge concentration for this analysis. The thermal guideline applied to cooling water (less than 3°C [5.4ºF] temperature rise within 100 meters [328.1 feet] of the discharge) was also applied to produced water.

Concentrations of oil and grease, scale inhibitor, and corrosion inhibitor are shown for the three scenarios (see Table 3-7) on Figure 3-6, Figure 3-7, and Figure 3-8, respectively. Oil and grease concentration decreases to less than 0.74 mg/L within 100 meters (328.1 feet) while scale inhibitor and corrosion inhibitor drop to less than 1.77 ppm and 3.54 ppm, respectively, within 100 meters (328.1 feet). The same level of mixing is expected for temperature rise, as seen on Figure 3-9, where the temperature rise drops to less than 0.48°C (0.86ºF) within 100 meters (328.1 feet).

Figure 3-6: Concentration of Oil and Grease (mg/L) with Distance (meters) from the Discharge for the Three Scenarios Modeled

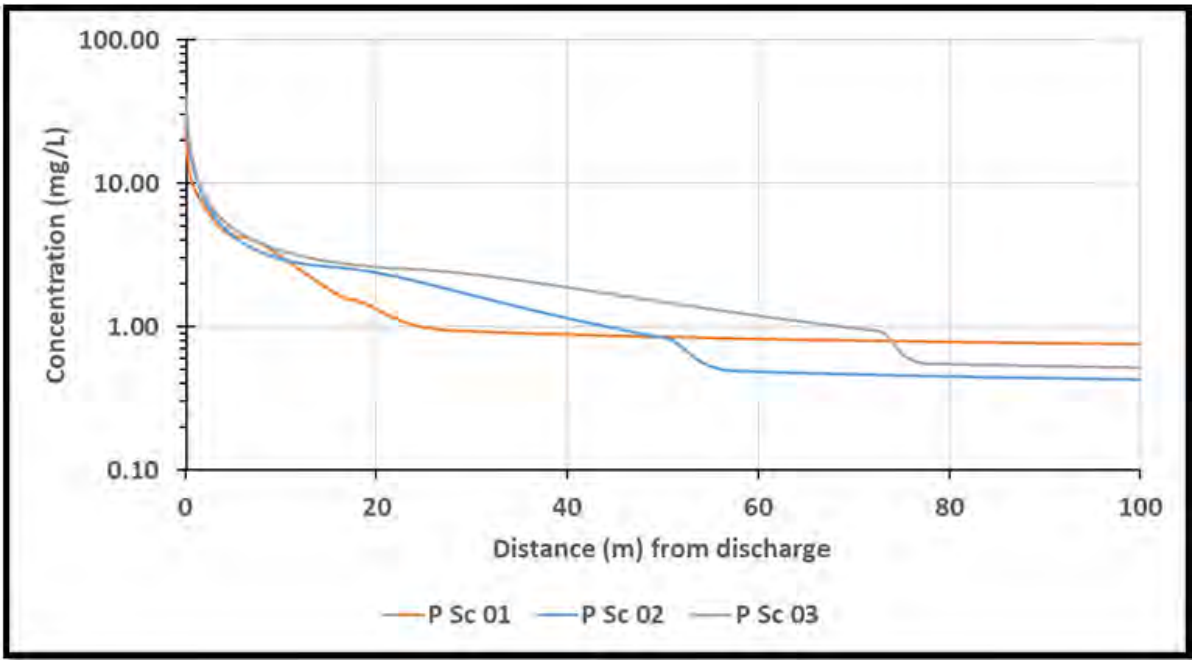


Figure 3-7: Concentration of Scale Inhibitor (ppm) with Distance (meters) from the Discharge for the Three Scenarios Modeled

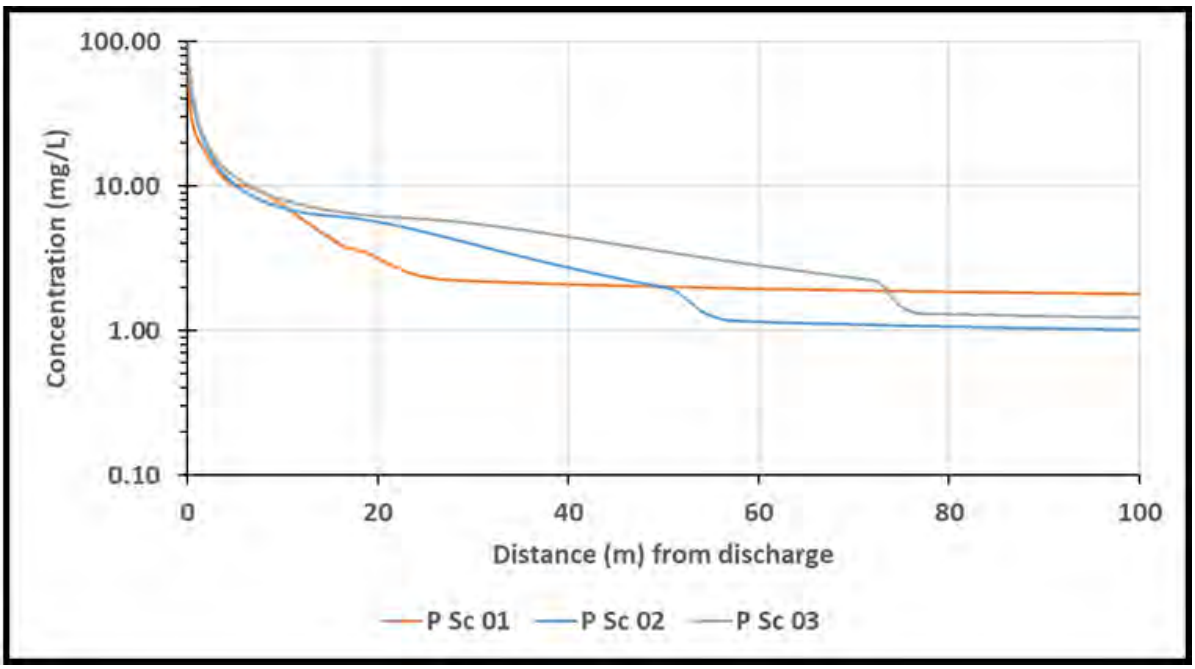


Figure 3-8: Concentration of Corrosion Inhibitor (ppm) with Distance (meters) from the Discharge for the Three Scenarios Modeled

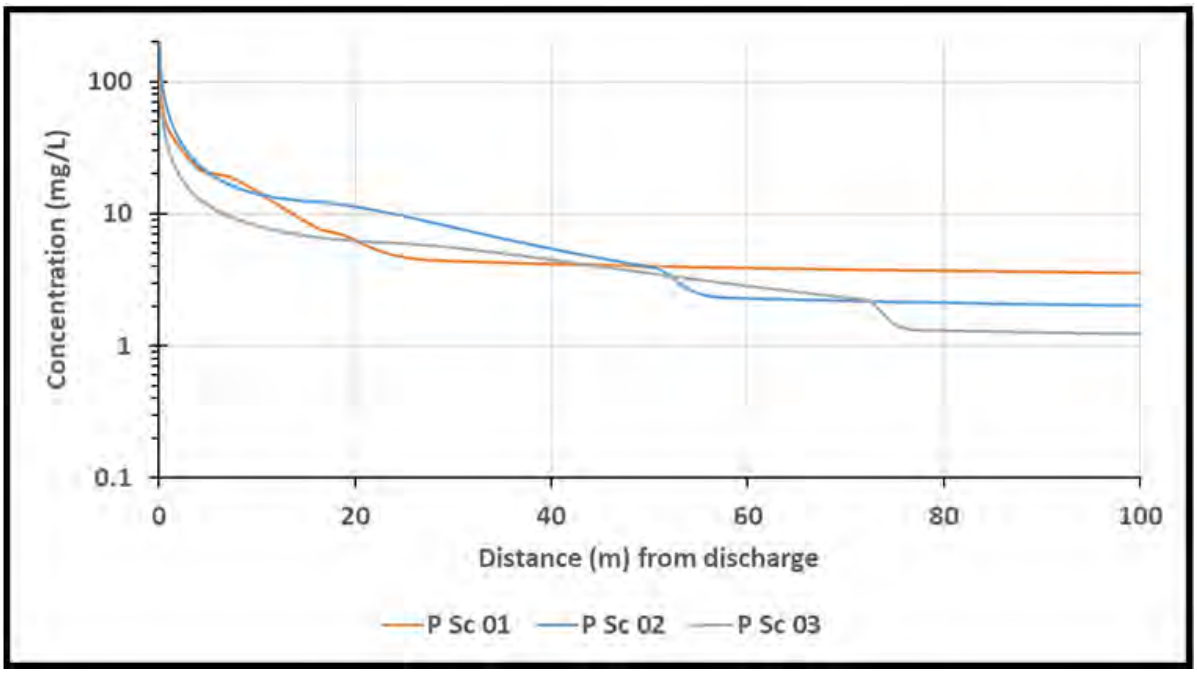
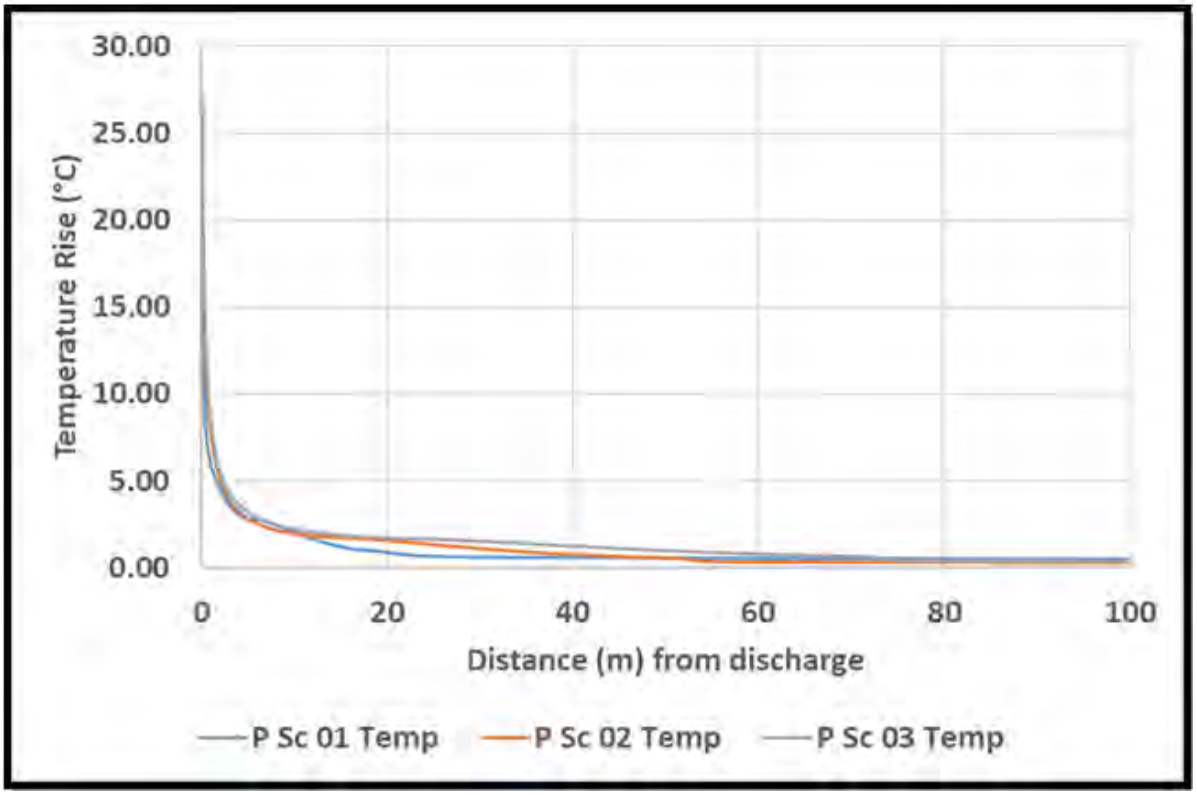


Figure 3-9: Temperature Rise with Distance (meters) from the Discharge for the Three Scenarios Modeled

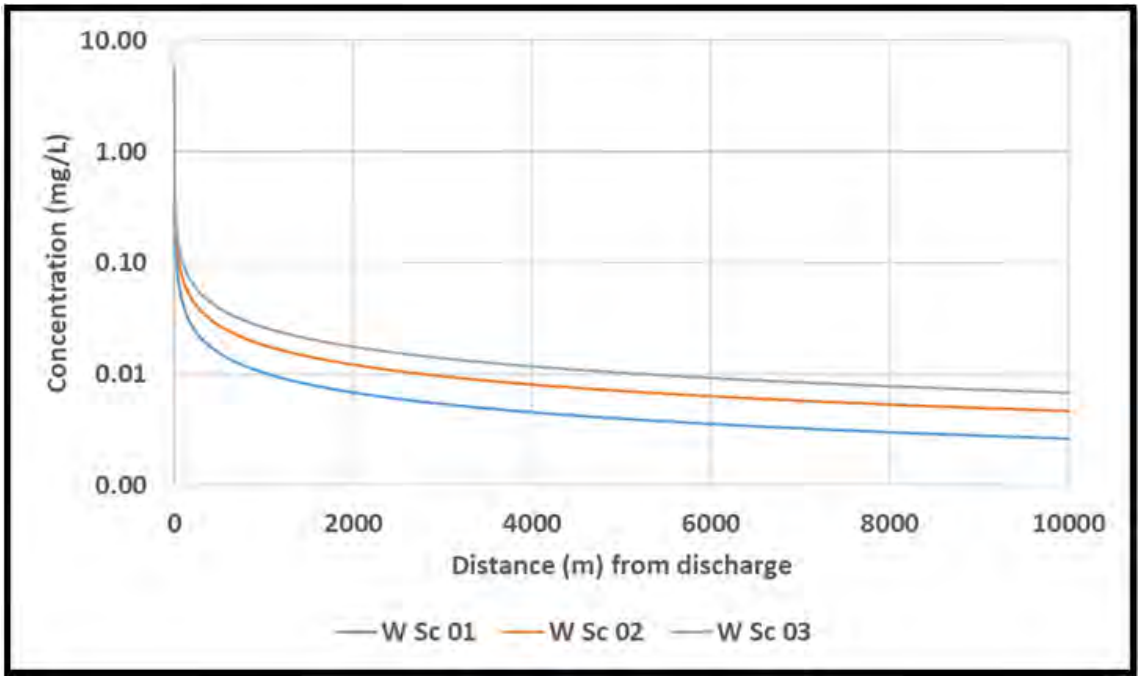


3.4.3 Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines

This discharge stream consists of a combination of processing brines from the SRU, ultrafiltration, and wash water reverse osmosis system. The main constituents are hypochlorite, electrolytes, biocides, oxygen scavenger, and scale inhibitor. It was assumed that the discharge pipe will not exceed a diameter of 58.42 centimeters (23 inches), and that the stream will be released at least 1 meter (3.28 feet) above the water surface. Any pipe of smaller diameter will result in increased mixing and a smaller plume.

The predicted biocide concentrations for the three scenarios modeled (see Table 3-7) are shown on Figure 3-10. The biocide concentration decreases to no more than 0.094 mg/L within 100 meters (328.1 feet) and 0.026 mg/L within 1,000 meters (3,280.8 feet) (99.5 percent reduction) for the worst-case scenario (high ambient currents). All other constituents will follow the same mixing pattern and experience the same percent reduction.

Figure 3-10: Concentration of Biocide (ppm) with Distance (meters) from the Discharge for the Three Scenarios Modeled

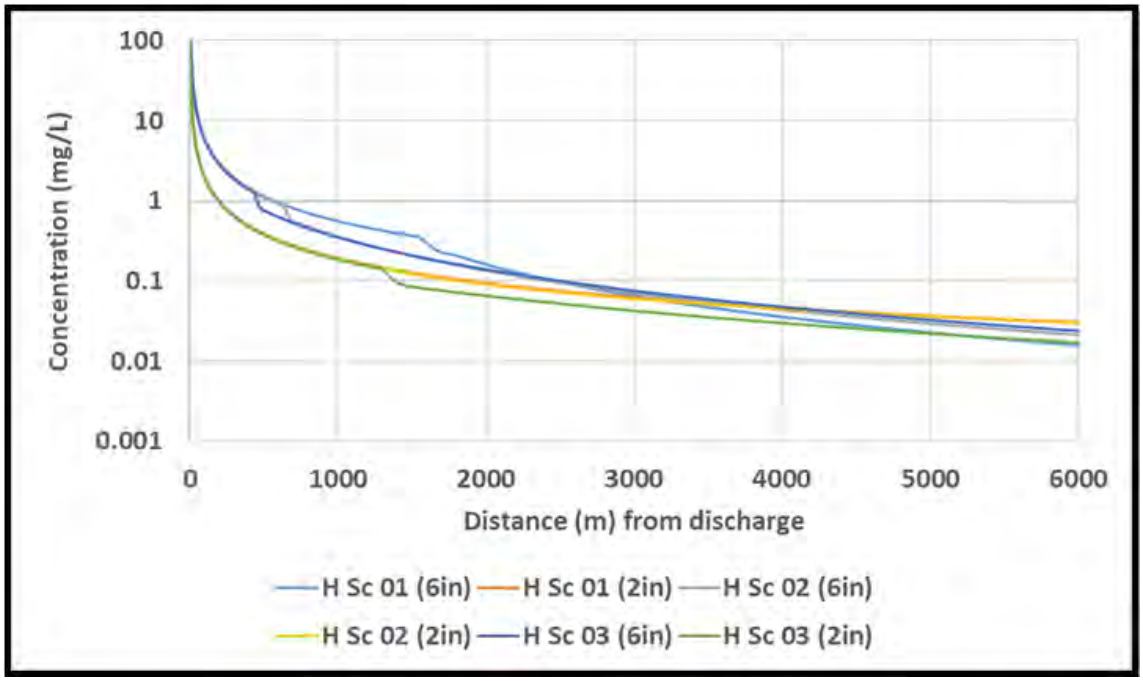


3.4.4 Hydrostatic Test Water

Hydrotesting is a necessary process to test for the integrity of the various subsea pipelines and risers prior to putting them in service for production operations. This is a critical procedure that is required for offshore projects of this nature. All pipeline and riser volumes were considered for this analysis and the largest single release was selected for modeling. It was assumed that once testing is complete, the total volume will be released within 60 minutes. Since the pipelines and risers are of different diameters, all three scenarios were run for pipe diameters of 5.1 centimeters (2 inches) and 15.2 centimeters (6 inches). Results for all three scenarios showing reduction in biocide concentration with the bounding pipe diameter cases are shown on Figure 3-11. For the worst case scenario (H Sc. 01 with 15.2-centimeter [6-inch] pipe), biocide decreases to 5.77 ppm within 100 meters (328.1 feet) of the discharge.

The other constituents (oxygen scavenger and corrosion inhibitor) will follow the same mixing pattern and experience the same percent reduction.

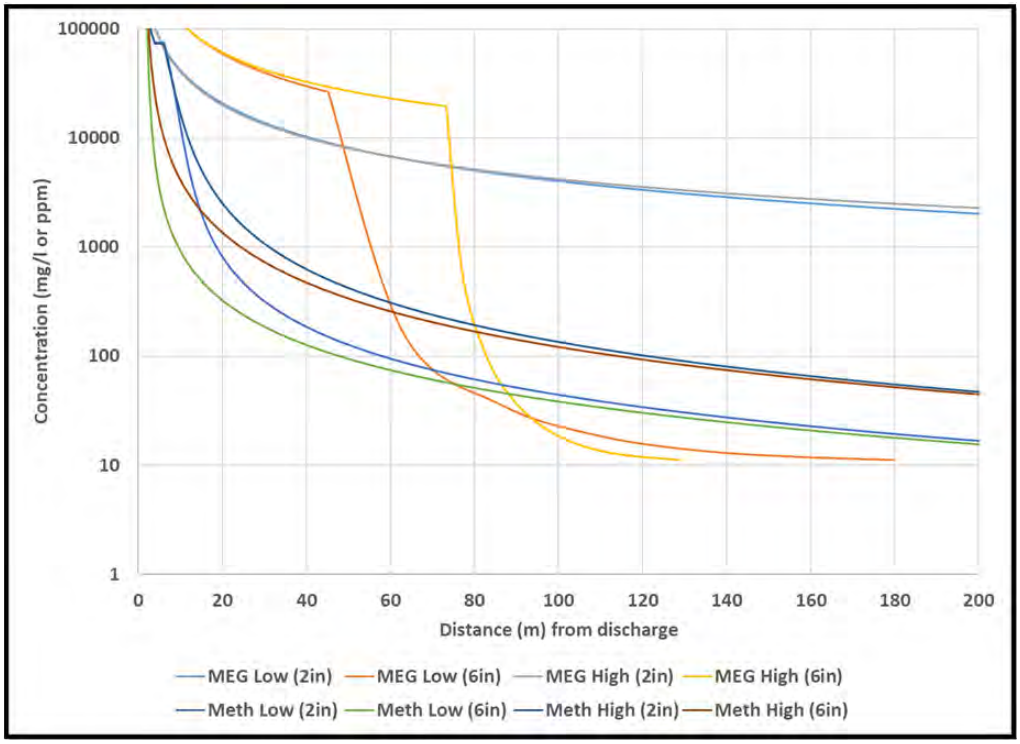
Figure 3-11: Concentration of Biocide (ppm) with Distance (meters) from the Discharge for the Three Scenarios and Two Pipe Diameters



3.4.5 Gas Re-injection Line Commissioning Fluids

As part of the gas re-injection line commissioning, a hydrate control fluid (concentrated methanol or ethylene glycol) will be discharged at the seafloor. The most probable volume for the hydrate control fluid will be 1,400 barrels (bbl) (224 cubic meters [m^3]), but a conservative value of 2,500 bbl (400 m^3) was assumed for the modeling analysis. Since the pipelines and risers are of different diameters, all three scenarios were run for pipe diameters of 5.1 centimeters (2 inches) and 15.2 centimeters (6 inches). Figure 3-12 shows the results for both methanol and ethylene glycol under the low and high ambient currents and 5.1-centimeter (2-inch) and 15.2-centimeter (6-inch) pipe diameters.

Figure 3-12: Concentration of Methanol or MEG (ppm) with Distance (meters) from the Discharge for the Low and High Currents and 2-inch and 6-inch Pipe Diameters



3.4.6 Black Water

An emergency scenario where an upset occurs for the onboard black water treatment system was considered. Under this emergency scenario, it was assumed that untreated black water from accommodations and the clinic would bypass the macerator and the sewage holding tank and be discharged directly overboard through an emergency outfall. The FPSO is designed for a maximum of 180 persons on board, with a black water design capacity of approximately 85 BPD (13.6 cubic meters per day [m^3/d]). Applying a contingency factor of 10 percent resulted in the modeled sewage generation and emergency discharge rate of 3,960 gallons per day (15 m^3/d).

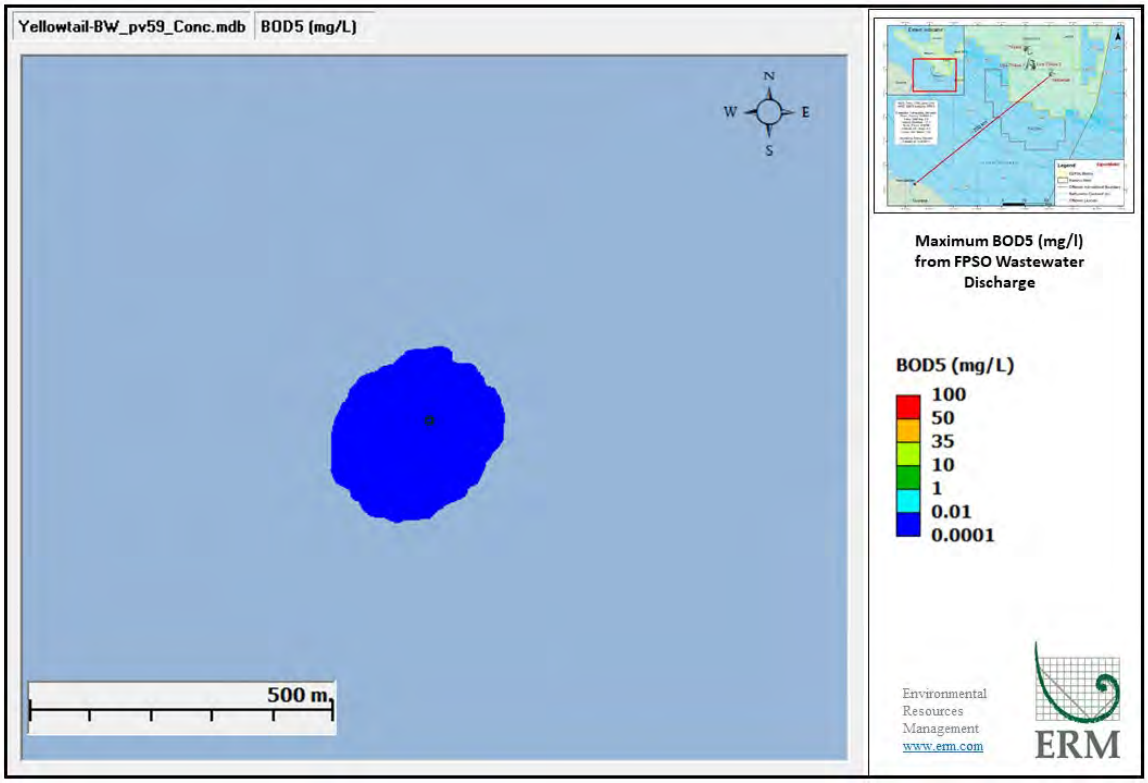
The untreated black water experiences instant mixing once it enters the ambient water. Although the constituents (BOD_5, TSS, and coliform) are released at high concentrations, immediate mixing and dilution results in steep declines in concentrations with distance. Due to the selected model resolution, this steep decline cannot be captured visually on the model results representation. The highest concentrations can only be reported as volume-averaged within the first modeled grid cell, which covers a volume of 200 cubic meters (10 meters x 10 meters x 2 meters), although higher peak concentrations will exist within this cell (<10 meters from the discharge).

Figure 3-13 shows the modeled maximum BOD_5 concentration across the model domain. As shown on the figure, there is no region in the modeling domain with a predicted BOD_5 concentration above 25 mg/L. Figure 3-14 shows the modeled maximum concentrations of TSS across the model domain. As shown on the figure, there is no region in the modeling domain with a predicted TSS concentration above 35 mg/L.

Figure 3-15 shows the modeled maximum concentrations of coliform across the model domain. As shown on the figure, there is no region in the modeling domain with a predicted coliform concentration above

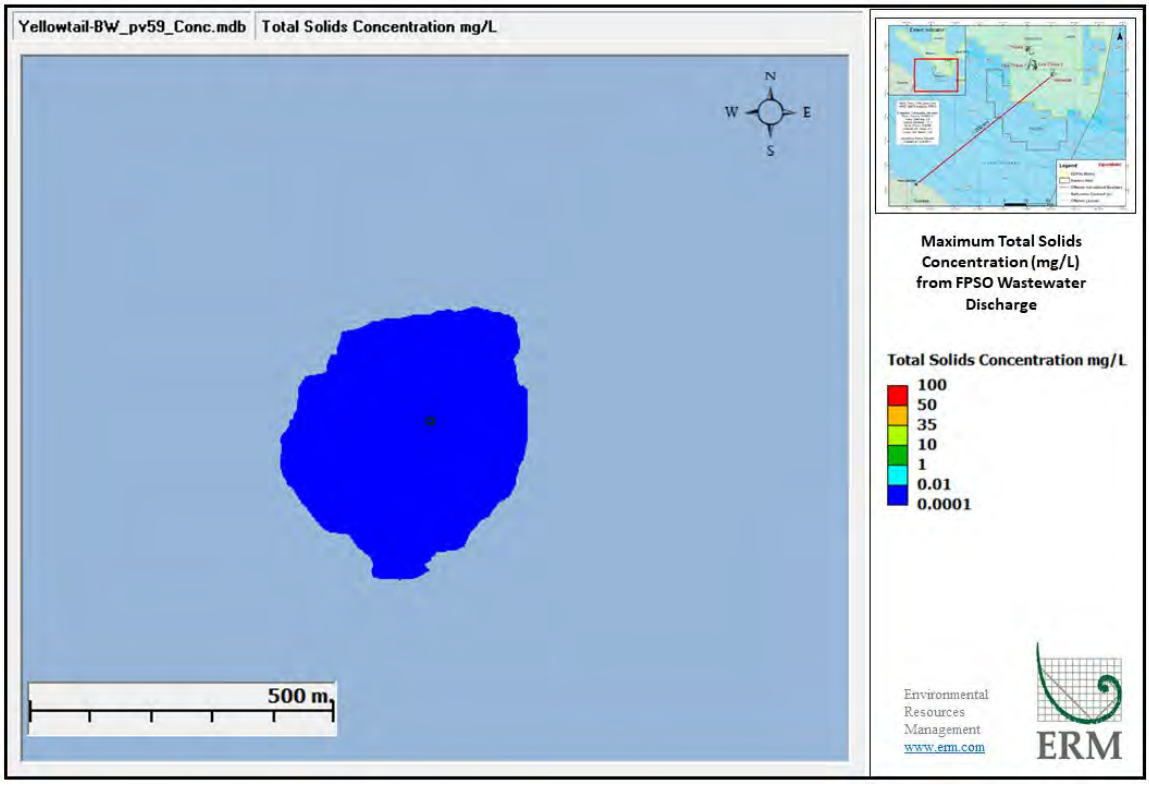
100 CFU per 100 milliliters. Further analysis of modeling results indicates that by 3 hours after the cessation of the discharge, the coliform concentration drops to less than 1 CFU per 100 milliliters.

Figure 3-13: Modeled Maximum Concentration of BOD_5 from an Untreated Black Water Discharge



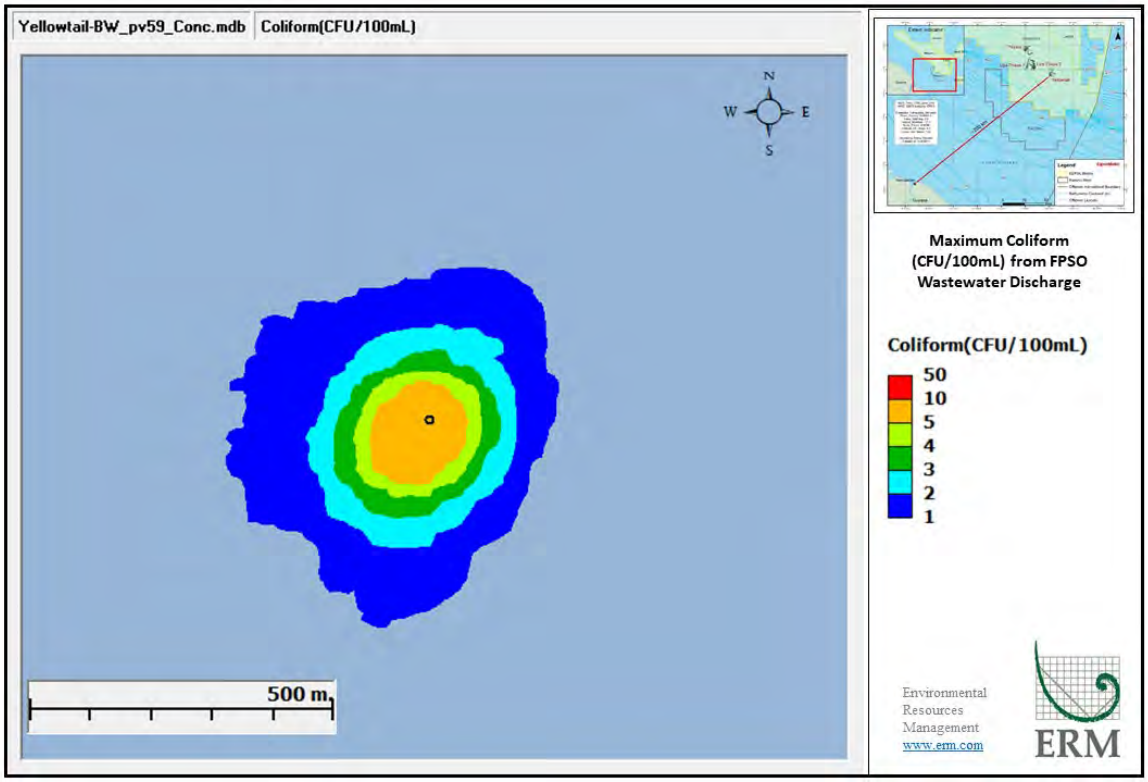
m = meters

Figure 3-14: Modeled Maximum Concentration of TSS from an Untreated Black Water Discharge



m = meters

Figure 3-15: Modeled Maximum Concentration of Coliform Bacteria from an Untreated Black Water Discharge



m = meters; mL = milliliter

3.5 Conclusions

Various operational and maintenance discharges and activities were modeled to estimate the extent of the associated discharge plumes. Extreme conditions and maximum expected discharge rates and concentrations were considered in this conservative analysis. The only relevant regulatory guideline related to ambient water quality is for the thermal discharges: temperature rises within 100 meters (328.1 feet) of the discharge point are recommended to be less than 3°C (5.4ºF). Since the Project is in a preliminary design phase, design specifications for the various discharge ports were not available. To address this lack of specific information, conservative estimates of the largest feasible pipe diameter were made, and modeling simulations were used to confirm that these upper-bound diameters will allow the guidelines to be met.

CORMIX, a near-field mixing zone model approved by USEPA, was used to model the various discharges (aside from the untreated black water discharge). It was found that even under upper-bound conditions discharge plumes were relatively small and subject to rapid mixing within the first 100 meters (328.1 feet). Although only thermal discharges are subject to regulatory limits, the reference distance of 100 meters (328.1 feet) is used for reporting purposes for all the discharges to demonstrate the rapid mixing that the discharge plumes experience. Table 3-8 summarizes the results of the modeling study for the planned offshore discharges.

Additionally, based on modeling of an untreated black water discharge using the GEMSS model, maximum concentrations of BOD_5, TSS, and coliform remain below the thresholds of 25 mg/L, 35 mg/L, and 100 CFU per 100 milliliters, respectively.

Table 3-8: Summary of Results of Modeling for Planned Offshore Discharges and Concentrations at 100-meter Reference Distance

No.	Discharge	Scenario Name	Discharge Concentration	Concentrations at 100 Meters [a]
1	Cooling Water—Thermal	Worst Case	Temperature: 50°C	Temperature Rise: <3°C
2	Cooling Water—Hypochlorite	Worst Case	Residual Chlorine: 5 ppm	Residual Chlorine: 0.10 ppm
3	Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines [b]	W Sc. 01	Hypochlorite: 5 ppm Electrolyte: 1 ppm Biocide: 5 ppm Oxygen Scavenger: 10 ppm Scale Inhibitor: 5 ppm	Hypochlorite: 0.042 ppm Electrolyte: 0.0083 ppm Biocide: 0.042 ppm Oxygen Scavenger: 0.083 ppm Scale Inhibitor: 0.042 ppm
		W Sc. 02	Hypochlorite: 5 ppm Electrolyte: 1 ppm Biocide: 5 ppm Oxygen Scavenger: 10 ppm Scale Inhibitor: 5 ppm	Hypochlorite: 0.068 ppm Electrolyte: 0.014 ppm Biocide: 0.068 ppm Oxygen Scavenger: 0.14 ppm Scale Inhibitor: 0.068 ppm
		W Sc. 03	Hypochlorite: 5 ppm Electrolyte: 1 ppm Biocide: 5 ppm Oxygen Scavenger: 10 ppm Scale Inhibitor: 5 ppm	Hypochlorite: 0.094 ppm Electrolyte: 0.019 ppm Biocide: 0.094 ppm Oxygen Scavenger: 0.19 ppm Scale Inhibitor: 0.094 ppm
4	Produced Water	P Sc. 01	Temperature: 55°C Oil and Grease: 42 mg/L Scale Inhibitor: 100 ppm Corrosion Inhibitor: 200 ppm	Temperature Rise: <3°C Oil and Grease: 0.74 mg/L Scale Inhibitor: 1.77 ppm Corrosion Inhibitor: 3.54 ppm
		P Sc. 02	Temperature: 55°C Oil and Grease: 42 mg/L Scale Inhibitor: 100 ppm Corrosion Inhibitor: 200 ppm	Temperature Rise: <3°C Oil and Grease: 0.42 mg/L Scale Inhibitor: 1.01 ppm Corrosion Inhibitor: 2.02 ppm
		P Sc. 03	Temperature: 55°C Oil and Grease: 42 mg/L Scale Inhibitor: 100 ppm Corrosion Inhibitor: 200 ppm	Temperature Rise: <3°C Oil and Grease: 0.52 mg/L Scale Inhibitor: 1.23 ppm Corrosion Inhibitor: 2.46 ppm
5	Hydrotest	H Sc. 01	Biocide (6-inch [15.2-cm] pipe): 500 ppm Biocide (2-inch [5.1-cm] pipe): 500 ppm	Biocide (6-inch pipe): 5.77 ppm Biocide (2-inch pipe): 1.92 ppm
		H Sc. 02	Biocide (6-inch [15.2-cm] pipe): 500 ppm Biocide (2-inch [5.1-cm] pipe): 500 ppm	Biocide (6-inch pipe): 5.71 ppm Biocide (2-inch pipe): 1.86 ppm
		H Sc. 03	Biocide (6-inch [15.2-cm] pipe): 500 ppm Biocide (2-inch [5.1-cm] pipe): 500 ppm	Biocide (6-inch pipe): 5.67 ppm Biocide (2-inch pipe): 1.93 ppm

No.	Discharge	Scenario Name	Discharge Concentration	Concentrations at 100 Meters [a]
6	Hydrate Control Fluid	Methanol Low 2in	Methanol (2-inch [5.1-cm] pipe): pure chemical at 800 kg/m^3	Methanol (2-inch pipe): 44.14 ppm
		Methanol High 2in	Methanol (2-inch [5.1-cm] pipe): pure chemical at 800 kg/m^3	Methanol (2-inch pipe): 133.63 ppm
		Methanol Low 6in	Methanol (6-inch [15.2-cm] pipe): pure chemical at 800 kg/m^3	Methanol (6-inch pipe): 38.24 ppm
		Methanol High 6in	Methanol (6-inch [15.2-cm] pipe): pure chemical at 800 kg/m^3	Methanol (6-inch pipe): 120.13 ppm
		MEG Low 2in	MEG (2-inch [5.1-cm] pipe): pure chemical at 1,115 kg/m^3	MEG (2-inch pipe): 4,017 ppm
		MEG High 2in	MEG (2-inch [5.1-cm] pipe): pure chemical at 1,115 kg/m^3	MEG (2-inch pipe): 4,190 ppm
		MEG Low 6in	MEG (6-inch [15.2-cm] pipe): pure chemical at 1,115 kg/m^3	MEG (6-inch pipe): 18.52 ppm
		MEG High 6in	MEG (6-inch [15.2-cm] pipe): pure chemical at 1,115 kg/m^3	MEG (6-inch pipe): 18.34 ppm

[a] Except for the thermal discharge (temperature rise), no standards exist for the listed discharge constituents. The distance of 100 meters (328.1 feet) is used as a reference distance to report dilution, and should not be interpreted as a criterion for regulatory compliance.

4. CUMULATIVE IMPACTS: OFFSHORE DISCHARGES

The Yellowtail Project will initiate after the Liza Phase 1, Liza Phase 2, and Payara Projects, and activities for the four Projects will therefore overlap in time. Although the Yellowtail Project's FPSO will be approximately 30.8 kilometers (19.1 miles) away from the Liza Phase 1 Project FPSO, 22.5 kilometers (14 miles) away from the Liza Phase 2 Project FPSO, and 41 kilometers (25.5 miles) away from the Payara Project FPSO, modeling was conducted to assess whether there is a potential for cumulative impacts on water quality due to simultaneous offshore discharges from the respective developments. The CORMIX model is limited in its ability to appropriately include other local or regional discharges and the resulting plume interactions. To address this limitation, and to appropriately quantify cumulative impacts from these four FPSOs, a separate 3-D hydrodynamic and water quality model was applied. The GEMSS model is capable of simulating temporally and spatially varying conditions, and can incorporate any number of discharges into one single model simulation. This section describes the use, application, and results of the GEMSS model for the cumulative impact analysis.

4.1 GEMSS

GEMSS® is an integrated system of 3-D hydrodynamic and transport modules embedded in a geographic information and environmental data system. GEMSS is in the public domain and has been used by the U.S. Bureau of Reclamation, Washington State Department of Ecology, Norwegian Institute of Water Research, Royal Institute of Sweden, and other international organizations.

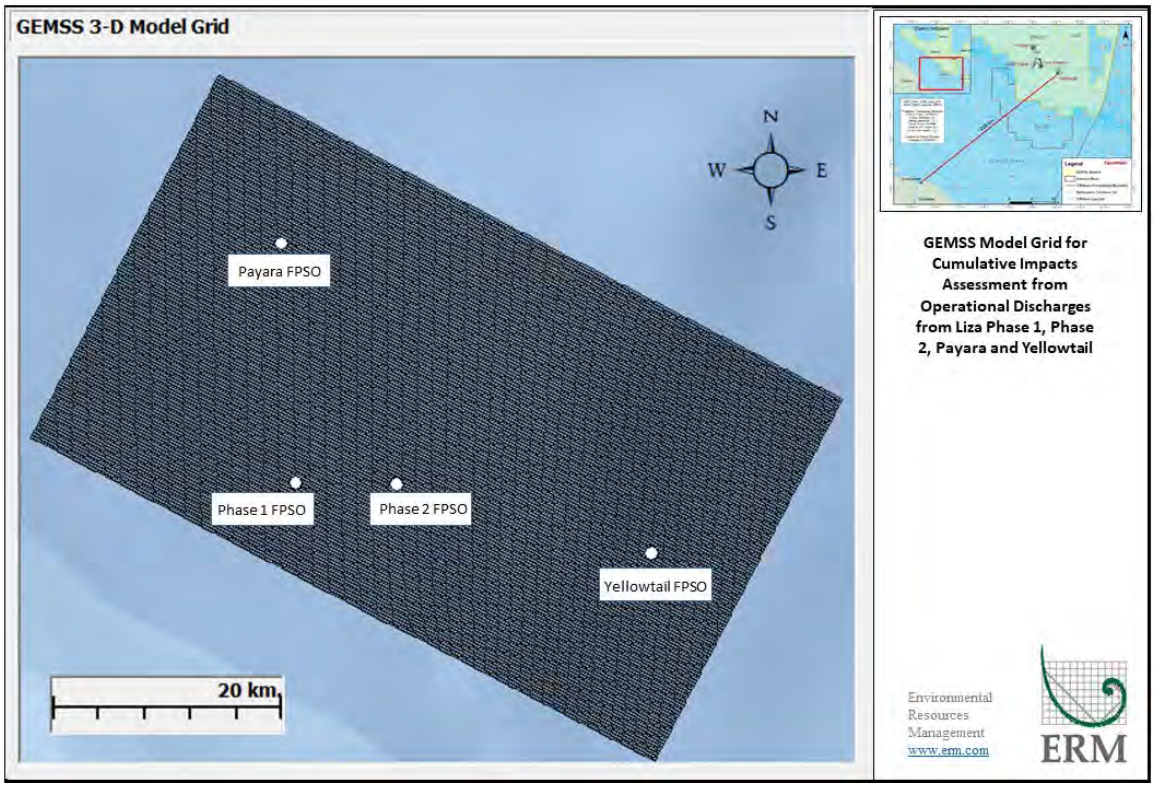
The theoretical basis of the hydrodynamic kernel of GEMSS is the 3-D Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport (GLLVHT) model, which was first presented in Edinger and Buchak (1980) and subsequently in Edinger and Buchak (1985). The GLLVHT computation has been peer reviewed and published (Edinger and Buchak 1995; Edinger et al. 1994 and 1997; Edinger and Kolluru 1999). The kernel is an extension of the well-known longitudinal-vertical transport model written by Buchak and Edinger (1984) that forms the hydrodynamic and transport basis of the United States Army Corps of Engineers' water quality model CE-QUAL-W2 (USACE 1986). Improvements to the transport model, construction of the constituent modules, incorporation of supporting software tools, GIS interoperability, visualization tools, graphical user interface, and post-processors have been developed by Kolluru et al. (1998; 1999; 2003) and Kolluru and Fichera (2003).

GEMSS and its component modules have met agency approval among federal and state governments within the United States. GEMSS has also been approved by regulatory agencies in the Bahamas, Qatar, India, Australia, Canada, and other countries.

4.2 Model Domain

A 3-D model such as GEMSS requires specification of a model domain that defines the boundaries of the region of interest. Based on the CORMIX modeling assessment, the region of interest around each of the FPSO discharges is very small due to the small sizes of the plumes. However, for the cumulative impact assessment, it is important to have a model domain that covers the region, including all operational discharges (i.e., all four FPSOs). The model domain, therefore, was selected as a region that would cover the four FPSOs and have sufficient region beyond these FPSOs to allow discharge plume spreading. The model domain, including the model computational grid and the locations of the FPSOs, is shown on Figure 4-1. The selected model domain is large enough to accommodate all operational discharges from the four FPSOs to assess cumulative impacts within a single model simulation.

Figure 4-1: Cumulative Impact Assessment Model Domain and Computational Grid



km = kilometer

4.3 Model Setup

As discussed in Section 3, there are several discharges from each FPSO. All of these discharges were included within a single GEMSS model simulation. Inclusion of all of these discharges for all four FPSOs affords the ability to perform a cumulative impact assessment by determining the overall extent of the discharge plumes within the modeled region. A key parameter in the assessment was the temperature rise above ambient, as there is thermal load associated with cooling water streams and produced water discharge from each of the FPSOs. There is potential for overlap of the thermal discharge plumes in the near-field for each FPSO, as the plumes from cooling water and produced water from a given FPSO may theoretically interact; further, the thermal plumes from separate FPSOs may also overlap. Although the individual assessments of the discharges performed in Section 3 show relatively small extents for these plumes, the lower values (<3ºC [5.4ºF] temperature rise) could theoretically combine to reach levels above 3ºC (5.4ºF) temperature rise. Both cooling water and produced water discharges were included in the model. Furthermore, the sulfate removal, ultrafiltration, and wash water processing brines discharges also were included in the model.

The model was configured such that the boundaries of the model computation grid received available time-varying temperature and salinity data from the HYCOM model and available time-varying water surface elevations from the SAT-OCEAN model. These data provide the necessary input for the GEMSS model to perform hydrodynamic and transport computations within the model computational domain. Each of the discharges was specified to the details available as shown in Table 4-1.

Table 4-1: List of Discharges and their Characteristics included in the GEMSS Model for Cumulative Impact Assessment

Offshore Discharge	Liza Phase 1 FPSO	Liza Phase 2 FPSO	Payara FPSO	Yellowtail FPSO
Cooling Water				
Flow, kBPD (m^3/d)	227 (36,320)	1,600 (256,000)	1,600 (256,000)	1,900 (304,000)
Temperature, ºC	50	50	50	50
Produced Water				
Flow, kBPD (m^3/d))	114 (18,240)	300 (48,000)	300 (48,000)	300 (48,000)
Temperature, ºC	55	55	55	55
Oil and Grease (mg/L)	42	42	42	42
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines				
Flow, kBPD (m^3/d)	100 (16,000)	265 (42,400)	265 (42,400)	315 (50,400)
Hypochlorite (ppm)	1	1	1	1

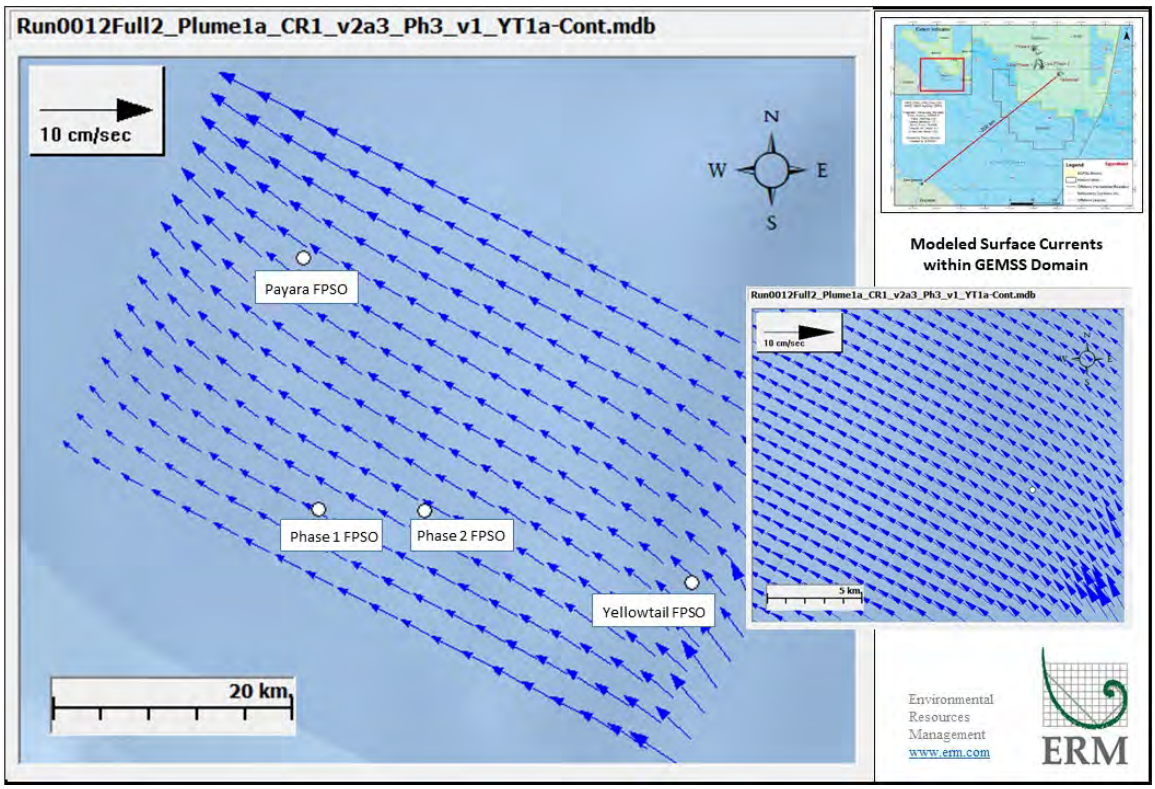
kBPD = thousand barrels per day

The model was run for a period of 28 days, which included a period of 7 days for model "spin-up." Model spin-up is defined as a time during which the computational model ramps up from stagnant condition to realistic conditions, as forced by the conditions specified at the boundaries. All model results were summarized statistically to obtain worst-case conditions (i.e., maximum concentrations during the entire model simulation period).

4.4 Model Results

The model, under conditions specified through the boundaries, provides results that consist of currents, water surface elevations, temperature, salinity, temperature rise above ambient, oil and grease concentration, hypochlorite concentration, and concentration of a dye constituent. A dye constituent was included in the model simulation so that concentrations of any constituents could be estimated by scaling the dye concentrations to the discharge values. The modeled currents were consistent with the known circulation pattern in the region (see Section 6.4.2.1, Oceanographic Conditions, of the Yellowtail EIA). The results show a strong Guiana Current toward the northwest (see Figure 4-2).

Figure 4-2: Snapshot of Modeled Hydrodynamics within the GEMSS Model Domain



km = kilometer
Note: The four white dots denote the locations of the four modeled FPSOs. The main image shows lower resolution and inset shows full resolution to demonstrate overall circulation patterns and strength.

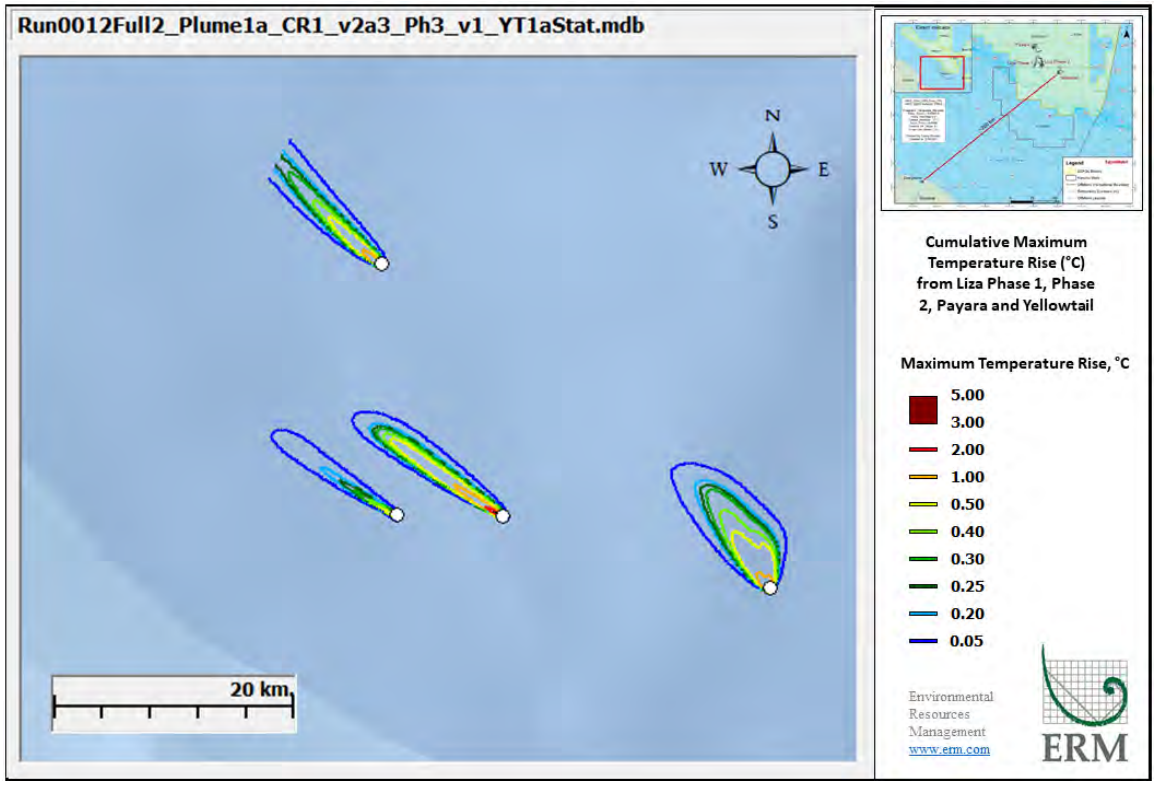
4.4.1 Temperature Rise

As noted earlier, a key parameter in the assessment is the temperature rise above ambient associated with the thermal plumes from the FPSOs. The reference guideline of no more than 3ºC (5.4ºF) temperature rise above ambient beyond 100 meters (328 feet) was used to evaluate if any region within the entire computational domain (outside of the 100-meter [328-foot] distance from each FPSO discharge) was predicted to experience a temperature rise above 3ºC (5.4ºF). To evaluate if such a condition exists, the statistical maxima of the temperature rises above ambient were computed during the entire model simulation period. Note that the map showing the statistical maxima (Figure 4-3) only shows the maximum values, but this does not mean these maximum values occurred at the same time. Different maximum values at different locations could have occurred at different times during the simulation period. However, they were evaluated within a single map (i.e., assuming they all occurred at the same time) to evaluate the potential of any region reaching the maximum temperature rise above ambient.

Figure 4-3 shows the maximum temperature rise above ambient across the model domain. The color scale uses a hybrid approach, where all temperature-rise iso-lines below 3ºC (5.4ºF) are unfilled, and all temperature-rise iso-lines above 3ºC (5.4ºF) are filled with a designated color. As shown on the map, there is no region in the modeling domain with a predicted temperature rise above 3ºC (5.4ºF). The blue iso-lines that extend between the FPSOs denote a 0.05ºC (0.09ºF) temperature rise. Individual snapshots (representing actual predicted conditions across the domain at a given time) show plumes much smaller than the statistical maxima; Figure 4-4 shows four such snapshots. Based on these results, it is clear that no thermal plume overlapping occurs and that all four FPSOs operating concurrently will result in

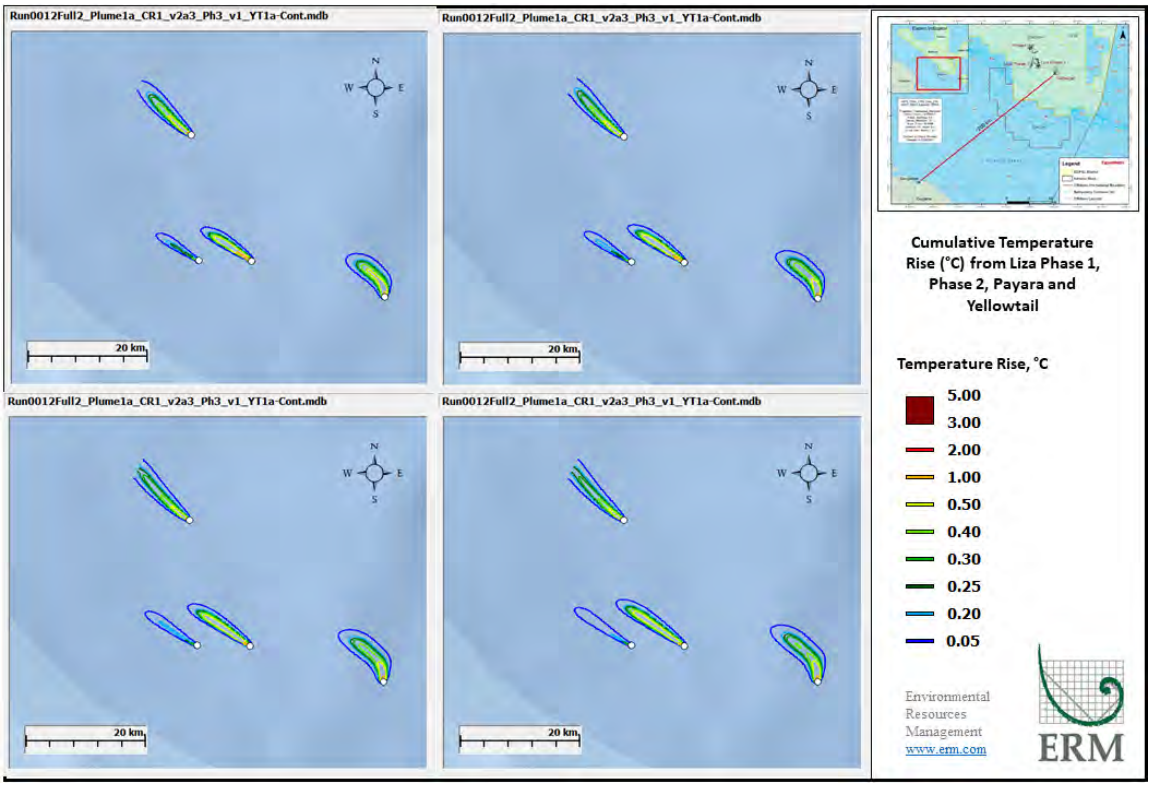
conditions that adhere to the <3ºC (<5.4ºF) temperature rise beyond 100 meters (328.1 feet) reference guideline.

Figure 4-3: Modeled Maximum Temperature Rise above Ambient when All Discharges (all Four FPSOs with Cooling Water and Produced Water) are Operational



km = kilometer

Figure 4-4: Example "Snapshots" of Modeled Time-Varying Temperature Rise above Ambient at Different Times (Every 6 Hours) during a Day

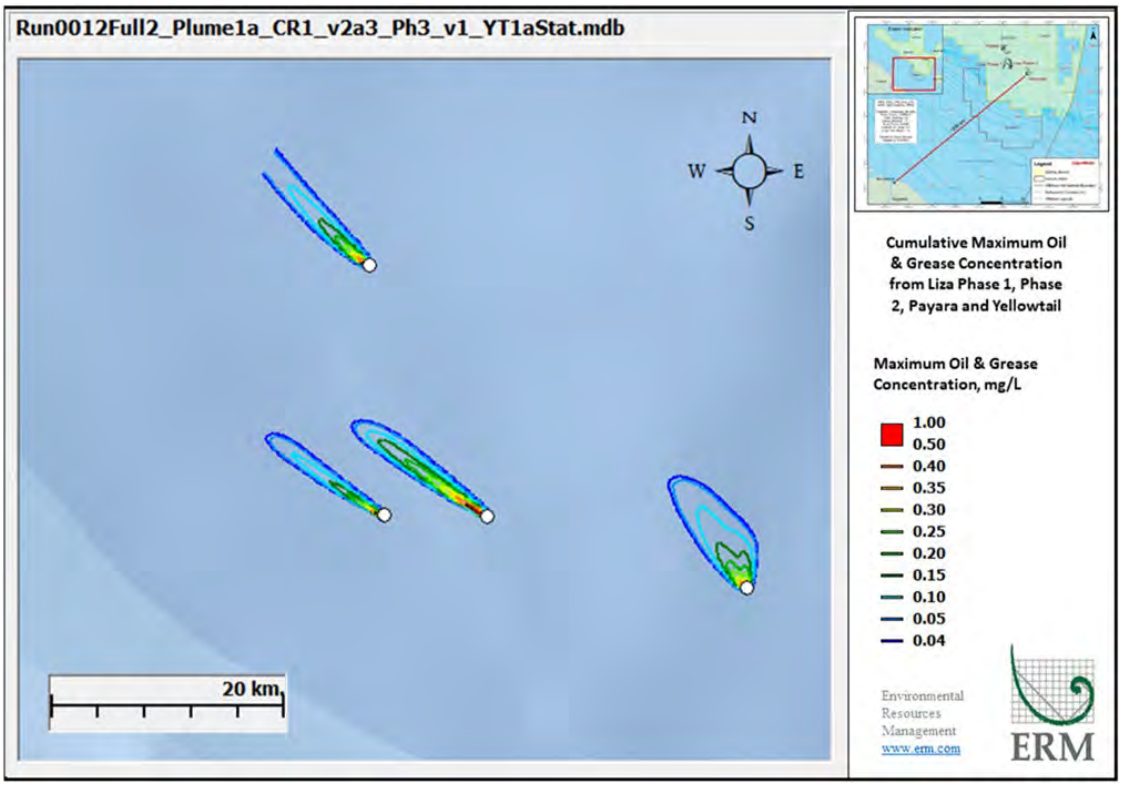


km = kilometer

4.4.2 Oil and Grease

Oil and grease is a constituent within the produced water that is limited to a daily maximum discharge value of 42 mg/L. Similar to the temperature rise above ambient, modeling of oil and grease concentrations shows that the produced water plumes experience rapid dilution and mixing, with no overlap between the discharges of the four FPSOs. Figure 4-5 shows the modeled maximum concentration of oil and grease in the model domain. The closest of the outermost iso-lines extending from each FPSO (0.04 mg/L) are more than 3 kilometers (1.9 miles) apart.

Figure 4-5: Modeled Maximum Oil and Grease Concentrations from Produced Water Streams of all Four FPSOs

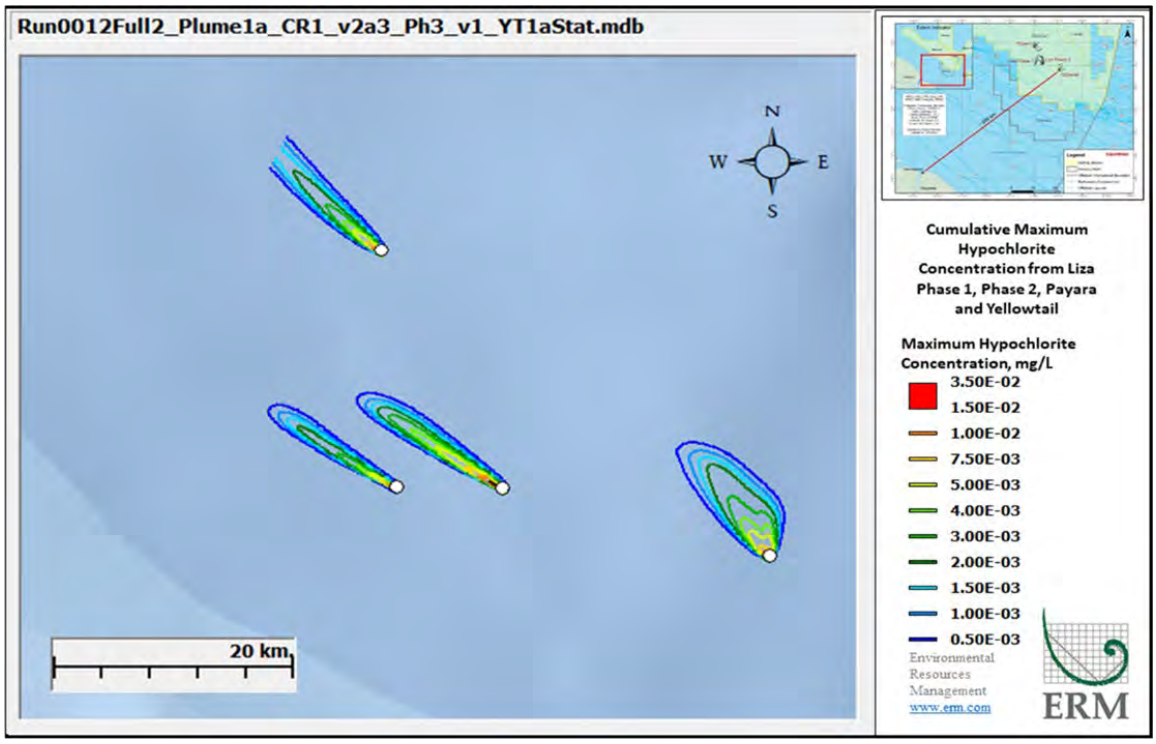


km = kilometer

4.4.3 Hypochlorite

Hypochlorite is a constituent included in both cooling water and sulfate removal, ultrafiltration, and wash water processing brines discharge. As noted earlier, there are no standards for hypochlorite in offshore waters. Similar to temperature rise and oil and grease, hypochlorite experiences rapid dilution and mixing once discharged. Figure 4-6 shows the maximum-modeled concentrations of hypochlorite during operation of the four FPSOs. The color scale is chosen to show the modeled plume and its potential to overlap. The color scale range is 0.0005 ppm to 0.035 ppm and even at these low values, there is no plume overlap.

Figure 4-6: Modeled Maximum Concentrations of Hypochlorite during Operation of all Four FPSOs

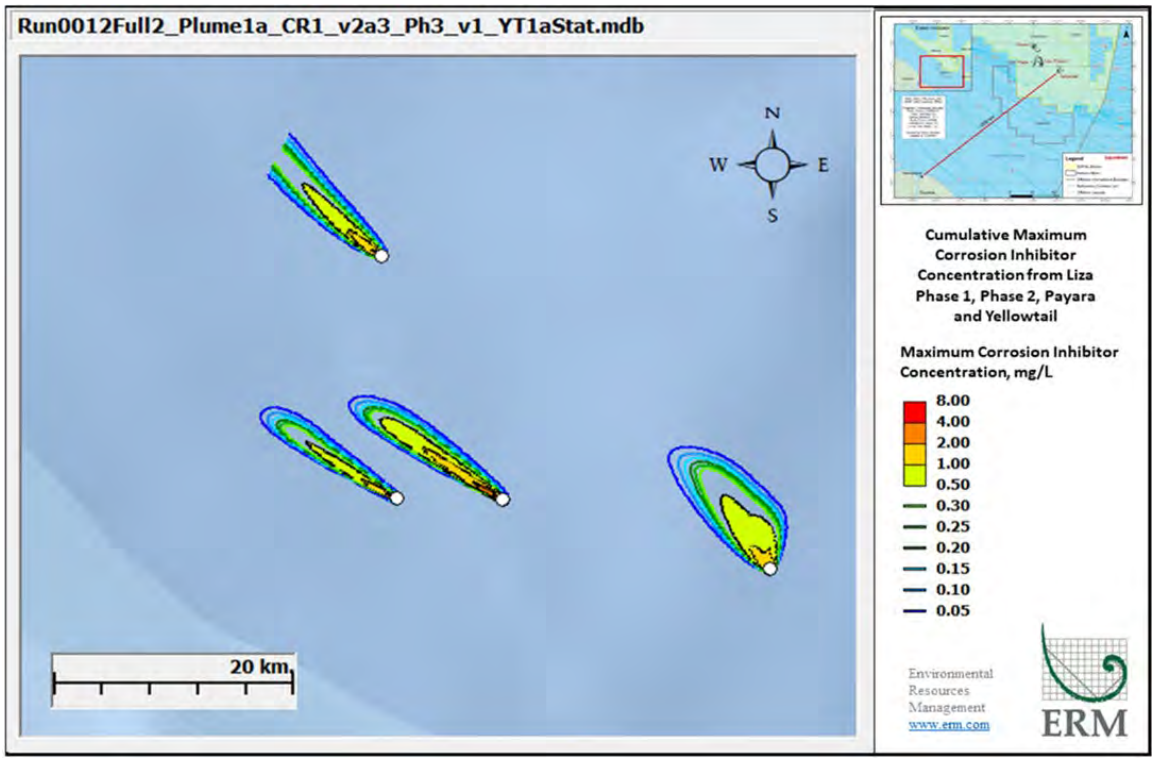


km = kilometer

4.4.4 Other Chemicals

In addition to temperature rise, oil and grease, and hypochlorite, the various discharge streams include other production chemicals such as corrosion inhibitor and scale inhibitor. These constituents experience similar rapid mixing and dilution as the other constituents described above. Modeling indicates the plumes do not overlap, even when mapping at extremely low concentrations. An example of modeled maximum concentrations for corrosion inhibitor is shown on Figure 4-7, where even iso-lines at 0.05 ppm show no overlap.

Figure 4-7: Modeled Maximum Concentrations of Corrosion Inhibitor

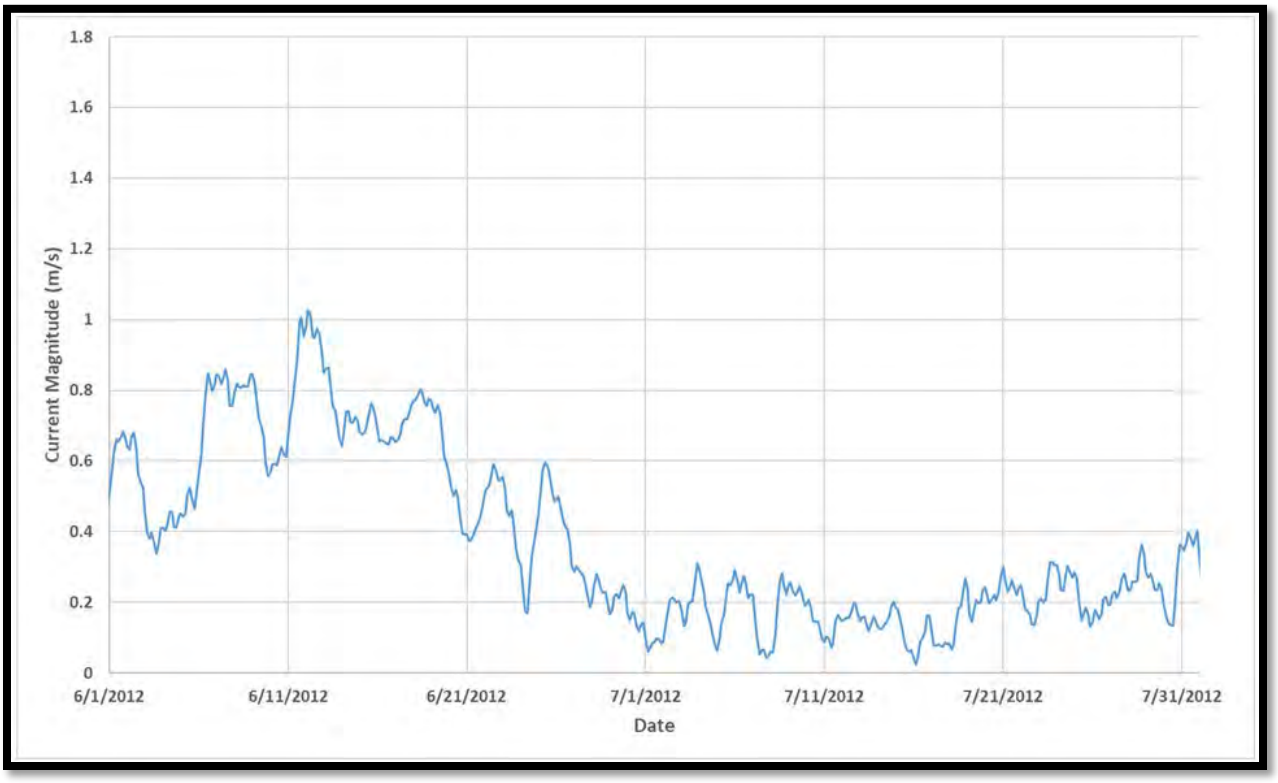


km = kilometer

4.5 Sensitivity Testing

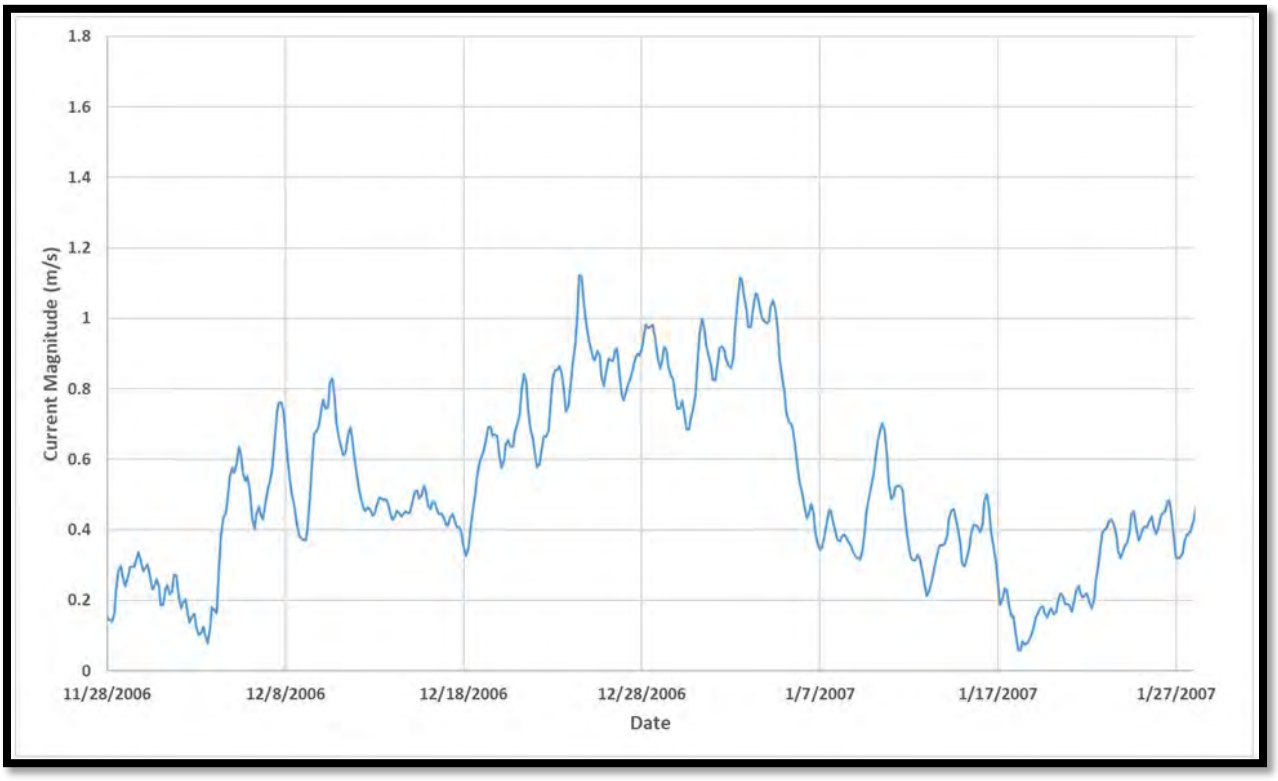
In addition to the conservative assessment under low currents described earlier, a high-current scenario was also simulated to assess the trajectory of the plumes under other conditions. Time series plots, shown on Figure 4-8 and Figure 4-9, were created to determine the current magnitude for each scenario. Figure 4-8 shows the period of low currents (for which results are described in Section 4.4, Model Results) and Figure 4-9 shows the period of high currents. A snapshot of the modeled hydrodynamics within the GEMSS model domain for the high-current scenario is shown on Figure 4-10. Figure 4-11 shows the maximum temperature rise above ambient across the model domain. These plumes are significantly smaller than the plumes discussed above for the conservative low-current scenario. Note that similar to the results presented in Section 4.4, these plumes are statistical maxima. Individual snapshots (representing actual predicted conditions across the domain at a given time) show plumes much smaller than these statistical maxima; Figure 4-12 shows an example of four such snapshots. Figure 4-13 shows the modeled maximum concentrations of oil and grease in the model domain from produced water discharges. Figure 4-14 shows the maximum-modeled concentrations of hypochlorite during operation of the four FPSOs. Lastly, an example of modeled maximum concentrations for corrosion inhibitor is shown on Figure 4-15. In summary, the plumes under high currents are significantly smaller than the low current conditions for which results are presented in Section 4.4.

Figure 4-8: Time Series Plot of Current Magnitude—Low Currents Period



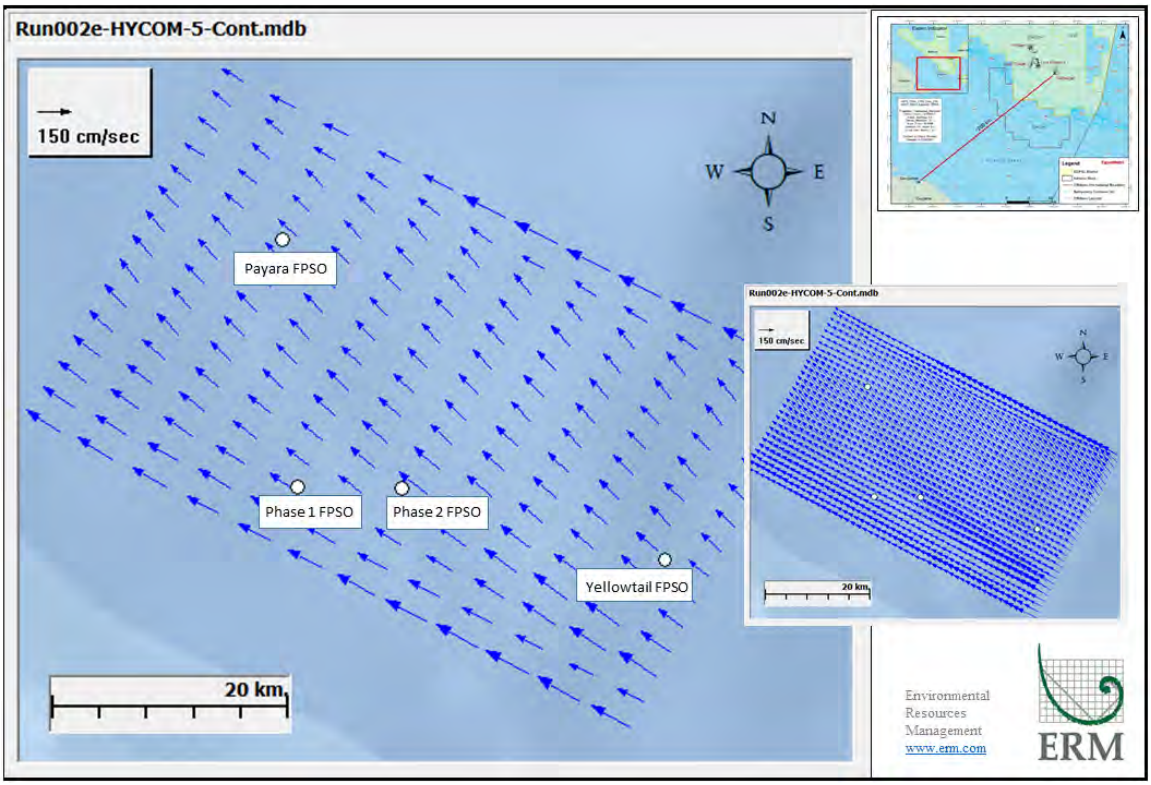
m/s = meter per second

Figure 4-9: Time Series Plot of Current Magnitude—High Currents Period



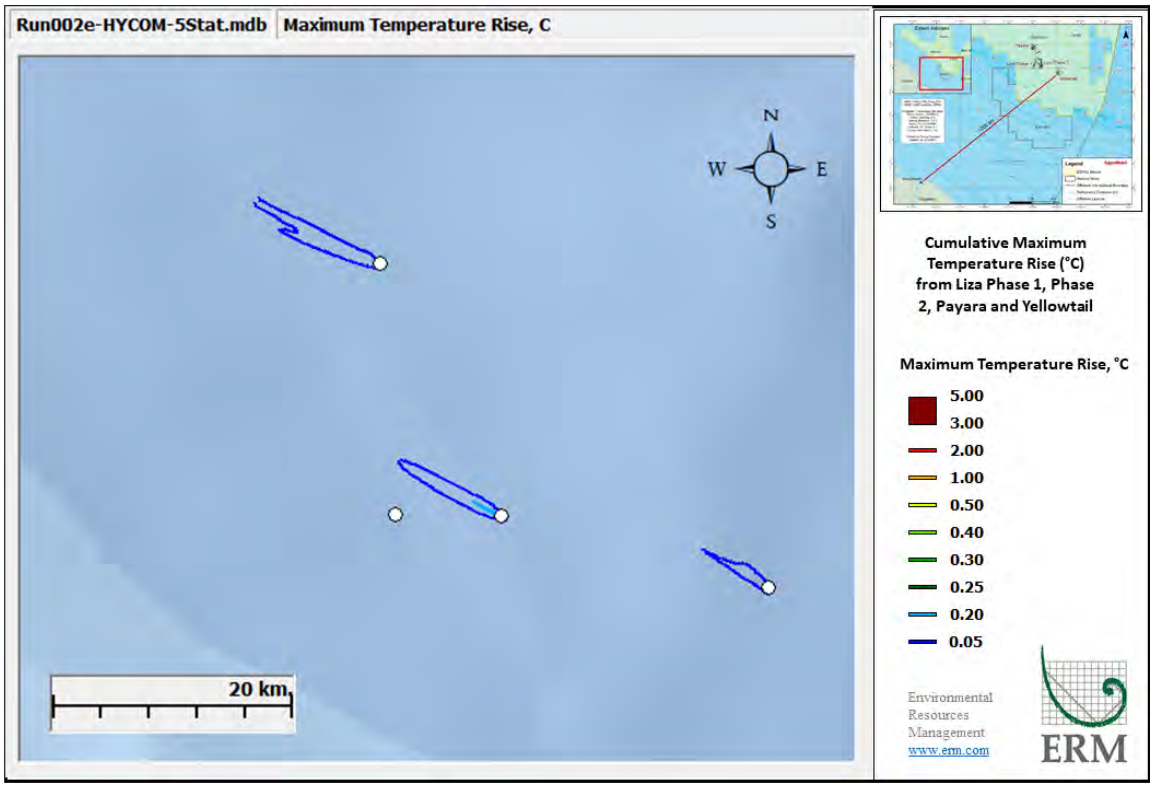
m/s = meter per second

Figure 4-10: Example "Snapshot" of Modeled Hydrodynamics within the GEMSS Model Domain during High Currents



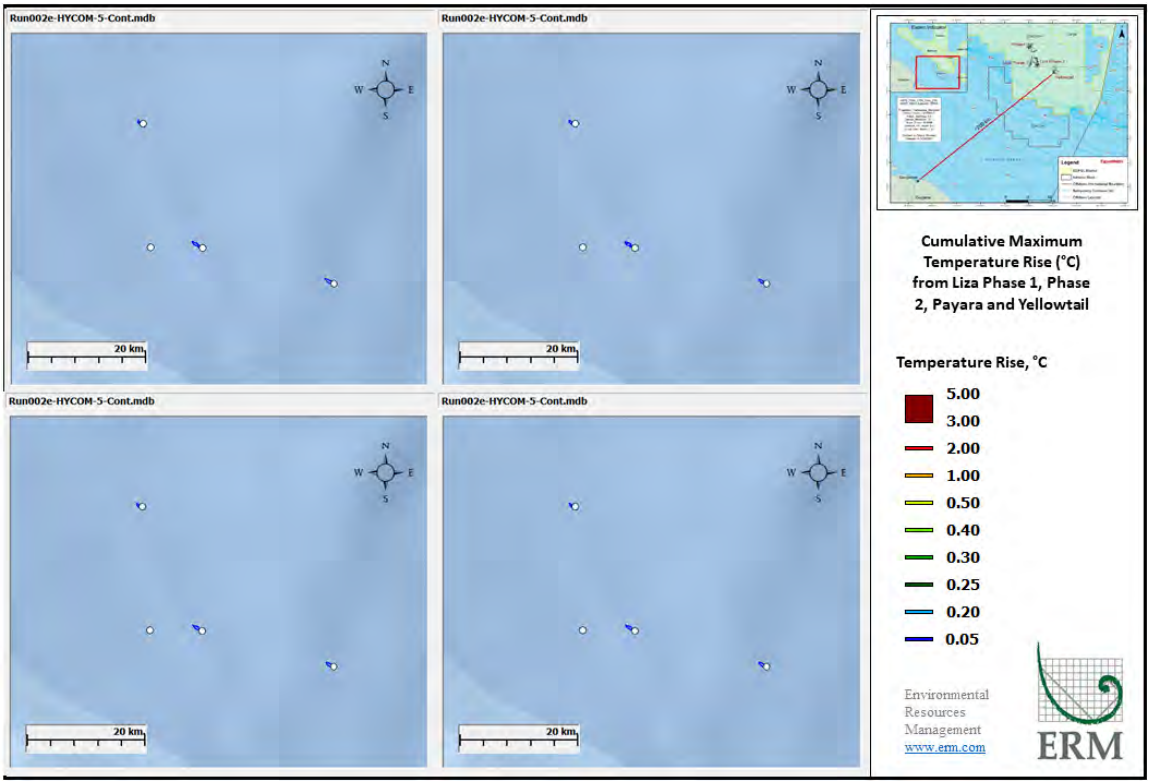
cm/sec = centimeter per second; km = kilometer
Note: The four white dots denote the locations of the four FPSOs. The main image shows lower resolution and the inset shows full resolution to demonstrate overall circulation patterns and strength.

Figure 4-11: Modeled Maximum Temperature Rise above Ambient when all Discharges (Four FPSOs with Cooling Water and Produced Water) are Operational—High Current Scenario



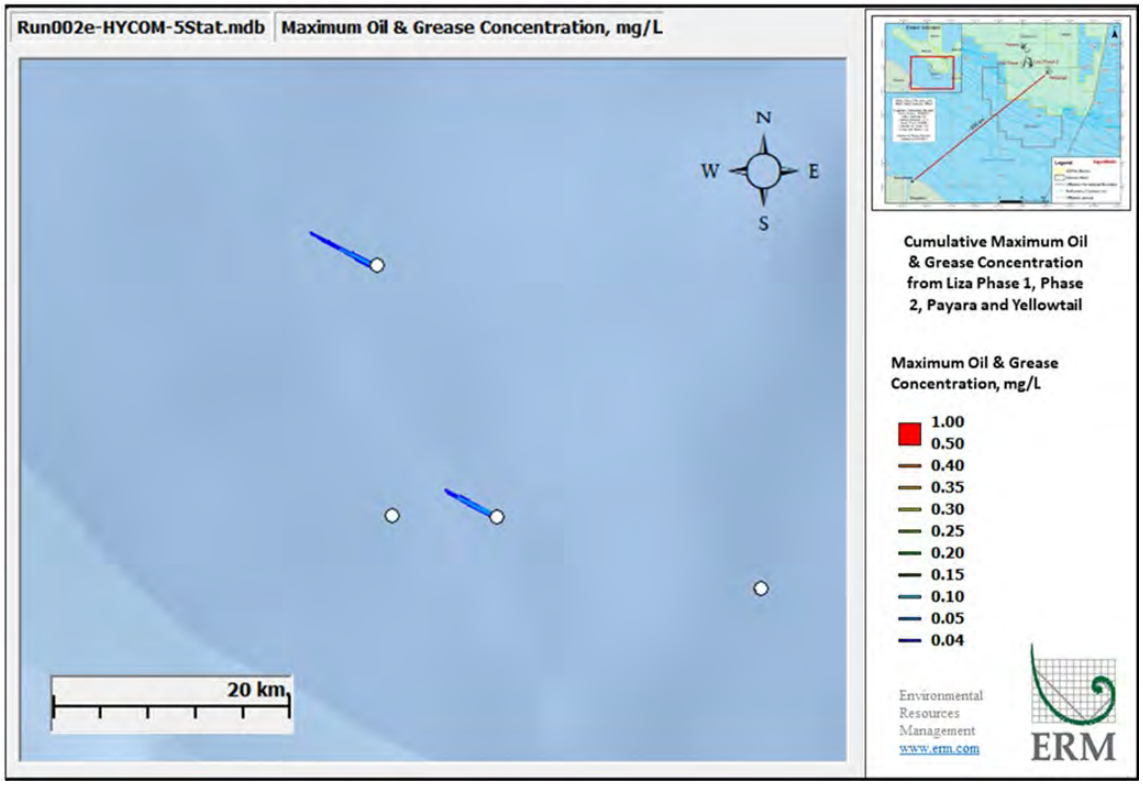
km = kilometer

Figure 4-12: Example "Snapshots" of Modeled Time-Varying Temperature Rise above Ambient at Different Times (Every 6 Hours) during a Day—High Current Scenario



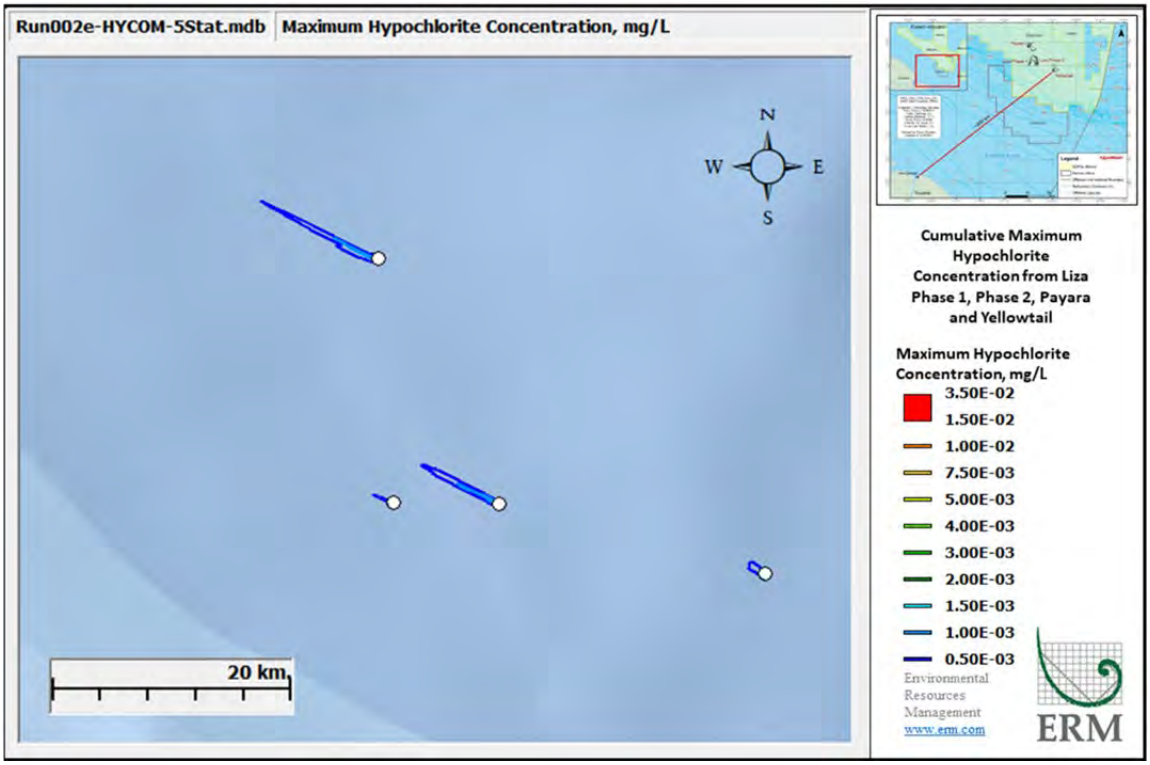
km = kilometer

Figure 4-13: Modeled Maximum Oil and Grease Concentrations from Produced Water Discharges from all four FPSOs—High Current Scenario



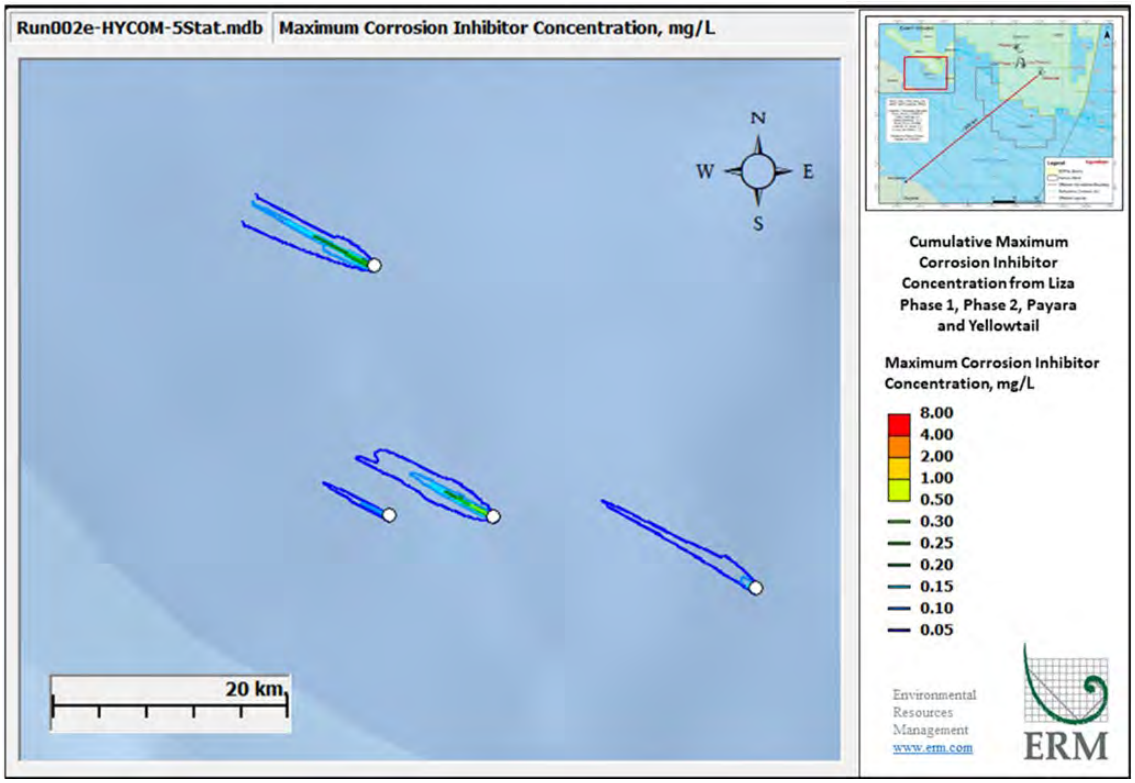
km = kilometer

Figure 4-14: Modeled Maximum Concentrations of Hypochlorite during Operation of all Four FPSOs—High Current Scenario



km = kilometer

Figure 4-15: Modeled Maximum Concentrations of Corrosion Inhibitor during Operation of all Four FPSOs—High Current Scenario



km = kilometer

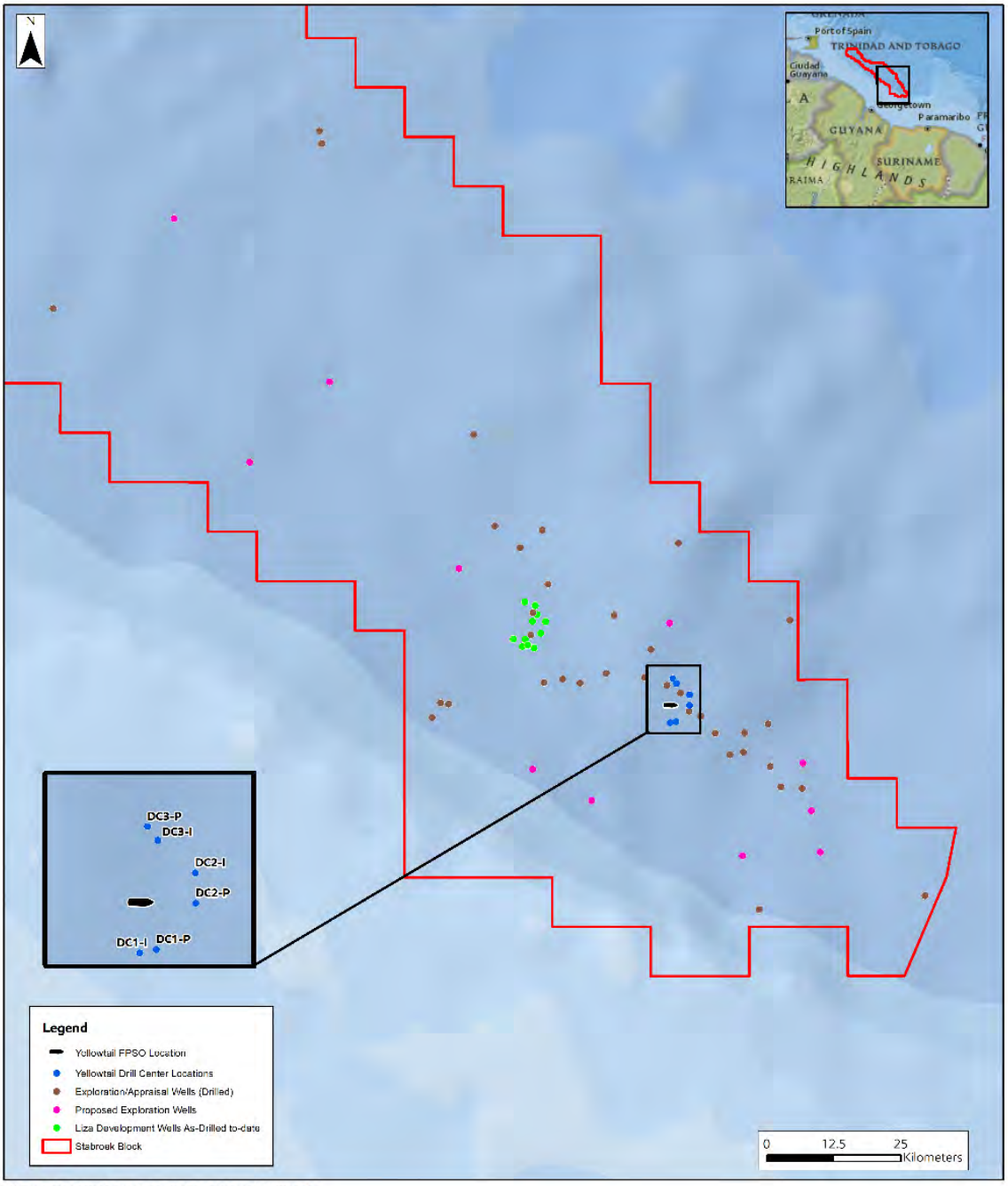
5. CUMULATIVE IMPACTS: DRILLING OPERATIONS

Similar to the operational discharges during production operations, drilling operations for the Yellowtail Project may occur simultaneously with drilling for other EEPGL development projects as well as EEPGL exploration drilling in the Stabroek Block. Although the footprint of drill cuttings deposition from drilling operations and the extents of associated TSS plumes are very limited, and are confined to within a close proximity of the respective drilling locations, an assessment was performed to evaluate the potential for cumulative impacts (overlap) from simultaneous drilling activities.

Figure 5-1 shows the locations of previously drilled EEPGL exploration/appraisal wells in the Stabroek Block, as well as proxy locations for future exploration wells in the Stabroek Block (selected for the purpose of this assessment based on exploration prospect areas identified in the previously approved Environmental Assessment & Management Plan for the Stabroek Block 25-well Exploration Campaign). Figure 5-1 also shows the previously drilled development well locations for the Liza Phase 1 and Liza Phase 2 Projects (the nearest development wells to the Yellowtail Project drill centers). As shown on Figure 5-2, the smallest distance between an exploration/appraisal well and a Yellowtail drill center is 1.07 kilometers (0.67 mile). Results of the drill cuttings modeling (see Section 2) shows that this distance of 1.07 kilometers (0.67 mile) exceeds the distance the cuttings deposition footprint or TSS plume would extend from a well. Similarly, the closest Liza Phase 1 or Liza Phase 2 development well to a Yellowtail drill center is a Liza Phase 2 well (LIZ-4P14), which is approximately 26 kilometers (16.2 miles) away from the nearest Yellowtail drill center. This distance also is significantly larger than the distance a drill cuttings deposition footprint or TSS plume extends from a well.

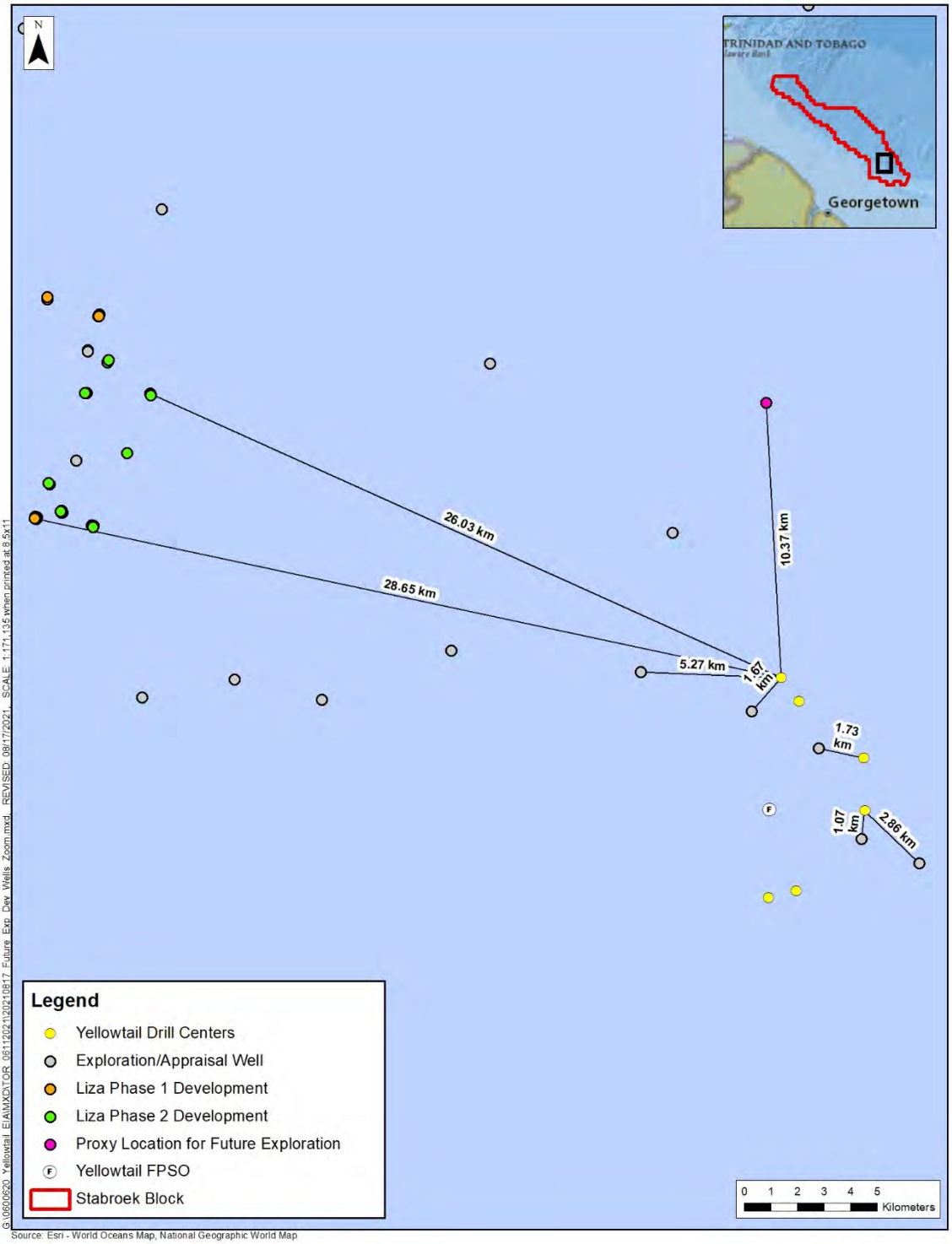
Furthermore, temporal aspects should also be considered in evaluation of the cumulative impacts. The threshold of sedimentation is 5 centimeters (2 inches) of deposition over a period of 30 days. For a combined deposition to result in cumulative impacts—even if the wells were close enough together to have overlapping deposition—another drilling operation would have to occur during the same 30-day period as a Yellowtail development well drilling operation. It is not likely that two such wells in such close proximity would be drilled within the same 30-day period. Similarly, the TSS plumes from drilling are highly ephemeral and will disperse rapidly under the ambient currents, resulting in a very low potential for any overlap with a TSS plume from another nearby drilling operation.

Figure 5-1: Locations of Drilled and "Proxy" Future Exploration Wells and Other Liza Phase 1 and Liza Phase 2 Development Wells Compared to Yellowtail Drill Centers



Source: Esri - World Oceans Map, National Geographic World Map

Figure 5-2: Distances from Yellowtail Drill Center Locations to Nearby Drilled or "Proxy" Future Exploration Wells and Liza Phase 1 and Liza Phase 2 Development Wells



km = kilometer

6. CONCLUSIONS

Spatially and time-varying modeling of potential cumulative impacts due to operations-stage discharges from four FPSOs was performed using the GEMSS model. The modeling included the major operational discharges assessed for the Yellowtail Project and assessed the potential for the Yellowtail discharge plumes and the plume from the same discharges for the other three modeled FPSOs to overlap and result in cumulative impacts. As shown on Figure 4-3 through Figure 4-7 and in Table 3-4, none of the modeled plumes showed potential for overlap—even when mapping to relatively small outer limits on the plumes. Modeling of all four FPSOs operating, with each FPSO discharging both produced water and cooling water (both of which add a thermal load), predicted no overlap in plumes. In the case of temperature rise, the outer edge of the mapped plumes from each FPSO was defined as a temperature rise of 0.05ºC (0.09ºF) (see Figure 4-3 and Figure 4-4). Modeling demonstrates that even at this level, there is no expected overlap of thermal plumes during simultaneous FPSO operations.

The potential for overlapping of drill cuttings deposition footprints and associated TSS plumes from Yellowtail drilling operations and other EEPGL drilling operations was also assessed. Based on consideration of the closest distance anticipated between two drilling locations, there is no potential for overlap in either drill cuttings deposition footprints or drilling-related TSS plumes (even under the very unlikely scenario were nearby drilling operations were conducted simultaneously).

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APPENDIX D

Participatory Fishing Study Final Report January 2019–March 2020

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Esso Exploration and Production Guyana Limited

Participatory Fishing Study Final Report

January 2019–March 2020

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The business of sustainability

Signature Page

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Participatory Fishing Study Final Report

January 2019 – March 2020

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Acronyms and Abbreviations

Name	Description
COVID-19	Coronavirus-2019
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental Impact Assessment
EMC	Environmental Management Consultants
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
GIS	geographic information system
GPS	Global Positioning System
GYD	Guyanese dollar
IUCN	International Union for Conservation of Nature
PFS	Participatory Fishing Study
QA/QC	quality assurance/quality control
RFCS	Rosignol Fishermen's Cooperative Society
USD	United States dollar
USDA	United States Department of Agriculture

1. INTRODUCTION

In 2016, ExxonMobil's affiliate, Esso Exploration and Production Guyana Limited (EEPGL), applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorisation for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On 1 June 2017, the Guyana EPA approved the Environmental Impact Assessment (EIA) submitted as part of the Application for Environmental Authorisation and issued an Environmental Permit for the Liza Phase 1 Development Project. As a condition of the Environmental Permit, the EPA required EEPGL to "conduct fishery-dependent studies in the nearshore zone augmented by fishery-independent studies in the nearshore and offshore zones...to develop a more complete understanding of the marine fish community outside the Liza Area of Interest." These studies were mandated to cover at least one wet and one dry season. EEPGL complied with this requirement by conducting a year-long fish study, the first year of which was completed in 2018 (ERM 2018a; ERM 2019). To supplement the fishery-dependent information collected during the first year of study, EEPGL implemented a program focused primarily on engagement with the artisanal fishing community, to serve as another approach to collecting baseline fisheries data.

EEPGL contracted with Environmental Resources Management (ERM), which partnered with the local Guyanese firm Environmental Management Consultants (EMC), to collaboratively execute a Participatory Fishing Study (herein referred to as the "study") to characterize the nektonic community (with a focus on fisheries) and map the principal local fisheries activities offshore Guyana. As part of the study, ERM and EMC engaged with local fisherfolk who agreed to participate on a volunteer basis (with a small stipend offered to cover any expenses) and provide data on their catch. The study had two primary components:

1. **The Coastal Landing Site Assessment** focused on data and photos of overall daily catch and catch characteristics (number of species, sizes, weights, etc.) at various coastal landing sites. Six regional supervisors from different landing sites in all six of the coastal regions participated in the study. The regional supervisors had experience in the area and knowledge of native species.
2. **The Local Artisanal Fishing Activities Assessment** focused on data, Global Positioning System (GPS) information, and photos of individual artisanal fishing activities, including daily catch, catch characteristics (number of species, sizes, weights, etc.), and routes to preferred fishing zones. Twelve onboard supervisors from two separate landing sites in each of the six coastal regions participated in the study.

Data collection efforts and subsequent analysis and assessment continued over the life of the study, covering the period from January 2019 through March 2020. These engagement efforts were the responsibility of EMC's biodiversity and fisheries project manager and a socioeconomics consultant (referred to herein as the study team). ERM provided international expertise on the methodology and data collected and analysis, including marine biology, socioeconomics, and imagery. This final report on the study provides the following:

- An introduction to the approach, methodology, and topics covered in the study;
- A characterization of the different types of fishing gear and vessels commonly used by artisanal fisherfolk in Guyana;
- A comprehensive analysis of data collected from the supervisors throughout the study;
- A comparative analysis of data collected from supervisors to identify key trends based on different fishing practices and seasonal variations;
- Graphic representation of preferred fishing grounds by onboard supervisors based on geographic information system (GIS) data collected while fishing; and
- Provision of species list along with photos for ease of fish identification (see Appendix A).

2. APPROACH AND METHODOLOGY

2.1 Selection of Landing Sites

From January 2019 to April 2019, the study team conducted initial field visits to landing sites along the coast from Regions 1 to 6. The primary purpose of these initial field exercises was to validate the selection of landing sites to be included in the study, but also to initiate engagement with fisherfolk to volunteer as potential regional and onboard supervisors. The team also took advantage of this early time at the landing sites with fisherfolk to collect landing site-specific baseline data (discussed in Section 2.3).

A total of 16 unique landing sites in Regions 1 to 6 were selected, as presented in Table 2-1. Figure 2-1 provides a map of the landing sites.

Landing sites were selected in each of the regions based on a combination of factors. The landing sites were selected to provide a representative spread of artisanal fishing activities based on the types of vessels and fishing gear used, target species, the duration of fishing trips, and the number of fisherfolk using the landing site. The selection process was guided by the knowledge and experience of the study team as well as the findings of an Ecosystem Services Study conducted as part of the Liza Phase 1 post-permit studies (ERM/EMC 2018). The selection of the landing sites was finalized based on the findings of the study's baseline data collection exercise.

Table 2-1: Landing Sites Selected in Regions 1 to 6

Landing Sites Selected for Regional Supervisors	Landing Sites Selected for Onboard Supervisors
Region 1—Smith's Creek/Morahwanna[1]	Region 1—Smith's Creek;[a] Waramuri/Haimokabra
Region 2—Charity	Region 2—Lima; Hampton Court
Region 3—Zeeburg	Region 3—La Grange; Windsor Forest
Region 4—Riverview (Unity, Mahaica)	Region 4—Riverview (Unity, Mahaica); Ogle
Region 5—Mahaicony Bridge	Region 5—Rosignol; Bushlot
Region 6—Rose Hall	Region 6—Complex 66; Albion

[a] The regional supervisor in Region 1 collected data from both Smith's Creek and Morahwanna. The onboard supervisor operating from Smith's Creek only operated from Smith's Creek; no onboard supervisor was located in Morahwanna.

2.2 Selection of Regional and Onboard Supervisors

During the initial field visits, two sets of supervisors were selected for the two different components. Regional supervisors were selected for the Coastal Landing Sites Assessment and Onboard Supervisors were selected for the Local Artisanal Fishing Activities Assessment. The methodologies used to select the supervisors are provided below and the questionnaires used for these selection processes are provided in Appendices B and C.

2.2.1 Regional Supervisors

The study team interviewed fisherfolk at each of the selected landing sites to determine interest level and relevant experience for participating in the study. Key criteria for the selection of a regional supervisor included, but was not limited to the following: specific experience in the area; leadership status and relationship with the relevant fishing cooperatives (co-ops) or organization(s) and individual fisherfolk operating at the site; and knowledge of native species. Individuals selected as regional supervisors were

nominated by the members of the fishing co-op (if there was one at the landing site) or by the fishing community in general—at landing sites without a co-op. The questionnaire was administered to the nominated individual to assess their level of experience and knowledge against a set of criteria. Once the nominee had satisfactorily satisfied the requirements outlined in the questionnaire, he/she was selected as a regional supervisor. If the nominee at a landing site did not satisfy the requirements, there was further engagement with the fisherfolk or co-ops to identify another suitable candidate.

The study team selected six voluntary regional supervisors at six different landing sites—one in each of the six coastal regions. Each regional supervisor was provided with a digital camera and a data sheet for which they would be given a monthly stipend to document daily catch of all fishing activity at their landing site. The program allowed for the provision of up to 20 daily catch records per month. The regional supervisor's role was to initially collect the registered fishing effort and associated data (gear type, bycatch, etc.) at their landing site, along with the catch characteristics (number of species, sizes, weights, etc.). Daily information from the landing site was then collected and entered into the provided data sheets (see Appendix D).

The study team also conducted several quality assurance and quality control (QA/QC) exercises to assess whether the regional supervisors were following the required methods for collecting data at their landing site. Over the course of the study, two QA/QC exercises were conducted (discussed in Section 2.6). If a regional supervisor did not satisfactorily or accurately collect data for their landing site (as determined through the QA/QC process) or opted to withdraw as a volunteer, a new regional supervisor was selected guided by the process and criteria outlined above. During the first round of QA/QC exercises, one regional supervisor was found to have falsified data sheets and was subsequently replaced.

2.2.2 Onboard Supervisors

The study team selected at least two boats/fisherfolk from two different landing sites in each of the six coastal regions. Each supervisor was provided with a GPS, a digital camera, and a simple one-page data sheet and given a monthly stipend to document their own daily catches—providing up to 20 data sheets per month. Like the regional supervisors, fishing co-ops were engaged, where they existed, to aid in the selection of the boats/fisherfolk at each landing site. At other sites, individual fisherfolk or the fishing community at large were engaged in the selection process. The selection process ensured there was a balanced representation of the offshore artisanal fishery sector, including a variety of vessel types based on fishing gear used, species targeted, and preferred fishing grounds. Once the vessels types were selected, onboard supervisors were assessed using the same questionnaire as for the selection of regional supervisors to test their knowledge of fishing. If the potential supervisor did not satisfy the requirements, there was further engagement with the fisherfolk or co-ops to identify another candidate.

During the QA/QC exercises (discussed in Section 2.6), random assessments of fisherfolk vessels occurred. In the event that an onboard supervisor did not satisfactorily or accurately collect data for their vessel (as determined through the QA/QC process) or opted to withdraw as a volunteer, a new onboard supervisor was selected guided by the process and criteria outlined above. Due to challenges encountered by the onboard supervisor at the Smith's Creek landing site (Region 1) (described further in Appendix F), an additional supervisor was selected mid-way through the program to augment data collection and improve the data pool in that region.

2.3 Baseline Data Collection

During the selection of landing sites and the training of regional and onboard supervisors, the study team also took advantage of time at the landing sites from January to April 2019 to collect baseline data. The baseline data collection consisted of a landing site assessment during which fisherfolk were interviewed

to determine number of vessels operating at the landing site, target species, typical catch composition, frequency of fishing trips, fisherfolk-preferred fishing ground, and where hauls are typically sold. At landing sites that had been shortlisted for inclusion in the study, the study team also solicited recommendations from fisherfolk on potential regional and onboard supervisors for the respective landing sites.

The baseline data collection efforts occurred during the off-peak season for fishing activities along the coastline (see Appendix E for data collection periods). As a result, at some of the larger landing sites, only a small number of fisherfolk who normally use the site were present to participate in the baseline data collection survey. Nonetheless, the baseline data collection was important to the overall knowledge of fisheries activities at the landing sites included in the study and the data collecting during that effort were updated as the study progressed. The initial baseline data collection and updated findings are included in the characterization of the landing sites presented in Appendices F through U and summarized in Sections 4.8 and 4.9.

2.4 Continuous Data Collection and Engagement with Supervisors

During the months from April 2019 through February 2020, the study team conducted regular visits to the landing sites in Regions 1 to 6. The objectives of these visits were to:

- Review completed data sheets from the regional and onboard supervisors;
- Meet with the supervisors to discuss data collected, trends, challenges, health and safety, and other information pertinent to the study;
- Engage with supervisors on lessons learned and areas of improvement;
- Collect photographs taken by regional and onboard supervisors;
- Collect GPS tracks and fishing waypoints from onboard supervisors;
- Replenish supplies, including new data sheets and batteries for cameras and GPS units;
- Check the status of equipment provided to the supervisors and replace any equipment found to be defective; and
- Provide volunteer stipends to supervisors based on the number of data sheets completed.

Two sets of data were collected from the supervisors (refer to Appendix D for a copy of the relevant data sheets):

1. The regional supervisors provided data that had been collected from vessels after landing at each of the six participating landing sites. For each landed vessel, data included fishing ground locations, total catch (including species and quantities), prices per species caught, and number of days spent at sea. Regional supervisors also collected biometric data (weights and lengths only[1]) of representative fish per landed species. The regional supervisors took photographs of fishes for which biometric data were recorded.
2. The onboard supervisors provided data that had been collected on their own vessels. These data included total catch per soaking (including species and quantities), GPS tracks showing the routes taken to fishing grounds, and GPS waypoints for the locations where fishing occurred. Onboard supervisors also measured and weighed the average-sized fish of each species caught per soaking and took photographs of their activities.

[1] No intrusive biometric sampling was performed as part of the study.

During the first of the continuous field visits starting in April 2019, the study team provided additional up-front training for the supervisors to reduce potential errors in the data collected. After the initial data collection field visits, and throughout the following year, supervisors in Regions 2 to 6 were visited either once or twice a month. Moreover, efforts were made to conduct visits to Region 1 at least once every month depending on the availability of the fisherfolk. However, visits to Region 1 were challenging to schedule and were ultimately based on the mutual availability of the study team and the supervisors. The study team was also in contact with all supervisors via telephone from all regions on a weekly basis to follow-up on their progress and to address any challenges encountered.

It should be noted that not all supervisors commenced data collection at the same time due to the selection and training process for supervisors being conducted sequentially over a period of 1 month at each of the landing sites. Moreover, timing and operational constraints led to smaller data pools collected by the onboard supervisors at the Rosignol (Region 5) and the Albion (Region 6) landing sites in the beginning months of the data collection efforts. Region 1 had the smallest data pools because the training and selection process was completed last in Region 1 due to the need to have tailored engagements with the village councils and Toshaos (Indigenous leaders), as well as the availability of the fisherfolk. Fuel shortages at Smith's Creek in Region 1 also curtailed fishing activities by the onboard supervisors and limited the data collected by the regional supervisor. For Waramuri in Region 1, the most recent data sets collected from the onboard supervisor were in November 2019. Efforts to collect data subsequently were curtailed due to the supervisor being at sea, and the closing of the community to outsiders due to the COVID-19 pandemic. A detailed schedule of the data collection periods analyzed in this report is presented in Appendix E.

2.5 Analysis and Reporting

Data that were collected biweekly and monthly were analyzed quarterly, beginning with the baseline data collection effort and continuing through February 2020. A summary of the key findings can be found in Section 4, while detailed findings by landing site, including data collected, trends, findings, and QA/QC results, can be found in Appendices F through U, with each appendix corresponding with a landing site.

It should be noted that the study team was unable to uplift the data sheets for the last 1 to 2 months in the final quarter of the study due to curtailment of all field work in February and March 2020 as a result of security and safety concerns pertaining to the General and Regional Elections and the COVID-19 pandemic. Accordingly, for most landing sites, the data pool for this study ends in February 2020. As of early May 2020, most of the study supervisors reported that they had collected data through March 2020 and that information will be presented to the study team if conditions allow. These supervisors also indicated that fishing activities had been continuing in spite of COVID-19 concerns; however, some supervisors stated that they had reduced their number of fishing trips, with only one onboard supervisor stopping his fishing activity altogether.

2.6 Quality Analysis/Quality Control

QA/QC exercises were conducted during the months of September–October 2019 and January–February 2020. The QA/QC exercises had the overall objective of identifying potential data deviations and standardizing data collection methods by the regional and onboard supervisors. Activities conducted as part of the QA/QC exercise included:

- Updating the landing site assessment, which was conducted as part of the initial baseline data collection effort to obtain information on fishing dynamics and significant events that are experienced at the sites. The landing site assessment was conducted based on interviews with fisherfolk who were present at the landing site when the study team visited.

- Conducting landing site assessments in parallel with the regional supervisors, including basic biometric measurements of landed fishes.
- Installing high-resolution (GoPro) cameras to vessels operated by selected onboard supervisors to conduct quality monitoring on how fishing activities are conducted. This aspect of the QA/QC exercise could only be conducted on vessels that spent less than 12 hours at sea due to constraints on camera battery life and memory storage.
- Taking biometric measurements of representative fishes caught by the onboard supervisors.

These exercises also included the video recording of fishing activities conducted on five onboard supervisors' boats at Region 3 (Windsor Forest and La Grange), Region 4 (Ogle), Region 5 (Bushlot), and Region 6 (Albion). The videos provided the study team with insight into specific fishing activities and provided a source for verifying the data collected.

The schedule of the QA/QC exercises is presented in Table E-2 in Appendix E.

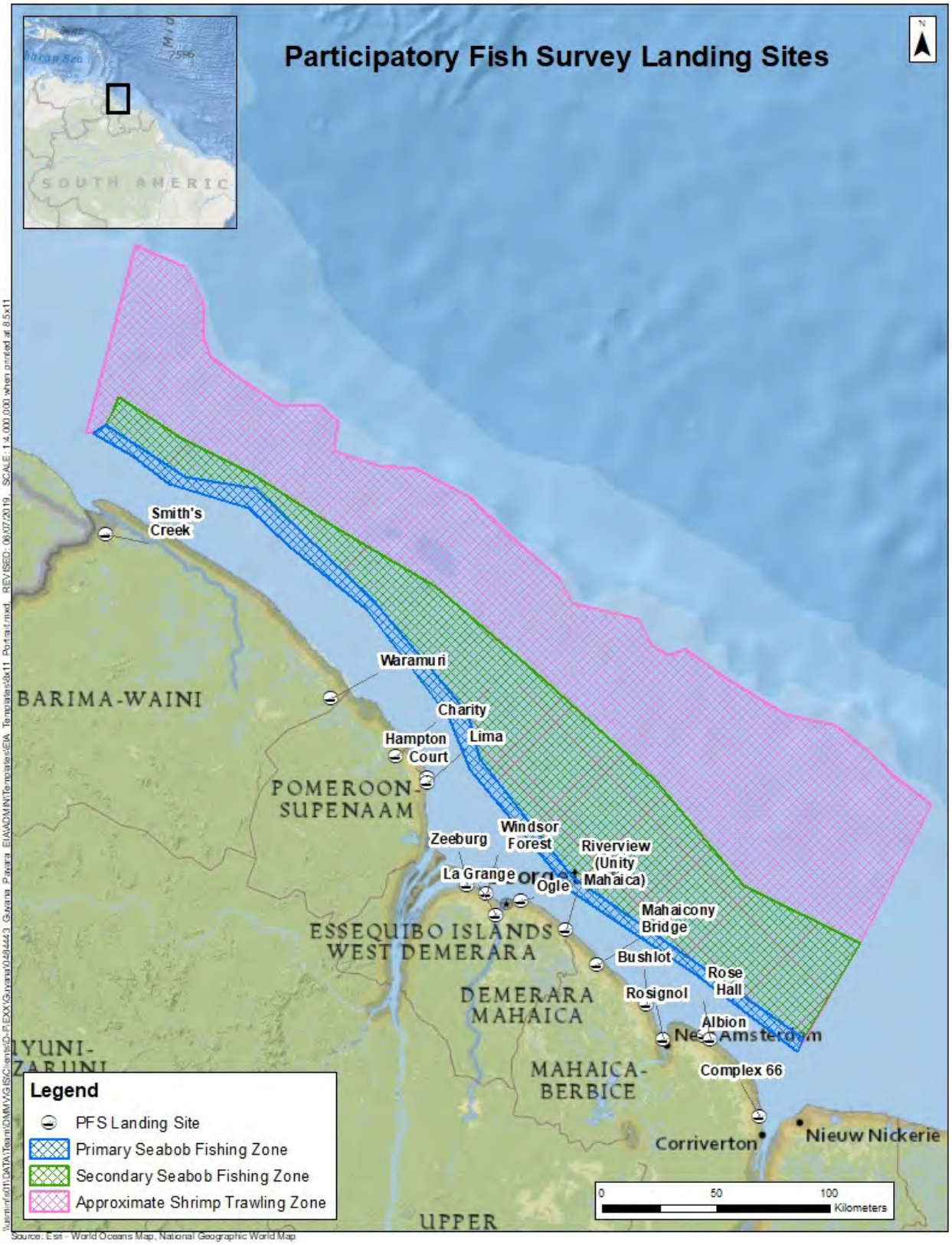

Figure 2-1: Locations of Landing Sites in Regions 1 to 6

3. OVERVIEW OF TOPICS

3.1 Marine Fisheries Species

For consistency throughout the report, Table 3-1 provides a table of commonly encountered species in Guyanese marine fisheries. See Appendix A for a full list and photos.

Table 3-1: Species Commonly Encountered in Guyanese Marine Fisheries

Species Name	Common Name
Micropogonias furnieri	basher, basha [a]
Cynoscion acoupa	grey snapper
Cynoscion virescens	trout
Cynoscion leiarchus	shine eye
Nebris microps	butterfish / butterhead
Carcharhinus limbatus	blacktip shark [b]
Carcharhinus porosus	san shark
Sphyrna lewini	hammerhead shark
Rhizoprionodon porosus	green shark
Chaetodipterus faber	spadefish / donkey fish
Sciades props	kukawri [c]
Batrachoides surinamensis	pacu
Macrodon ancylodon	bangamary [d]
Stellifer rastrifer	rockhead / white / rat mouth
Ctenosciaena gracilicirrhus	brickhead / rock head
Scomberomorus cavalla	kingfish
Scomberomorus brasiliensis	mackerel
Xiphopenaeus kroyeri	coarse shrimp / seabob
Cynoscion sp.	bangamary [d]
Odontognathus mucronatus	netly
Trichiurus lepturus	silverbelt
Lonchurus elegans	Chinese butterfish
Nematopalaemon schmitti	white belly shrimp
Achirus achirus and *Symphurus plagusia*	flounder
Centropomus undecimalis	snook
Farfantepenaeus sp. and *Litopenaeus* sp.	prawns [e]
Bagre bagre	sea catfish
Lobotes surinamensis	paggie / sea congo
Cathorops spixii	spring cuirass
Cathorops sp.	round head
Cathorops sp. and *Sciades* sp.	cuirass
Sciades parkeri	gillbacker
Megalops atlanticus	cuffum / tarpon

Species Name	Common Name
Genyatremus luteus	annafoke / old wife
Mugil cephalus	Suriname mullet
Anchoa spinifer	small herring
Elops saurus	long john
Pomatomus saltatrix	salmon
Harengula humeralis	shad
Brachyplatystoma vaillantii	lau
Sciades couma	cuma cuma / blinka
Cetengraulis edentulus	big eye herring
Echiophis punctifer	mud eel
Cynoscion similis	black tail basha
Pellona harroweri	mail boy
Isopisthus parvipinnis	flat banga
Mugil curema	quirman
Penaeus monodon	tiger shrimp
Prionotus punctatus	sea robin / flying fish
Katsuwonus pelamis	bonito / tuna
Anableps anableps	four eye
Rachycentron canadum	cabio
Physalia physalis	man O war
Callinectes sapidus	crab
Amphiarius rugispinis	twee
Bunocephalus sp.	banja man
Mugil sp.	cannapa
Selene vomer	chiny man / moonfish
Sphyraena guachancho	barracuda
Diapterus rhombeus	deep-sea fish
Pseudauchenipterus nodosus	sweet man
Oligoplites saliens	copper fish / thing bad
Epinephelus itajara	jewfish
Cynoscion sp.	bright eye
Caranax hippos	crevalle
Rhinoptera bonasus	sea Bat
Notarius grandicassis	Thomas
Trachinotus sp.	pompano
Hypanus sp. *Frontitrygon* sp.	stingray
Narcine bancroftii	shocking fish, electric ray
Menticirrhus americanus	crooker

[a] Basha and basher are used in different regions of Guyana and both refer to *Micropogonias furnieri*.
[b] All photos collected showed *C. limbatus*, but the data could have small numbers of other shark species included.

[c] Kukawri is used to refer to *Sciades proops* in this report, but the species is also known as kokwari and hard head cuirass in Guyana.
[d] Bangamary is used in Guyana to refer to both *Macrodon ancylodon* and *Cynoscion* sp.
[e] In Guyana, prawn is a blanket term used for both *Farfantepenaeus* sp. and *Litopenaeus* sp.

3.2 Measuring Hauls

Also, for consistency throughout this report, it is important to note that a variety of measurement units (baskets, tubs, buckets, and pounds) are used across landing sites in the various regions. During the engagements with fisherfolk and supervisors at each of the landing sites, the study team developed the following conversion units for estimating the volume of catch:

- One basket of fish is equivalent to 36.2 kilograms (80 pounds).
- One tub of fish is equivalent to 27.2 kilograms (60 pounds).
- One parcel of fish is equivalent to 4.5 kilograms (10 pounds).
- One bucket of shrimp is equivalent to 9.1 kilograms (20 pounds).

These measurement units are described throughout the report with the corresponding weight associated with that unit.

3.3 Characterization of Commercial Species

The artisanal fishing community assessed in this study targets several commercial species using specialized fishing gear and vessels. The species most prevalent in the study include bangamary, grey snapper (commonly referred to as snapper), and the two major shrimp species—white belly shrimp and coarse shrimp/seabob. Other frequently caught high-value and high-demand species include trout, gillbacker, and cuirass. Fisherfolk have also reported catching jewfish and shark, which are both endangered, rare, and threatened species. The following sections provide a brief description of each of these species as recorded historically and during the study. The mature lengths of the species were based on data sourced from Fish Base (2020), which is the largest global species database.

3.3.1 Bangamary

When mature, bangamary has an average standard length of 32 centimeters (12.6 inches) and some fish can grow to lengths exceeding 40 centimeters (15.7 inches). As juveniles, bangamary live in mud or in sandy mud bottoms. Bangamary feed mainly on shrimp and small fishes. They are commonly found along the northern coast of South America. Bangamary has a known life expectancy of up to 6 years (Haimovici and Cardoso 2011).

In Guyana's artisanal fishing industry, mature bangamary are targeted with drift seines with mesh sizes of 7 centimeters (2.75 inches) and the juveniles are caught with Chinese seines. Fisherfolk in Guyana refer to bangamary as "the fish who bites twice" in reference to the fish biting lines and to the frequent cuts to their hands from handling the fish when caught.

3.3.2 Snapper

Snapper are bottom-oriented fish that prefer mouths of rivers with muddy and sandy bottoms. During the day, snapper hide in crevices, but come out to hunt crustaceans and smaller fishes at night (Rodrigues et al. 2008). These fishes tend to form schools. Juveniles live primarily in the mangroves, a behavior that helps to protect them from predators. Mature snapper have been recorded as growing up to 110 centimeters (43.3 inches) in length.

In Guyana, snapper is considered a high-value species. In recent years, the markets and prices for the swim bladders of snapper, referred to locally as *glue*, have significantly expanded. Although snapper was

already a highly targeted species, high demand and prices for glue have incentivized the increased targeting of this fish species. Fisherfolk targeting snapper use drift seines with mesh sizes of 18 centimeters (7 inches) and vessels capable of spending extended periods at sea, typically up to 2 weeks.

3.3.3 Shrimp

Two major shrimp species occur in Guyana—white belly shrimp and seabob, the latter of which is frequently referred to as coarse shrimp. Both species occur in brackish waters in the benthic zone, where they feed on plant matter along with dead and decaying animal matter. White belly is the smaller of the two species, which at maturity achieves a maximum length of approximately 8 centimeters (3.1 inches). The larger species, seabob, can grow up to 11 centimeters (4.3 inches).

Shrimp spawn mainly during two seasons in Guyana: January to April and June to July (Periera 2017). In Guyana, fisherfolk use Chinese seines to target these shrimps. An invasive shrimp species, the tiger shrimp, has recently become established in Guyana and is sometimes caught by local fisherfolk.

3.3.4 Trout

Trout live in muddy sandy bottoms in coastal waters near the mouths of rivers. Juveniles live in estuaries and mangroves. Like snapper, adults stay in deep water during the day and come out to feed during the night. Their diet is mainly comprised of small fishes and crustaceans. Mature trout can achieve lengths of 90 centimeters (35.4 inches).

In Guyana, trout is considered a medium- to high-value species. Like snapper, markets and prices for its glue have significantly increased in recent years. Trout is typically the second or third most abundant species caught using drift seines with mesh sizes of 7 to 18 centimeters (2.5 to 7 inches), which are designed to target bangamary and snapper.

3.3.5 Cuirass

Cuirass refers to catfishes from the family Ariidae and may either be part of the genus *Cathorops* or *Sciades*. Several species are referred to as cuirass in Guyana including spring cuirass, flat head cuirass, hard head cuirass (also called kokwari), and mud cuirass. Cuirass are characterized by having very hard cranial bones and live in turbid estuaries and mangrove-lined lagoons with shallow soft bottoms. They feed on numerous pelagic organisms found in mangroves, including small crabs and fishes. Spawning season occurs from September to January and females incubate eggs in their mouths for 20 to 50 days. Mature fishes have lengths of 40 to 55 centimeters (15.7 to 21.6 inches), but some species can grow to a maximum of 94.5 centimeters (37.2 inches).

In Guyana, cuirass are typically low- to medium-value fishes in the marketplace. The swim bladders from cuirass are also sold, but this is not as prevalent or as high-value as the glue from snapper and trout. They are not the target species of any fishing practices, but are widely caught nonetheless by virtually all seine types, and are therefore one of the main commercial species. Cuirass is mainly sold in local markets.

3.3.6 Jewfish

The jewfish is commonly referred to as the Atlantic goliath grouper and is classified as a critically endangered species by the International Union for Conservation of Nature (IUCN). Jewfish live in environments with corals and in muddy bottoms of the seafloor and are also known to occupy shipwrecks. Jewfish occupy a range extending from the Florida coast to the Brazilian coast, inhabiting the entire Caribbean Sea. They typically spawn in estuaries from July to August. Jewfish feed on small turtles,

fishes, and crustaceans. Jewfish is one of the largest bony fish species and can reach a maximum length of 240 centimeters (94.5 inches) and weigh over 272 kilograms (600 pounds).

As part of this study, jewfish were recorded in Regions 1, 2, and 6. It was not targeted by these fisherfolk, but was sold on commercial markets when caught. Additional research is required to determine the prevalence of this species in Guyana's nearshore coastal waters.

3.3.7 Gillbacker

The gillbacker is another species of catfish popular in Guyana. They are commonly found in muddy and sandy bottoms, spawning near estuaries during the rainy seasons, and are distributed along the coast of South America. Gillbacker mature at around 46 centimeters (18.1 inches), but can achieve maximum lengths of 190 centimeters (74.8 inches) and weights of 50 kilograms (110 pounds).

Gillbacker was previously one of the highest-value fish species on local and export markets. In 2018, the United States Department of Agriculture (USDA) banned the import of catfishes and catfish products from Guyana because food safety inspection systems were not equivalent to U.S. inspection systems. At peak prices before the ban, it retailed for $2,200 Guyanese dollars (GYD) per kilogram ($10.5 United States dollars [USD] per kilogram). The loss of this export market significantly reduced the prices of gillbacker on local markets and retail prices are now less than half of the previous peak prices.

3.3.8 Shark

Several species of sharks occur in Guyana, but identification of sharks caught by artisanal fisherfolk is extremely challenging due to the similarities in many coastal sharks' appearance, the tendency to bring sharks to market without heads (which eliminates several diagnostic features that could be used to identify specimens), and a tendency among fisherfolk to simply group all sharks into a single category. Despite these challenges, the shark fishery in Guyana is known to target a diverse group of species. The most common shark species caught for commercial sale by artisanal fisherfolk are often reported to be blacktip shark, tiger shark, bull shark, and hammerhead shark, but a genetic study conducted in 2017 documented 13 species of sharks in fish markets based on DNA analysis. Over 70 percent of the total sample diversity was represented by five species: Brazilian sharpnose shark (*Rhizoprionodon llandii)*-18.9 percent), smalltail shark (*Carcharhinus porosus)*-17 percent, scalloped hammerhead (*Sphyrna lewini*)-17.4 percent, great hammerhead (*Sphyrna mokarran*)-10.6 percent, and blacktip shark (*Carcharinus limbatus*)-8.3 percent (Kolmann et al. 2017). This study suggests that the Guyanese shark fishery captures a more diverse group of small requiem sharks than once thought.

Sharks are generally viviparous and have a relatively slow rate of reproduction compared to other fishes that lay thousands of eggs. Age and size at maturity vary by species, but the species that comprised the bulk of the catch in the 2017 study mature at between 2 years of age (sharpnose sharks) and 20 years of age (great hammerhead sharks). Sharpnose and smalltail sharks are relatively small sharks, maturing at around 1 meter in length, blacktip sharks are slightly larger with a maximum size of about 2 meters, but great hammerheads can reach well over 3 meters in length.

Regardless of species, the Guyana shark fishery tends to capture juvenile sharks. Sharks are relatively low-value on local commercial markets. As a result, sharks are not targeted species by artisanal fisherfolk, especially the nurse shark and whale shark, which are typically released if caught.

3.4 Seine Characterization

Several types of fishing methods and gear are used by artisanal fisherfolk for marine fishing, including pin seines, Chinese seine (also referred to as fyke nets), Cadell lines (also referred to as demersal long lines), and drift seines. The nets are manufactured in various mesh sizes and the Cadell lines may have

different hook sizes depending on the species and size of fish that are targeted in a specific location. Data for each of these fishing types were captured by the study's regional and onboard supervisors and are described below.

3.4.1 Pin Seine

Pin seines, also referred to as beach seines, are set on the mudflats a few meters offshore. In this method of fishing, short poles are stuck in the ground, and the seines are attached to the poles. Similar to the Chinese seine fishing method, tidal currents push fishes into the seine. Seines are set and left out during high tides and fisherfolk return to collect their catch during low tides. Fisherfolk access their seines by traveling via modified surfboards (*catamarang*) or small boats into which the catch is loaded and pushed to shore. Figure 3-1 shows the poles to which pin seines are attached. This type of fishing does not target any specific marine species, and may capture several nearshore species, including white belly shrimp, coarse shrimp, bangamary, and cuirass.

Figure 3-1: Pin Seine at Rose Hall Beach

3.4.2 Chinese Seine (Fyke Net)

Chinese seines are typically used relatively close to shore, approximately 10 meters (32.75 feet) from the shoreline. Chinese seine mesh can range from 1.27 to 10.16 centimeters (0.5 to 4 inches). These seines are normally attached to poles, commonly referred to as "pens," that are placed perpendicular to the tidal current. Normally, a series of seines are attached to pens. Within the poles, the seine is an open-faced square that tapers at one end into a funnel-like projection. Fishes are forced into the seines by the tidal currents. Figure 3-2 shows the shape a Chinese seine takes within the pen. The same person may fish one or more pens based on their needs and accessibility.

Fisherfolk travel to and from shore via channels to set their seines; the channels are accessible mainly at high tide. The fisherfolk using this method spend about 3 to 4 hours at sea, mainly to repair seines, collect the catch, and re-set the seines. Fisherfolk using Chinese seines normally target shrimp, including white belly shrimp and seabob/coarse shrimp. Catch also typically includes cuirass, sea catfish, small

bangamary, and silverbelt; these species are often captured in Chinese seines due to the relatively small mesh sizes used in this type of gear.

Figure 3-2: Chinese Seine Pen Poles Outside the Ogle Shore

3.4.3 Cadell Line (Demersal Longline)

Cadell line fishing is performed with a line of baited hooks anchored to the sea floor (see Figure 3-3 showing the nets). Cadell lines may be more than 2 kilometers (1.24 miles) long and have close to 100 hooks. Bait includes beef, small herrings, and mullet fishes. Fisherfolk using this method may venture as far as 40 kilometers (24.9 miles) offshore. This type of fishing does not target specific species, but some selectivity is possible based on the size of hook used. In general, catch includes sea catfish, gillbacker, snapper, trout, kokwari, and bangamary. This method of fishing has little-to-no bycatch and few fish are discarded regardless of species.

Figure 3-3: Cadell (Demersal Long Line) Nets Used for Fishing Activity

3.4.4 Drift Seine (Gillnets)

Drift seines are the most commonly used gear among artisanal fisherfolk in Guyana. They are modified gillnets and typically are large and circular with floats at the top and weights attached to the bottom. Drift seines are characterized by their mesh sizes. The size of the mesh on a drift seine can be designed to target specific species. For example, seines with mesh sizes of 7 centimeters (2.75 inches) typically target bangamary, while seines with mesh sizes of 11.4 and 17.8 centimeters (4.5 and 7 inches) target snapper. Some drift seines may have mesh as large as 20.3 to 22.9 centimeters (8 to 9 inches) to target larger similar species such as gillbacker and snapper. Drift seines are deployed in open waters about 20 kilometers (12.4 miles) from shore. Fisherfolk using this method may take daily fishing trips spending approximately 8 hours at sea (see Figure 3-4 for an example of the boats used); however, drift seining vessels have been known to be at sea for extended periods of up to 2 weeks.

Figure 3-4: Drift Seines at the Charity Landing Site

3.5 Vessel Characterization

In Guyana, most artisanal fishing vessels are categorized as an inboard cruiser or outboard cruiser based on size and the position of the engine. However, fishing vessels that do not require engine power are also used by some artisanal fisherfolk. Regional and onboard supervisors collected data on hauls and fishing practices for all types of vessels used in artisanal fishing.

3.5.1 Vessels Used for Pin Seine Fishing

Vessels used for pin seine fishing are the smallest vessels used by artisanal fisherfolk in Guyana. These vessels are modified surfboards (*catamarangs*) that are approximately 2 meters long with a wooden box affixed near the center of the board and are not powered by engines (Figure 3-5). Pin seines are set on the mudflats a few meters off the shore. These vessels are used by a single crewmember who pushes out to the seines during low tide to collect the catch. These vessels can carry up to 90 kilograms (200 pounds) of catch from the seines to shore. Pin seine fishing is prevalent across the coast because vessels can be launched directly from the mudflats and are relatively low-cost in comparison to other fishing vessels.

Source: Philander 2017

Figure 3-5: Catamarang used for Pin Seine Fishing at the La Bonne Intention Landing Site

3.5.2 Sailboats

Sailboats were popularly used by artisanal fisherfolk in Guyana about 15 years ago and at that time, the Better Hope landing site was the largest landing site for these vessels. However, their popularity drastically declined as the use of engines became widespread in artisanal fishing. Sailboats are typically approximately 8 meters long, 2 meters wide, and 1 meter high (Figure 3-6). Sailboats use drift seines with mesh sizes of 7 to 18 centimeters (3 to 7 inches). These vessels depend on the wind to travel to their fishing grounds approximately 10 kilometers offshore at depths of 8 meters. However, some sailboats also have 15 horsepower (hp) outboard engines that are used when the wind is not sufficient to power the vessel or the direction of the wind is not suitable for fishing activities. These vessels have crews of one to two persons who spend up to 24 hours at sea. These vessels have haul capacities of approximately 450 kilograms (1,000 pounds). Currently, only the Bushlot landing site in Region 5 has a large number of sailboats in Guyana.

Figure 3-6: Sailboat at Bushlot Landing Site Region 5

3.5.3 Outboard Cruisers Used for Chinese Seine Fishing

Artisanal vessels using Chinese seines are categorized as outboard cruisers and are among the smaller vessels in Guyana (Figure 3-7). These vessels are approximately 8 meters long, 1.5 meters wide, and 1 meter high. Generally, 15 hp engines are used by these vessels and placed at the rear of the vessel. These vessels travel to fishing grounds approximately 5 kilometers offshore, and 9 meters deep. They have crews of one to three persons who spend from 6 to 12 hours at sea. These vessels have haul capacities of approximately 500 kilograms (1,100 pounds) and catch is stored in baskets, buckets, and coolers while at sea.

The major landing sites for Chinese seine fishing are: Lima and Hampton Court landing sites in Region 2; Zeeburg, Windsor Forest, and Goed Fourtin landing sites in Region 3; Ogle landing site in Region 4; and Rosignol landing site in Region 5.

Figure 3-7: Chinese Seine Vessels at Windsor Forest

3.5.4 Outboard Cruisers Used for Drift Seine (Bangamary Seines) Fishing

Outboard cruisers that use 7-centimeter (2.75-inch) mesh size drift seines are commonly referred to as bangamary seines, as they primarily target this species (Figure 3-8). They are approximately 11.5 meters long, 2 meters wide, and 1 meter deep. Generally, these vessels use 40 to 48 hp engines that are positioned at the rear of the vessel (Figure 3-8). These vessels travel approximately 30 kilometers offshore and fish at depths of 20 meters. These vessels have crews of two to four persons who spend at least 12 hours, but no more than 3 days at sea. They have a haul capacity of up to 2,045 kilograms (4,500 pounds) and they typically utilize iceboxes for storage of catch while at sea.

The major landing sites for these vessels are located in Good Hope, Enmore, Hope, Bee Hive, and Riverview (Unity, Mahaica) in Region 4; Mahaicony Bridge, Abary, and D'Edwards in Region 5; and Albion in Region 6.

Figure 3-8: Outboard Cruisers Using Drift Seines (Bangamary Seines) at Riverview (Unity Mahaica)

3.5.5 Outboard Cruisers Used for Drift Seine (Snapper Seine) Fishing

Outboard cruisers that use 18-centimeter (7-inch) mesh size drift seines are among the largest vessels used by artisanal fisherfolk in Guyana, and primarily target snapper (Figure 3-9). The vessels are generally 14 meters long, 2.2 meters wide, and 2 meters high. These vessels may have up to two outboard engines positioned at the rear of the vessel. These engines are 48 to 60 hp and travel to fishing grounds approximately 40 kilometers offshore at depths of 37 meters. The vessels have crews of four to seven persons and spend 1 to 3 weeks at sea. These vessels have haul capacities of approximately 4,545 kilograms (10,000 pounds).

Major landing sites for these vessels include Charity and Hampton Court in Region 2; Parika in Region 3; Meadow Bank, Montrose, Hope, and Riverview (Unity, Mahaica) in Region 4; Mahaicony, Rosignol, and D'Edwards in Region 6; and Adventure, Number 65, and Complex 66 in Region 6.

Figure 3-9: Outboard Cruiser Using a Drift Seine (Snapper Seine) at Complex 66

3.5.6 Inboard Cruisers

Inboard cruisers are the largest artisanal fishing vessels (Figure 3-10). Engines for these vessels can exceed 100 hp and are normally built into the boat, hence their name. They are 16 meters long, 4 meters wide, and 3.5 meters high. These vessels use drift seines with mesh sizes of 19 centimeters (7.5 inches) and generally target snapper. These vessels have crews of four to seven persons who spend approximately 18 days at sea. The holds of these vessels are designed to store large quantities of ice, which is used to preserve catch during extended periods at sea. Their fishing grounds are usually 40 kilometers offshore at depths of 70 meters. These vessels have haul capacities of 18,000 kilograms (39,600 pounds). The major landing sites where these types of vessels are found are Charity (Region 2) and Meadow Bank (Region 4).

Figure 3-10: Inboard Cruiser at the Charity Landing Site Region 2

4. KEY FINDINGS

The artisanal fisherfolk from whom the regional and onboard supervisors collected data used a variety of fishing practices. These varied fishing methods produced significant differences in the catch composition and total haul volumes. These differences are attributed to a variety of factors including, but not limited to:

- Type of fishing gear used (seine type and mesh size)
- Type of vessel used and length at sea
- Target species that are considered commercially viable at each landing site
- Seasons in which fishing activities occur

4.1 Gear Type and Target Species

As demonstrated in the data collected by both the onboard and regional supervisors, specific types of fishing gear are used to reliably target specific species of fishes, even though fishing may occur in different ecological zones and different locations across Guyana's coastal regions. Moreover, seines with larger mesh sizes catch larger fishes, most of which have reached sexual maturity because smaller species and smaller fishes are more likely to escape capture. Seines with larger mesh sizes typically have less species diversity per haul. **As a result, the type of fishing gear used is a good indicator of the species composition of the hauls as well as the most abundant species caught**. The following information was gathered on typical species caught for each seine type:

- Drift seines with mesh sizes of 10 to 20 centimeters (4 to 8 inches) were used at the Charity landing site to target snapper. These seines are commonly referred to as "snapper seines" by fisherfolk. As the target species, snapper accounted for 60 percent of the total recorded haul by weight at this landing site. The second most abundant species caught using this seine type was trout. Similar catch compositions were observed in hauls from onboard supervisors at the Rosignol (Region 5) and Complex 66 (Region 6) landing sites where drift seines with mesh sizes of 19 centimeters (7.5 inches) were also used to target snapper. The onboard supervisor from the Hampton Court

landing site (Region 2) used drift seines with mesh sizes of 20 centimeters (8 inches) to target large species like snapper and gillbacker.

- Drift seines with mesh sizes of 6.5 to 7 centimeters (2.5 to 2.75 inches) were the principal types of gear used at landing sites in Riverview (Region 4) and Mahaicony Bridge (Region 5) to target bangamary. These seines are commonly referred to as “bangamary seines” by fisherfolk. The target species bangamary accounted for 36 and 76 percent of the total hauls at Riverview and Mahaicony Bridge landing sites, respectively. The second and third most abundant species caught using the bangamary seines were butterfish and trout. Similar catch composition of the three most abundant species caught was observed in the data collected by the onboard supervisors at landing sites in Riverview and Albion (Region 6) where bangamary seines were also used. Although these three species were the most abundant, the species diversity of hauls from bangamary seines was relatively high.
- Drift seines with mesh sizes of 2.5, 5, 7.5, 10, and 12.7 centimeters (1, 2, 3, 4, and 5 inches) were used by the onboard supervisor of Vessel A at the Smith’s Creek landing site (Region 1). The 2.5-, 5-, and 7.5-centimeter (1-, 2-, and 3-inch) mesh size seines were used to target sea bats. Sea bats accounted for 36 percent of the onboard supervisor’s haul. Typically, the onboard supervisor used drift seines with a variety of mesh sizes to fish, but opted to target sea bats during the study because of a valuable export market to Venezuela. Based on the data collected by the regional supervisor, sea bats were considered a commercial species at the Smith’s Creek landing site but not reported by other fisherfolk in great abundance.
- Chinese seines have smaller mesh sizes and are used to target shrimp species. At the Zeeburg landing site (Region 3), Chinese seines with mesh sizes of 2.5 to 10 centimeters (1 to 4 inches) yielded hauls of which white belly shrimp comprised approximately 85 percent. At landing sites in Lima (Region 2) and Ogle (Region 4), Chinese seines also yielded white belly shrimp and coarse shrimp as the most abundant species caught. The onboard supervisor at the Windsor Forest landing site (Region 3) also used Chinese seines as the principal gear type to target white belly shrimp, but bangamary was the most abundant species caught. The majority of fishes caught using Chinese seines had not achieved sexual maturity.
- Pin seines also have smaller mesh sizes than drift seines, and unlike Chinese seines do not have a specific target species. However, at the Rose Hall landing site (Region 6), the most abundant species caught were white belly shrimp and coarse shrimp. Shrimps were likely the most abundant species caught because of the relatively small mesh sizes of the seine. Although pin seines were used occasionally by the onboard supervisor at Lima (Region 2), the supervisor did not disaggregate the hauls on the fishing trip based on the different gear used, so further analysis was not possible.
- Cadell lines were used to target sea catfish by the onboard supervisors at Waramuri (Region 1) and La Grange (Region 3). More than 75 percent of the hauls from these two landing sites were sea catfish. In addition, sea catfish was the second most abundant species caught by the onboard supervisor at the Windsor Forest landing site (Region 3) using Cadell lines as a secondary gear type.

A summary of these key findings at each landing site is presented in Table 4-1.

Table 4-1: Summary of Key Findings at Landing Sites

Landing Site	Gear Type	Target Species	Percentage of Haul by Weight
Charity	Drift seines, 10-20 cm	Snapper	60%
Rosignol, Complex 66	Drift seines, 19 cm	Snapper (see above)	50-65%
Hampton Court	Drift seines, 20 cm	Gillbacker (pictured) and Snapper (see above)	56% (Gillbacker) 40% Snapper
Riverview, Mahaicony Bridge, Albion	Drift seines, 6.5-7 cm (referred to as bangamary seines)	Bangamary	36-76%
Smith's Creek	Drift seines, 2.5, 5, & 7.5 cm	Sea Bats	36%
Zeeburg	Chinese seines, 2.5-10 cm	White Belly Shrimp	85%
Ogle	Chinese seines, 2.5-10 cm	Coarse Shrimp	71%
Lima, Windsor Forest	Chinese seines, 2.5-10 cm	White Belly Shrimp (see above)	11-30%

Landing Site	Gear Type	Target Species	Percentage of Haul by Weight
Waramuri, La Grange	Cadell lines	Sea Catfish	>75%

cm = centimeters

Unlike the other landing sites from which regional supervisors collected data, there was no specialization of gear type used by the fisherfolk at the Smith's Creek landing site (Region 1). Instead, fisherfolk used a variety of seines and mesh sizes including drift seines with mesh sizes ranging from 2.5 to 18 centimeters (1 to 7 inches), Cadell lines, and pin seines. As a result, the species most frequently caught by fisherfolk in Smith's Creek were cuirass, which can be caught in relative abundance with any of the fishing gear used, particularly in the estuaries where most fishing activities occur. Snook was also frequently caught and, like cuirass, may be caught with any of the seine types. The other six species most frequently caught included bangamary, butterfish, trout, snapper, snook, and sea catfish, which are the target species of bangamary seines, snapper seines, and Cadell lines. Similarly, the onboard supervisor of Vessel B at the Smith's Creek landing site used drift seines with a variety of mesh sizes including 2.5, 5, 7.5, 10, and 12.7 centimeters (1, 2, 3, 4, and 5 inches). The most abundant species caught was snapper, which indicates that snapper seines were used frequently during the study. Other abundant species caught included cuirass, snook, and paggie, which can be caught by a variety of gear types.

Fishing grounds may also influence the abundance with which target species are caught relative to other species in the haul. The onboard supervisor from the Bushlot landing site (Region 5) used drift seines with mesh sizes of 11 centimeters (4.5 inches), 13 centimeters (5 inches), and 18 centimeters (7 inches), which are generally intended to target larger species like snapper and trout. However, the species most frequently caught was cuirass, which can be caught with a variety of seine types. Snapper and trout were the second and fifth most abundant species caught, respectively. In contrast to other onboard supervisors targeting snapper and trout, the Bushlot onboard supervisor stayed relatively close to the shore and had shorter fishing trips. The importance of these factors in achieving hauls in which the target species are also the most abundant species caught is discussed further below.

4.2 Effort and Haul

A significant determinant of haul volumes is the type of vessel used. Vessel type directly determines haul volumes because larger vessels have greater haul capacities. For example the largest artisanal vessel inboard cruisers have haul capacities of 18,000 kilograms (39,683 pounds). By contrast, the catamarangs used by pin seine fisherfolk only have a haul capacity of 90 kilograms (198 pounds). The vessel haul capacities also influence the level of effort because vessels that have greater haul capacities can spend longer periods at sea per fishing trip. In some instances, fishing practices can further create opportunities for maximizing the vessel's haul capacity on each fishing trip. For example, fisherfolk at the Charity landing site gut fishes at sea as a preservation method, but also as a means of reducing haul weights. Lower haul weights over time create the opportunity for increased soaking of the seine and allow for optimal use of the vessel's haul capacity. As shown on Figure 4-1, the size of the haul varies by region, and fisherfolk from each region (with the exception of Region 1) typically used one type of vessel predominantly.

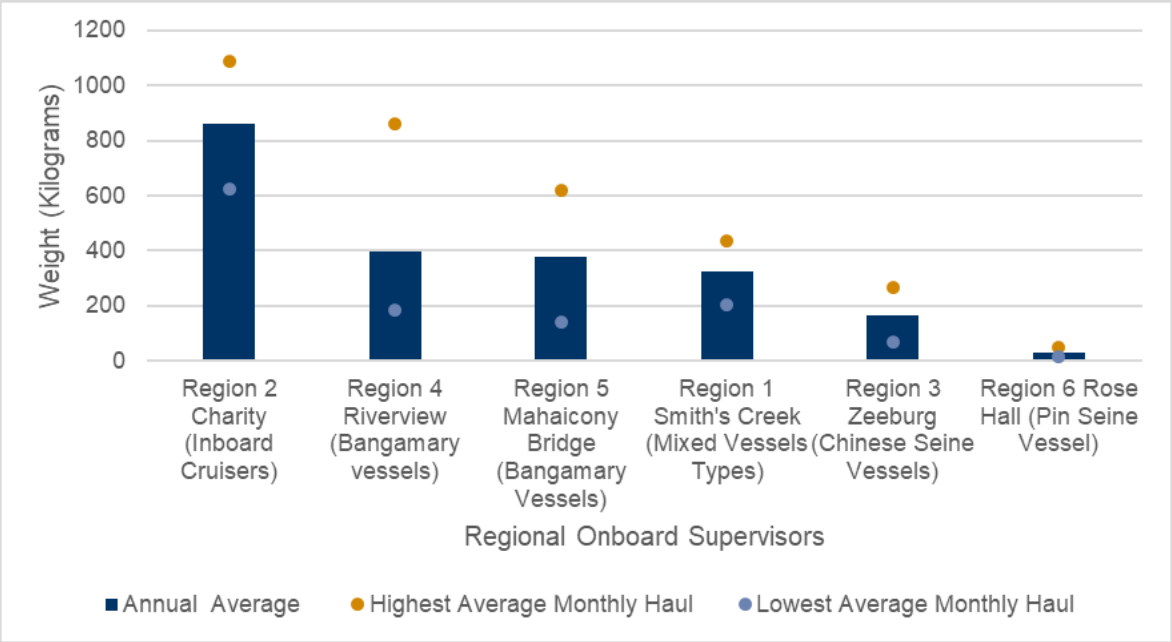

Figure 4-1: Haul Volumes at Landing Sites with Regional Supervisors

Vessel type also influenced the effort expended per fishing trip. Typically, larger vessels are capable of spending longer periods at sea fishing and traveling farther away from their landing sites to access preferred fishing grounds. The inboard cruisers at the Charity landing site (Region 2) expend the greatest effort of all artisanal vessel types. These vessels typically spend upwards of 2 weeks at sea per fishing trip due to larger capacities that can accommodate crew, maintain a stock of supplies, and store ice used to preserve the haul. These fisherfolk also prefer to fish in the Waini and Barima rivers in Region 1 and in doing so, travel farther away to fish.

As seen on Figure 4-2, the greatest average effort made during the study was expended by inboard cruisers at Charity (Region 2). By contrast, the lowest effort was expended by fisherfolk at Zeeburg (Region 3) and Rose Hall (Region 6), where the smallest artisanal vessels were used for activities targeting shrimp. Both Chinese seine and pin seine fishing are tidal activities. Fishing grounds are typically in fixed locations offshore, namely the “pens” used for Chinese seines and the poles erected for attaching pin seines. As a result, effort expended per fishing trip was relatively stable throughout the study period. At Zeeburg and Rose Hall landing sites, the average effort expended per fishing trip during the study was 7 hours and 12 hours, respectively.

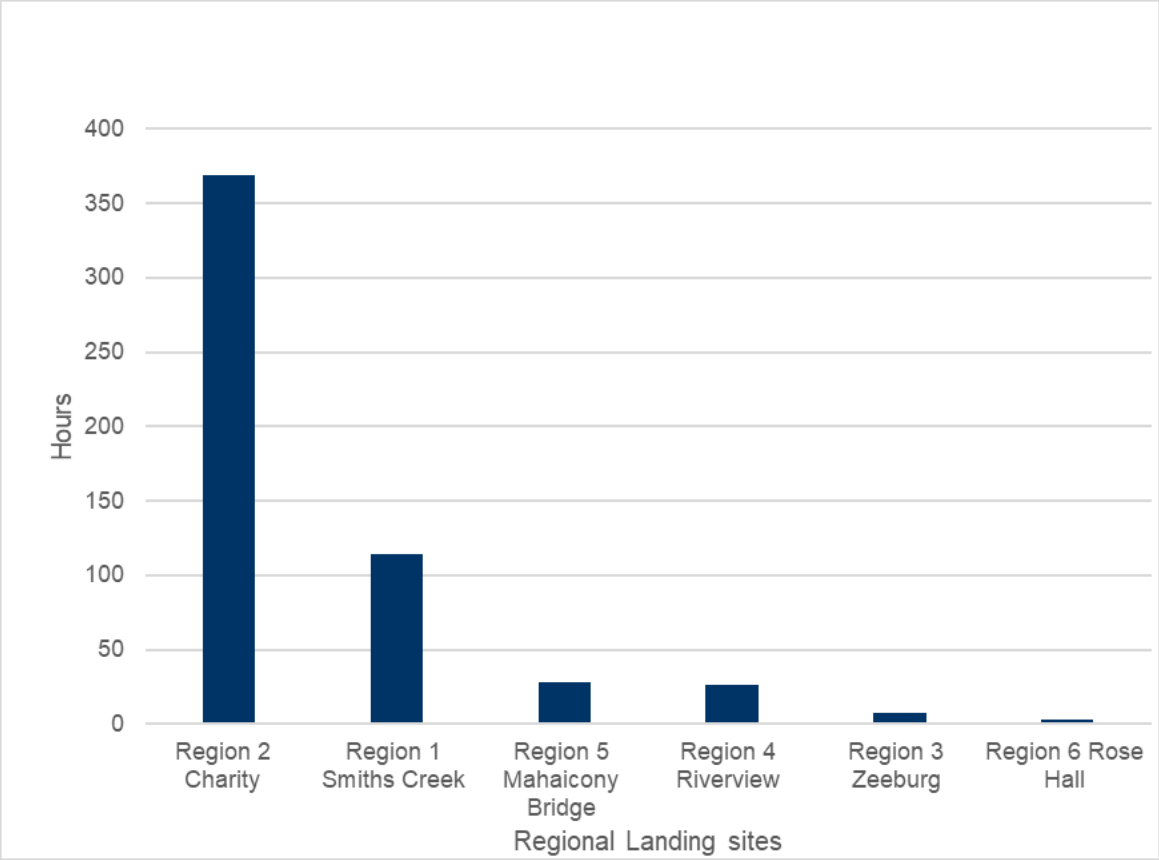

Figure 4-2: Average Fishing Effort per Month at Landing Sites with Regional Supervisors

Larger vessels have significantly higher expenses per fishing trip than smaller vessels. Typically, fisherfolk at the Charity landing site expend approximately $540,000 GYD ($2,583 USD) on fuel, ice, and rations per trip. By contrast, almost no expenses are associated with the use of catamarangs for fishing activities. Fuel required to conduct fishing trips using Chinese seines costs approximately $5,000 GYD ($24 USD) per trip. However, as observed at Smith's Creek and Morahwanna landing sites, external factors increased fuel prices during the study and thereby also increased the costs associated with conducting a fishing trip.

Generally, larger predatory fishes like snapper and trout require greater effort to catch. As a result, fisherfolk targeting these species tend to spend prolonged periods at sea. For example, fisherfolk targeting snapper at the Charity landing site typically have fishing trips lasting more than 2 weeks, whereas fisherfolk targeting smaller species, such as shrimp, expend lower effort to achieve optimum hauls. As such, greater effort per fishing trip was also observed from onboard supervisors at Hampton Court (Region 2), Rosignol (Region 5), and Complex 66 (Region 6) who also target larger species like snapper, trout, and gillbacker.

Level of effort was also observed to be influenced by the distances that fisherfolk had to travel to access their preferred fishing grounds. For example, fisherfolk at Smith's Creek and Morahwanna (Region 1), Riverview (Region 4), and Mahaicony Bridge (Region 5) have similar vessel types. However, preferred fishing grounds are located farther from the landing site for fisherfolk from Smith's Creek/Morahwanna and as a result, greater effort is required to access these fishing grounds. In addition, greater effort was likely expended at Smith's Creek and Morahwanna as a result of the high fuel prices which encouraged

fisherfolk to spend longer periods at sea as a strategy to maximize fuel consumption efficiency. However, it is likely that the duration of the fishing trips was ultimately limited by the haul capacities of the vessels. Given the haul capacities of the vessels used, the annual average haul and the maximum total haul at Smith's Creek and Morahwanna was lower than Riverview and Mahaicony Bridge.

Similarly, based on data collected by the onboard supervisors, fishing practices were a major factor in determining the effort expended per fishing trip. Consequently, the onboard supervisors from Hampton Court (Region 2), Rosignol (Region 5), Bushlot (Region 5), and Complex 66 (Region 6), who all used seines with larger mesh sizes to target larger fishes like snapper and trout, consistently expended greater effort per month. Moreover, the vessels used by the onboard supervisors from Hampton Court, Rosignol, and Complex 66 had greater haul capacities than any of the vessels used by the other onboard supervisors and therefore, longer periods could be spent at sea in pursuit of the target species. Only these three onboard supervisors expended more than 200 hours monthly on average for fishing activities. The onboard supervisor from Bushlot had a smaller vessel and did not spend prolonged periods at sea per fishing trip, but completed more fishing trips than the other three supervisors.

The second highest average monthly effort was expended by the onboard supervisors from Riverview (Region 4) and Albion (Region 6) who used bangamary seines for fishing. The average effort expended by these supervisors was comparable, with 165 hours and 167 hours monthly being expended on average at Riverview and Albion, respectively. The lowest effort was expended by the onboard supervisors from Lima (Region 2) and Ogle (Region 4) who used Chinese seines for fishing. Moreover, although the onboard supervisors from Waramuri (Region 1) and La Grange (Region 3) both used Cadell lines, monthly effort by the Region 1 supervisor was significantly higher than by the Region 3 supervisor. This was likely due to the onboard supervisor from Waramuri having fishing trips that lasted up to 10 days to travel, whereas the onboard supervisor from La Grange spent 12 hours at sea per fishing trip.

Unlike the data collected from the regional supervisors for the total hauls of landing vessels, onboard supervisors reported the weight of hauls per soaking of the seines, and this further illustrated the elusive nature of large species like snapper. As shown on Figure 4-3, the most productive hauls per soaking were recorded by the onboard supervisor who used bangamary seines in Riverview (Region 4) and Albion (Region 6), and Chinese seines in Lima (Region 2), Windsor Forest (Region 3), and Ogle (Region 4) for fishing. By contrast, the onboard supervisors who targeted snapper and expended greater effort all recorded relatively lower hauls per soaking. For example, as shown on Figure 4-4, at Complex 66, monthly effort was 288 hours with an average weight of hauls per soaking of 559 kilograms (1,232 pounds), whereas at Riverview, average monthly effort was 165 hours, but the average weight of hauls per soaking was significantly higher with a recorded 4,045 kilograms (8,918 pounds). This difference may be due to the larger number of species caught and considered commercial at Riverview compared to Complex 66. Despite the high ratio of effort to hauls, such as at the Complex 66, the effort was considered economically viable because, although smaller quantities of snapper were caught, it is the most expensive fish per kilogram at most of the landing sites in the study and fisherfolk who target snapper may also have additional earnings if the glue is sold separately.

Another interesting trend that emerged at most of the landing sites is that total effort typically peaked during the period with the lowest productivity (the "hard seasons"). Only two onboard supervisors expended greater effort during the most productive period ("good season") at the Albion and Complex 66 landing sites in Region 6. The greater effort resulted in greater total hauls per soaking during the good seasons because the average weight of hauls per soaking was also greater. Moreover, comparable levels of effort in the good and hard seasons did not result in comparable hauls because the productivity of soaking of the seine was lower during the hard seasons. As such, effort was deemed to be a reasonable predictor of haul based on the season in which fishing activities occurred.

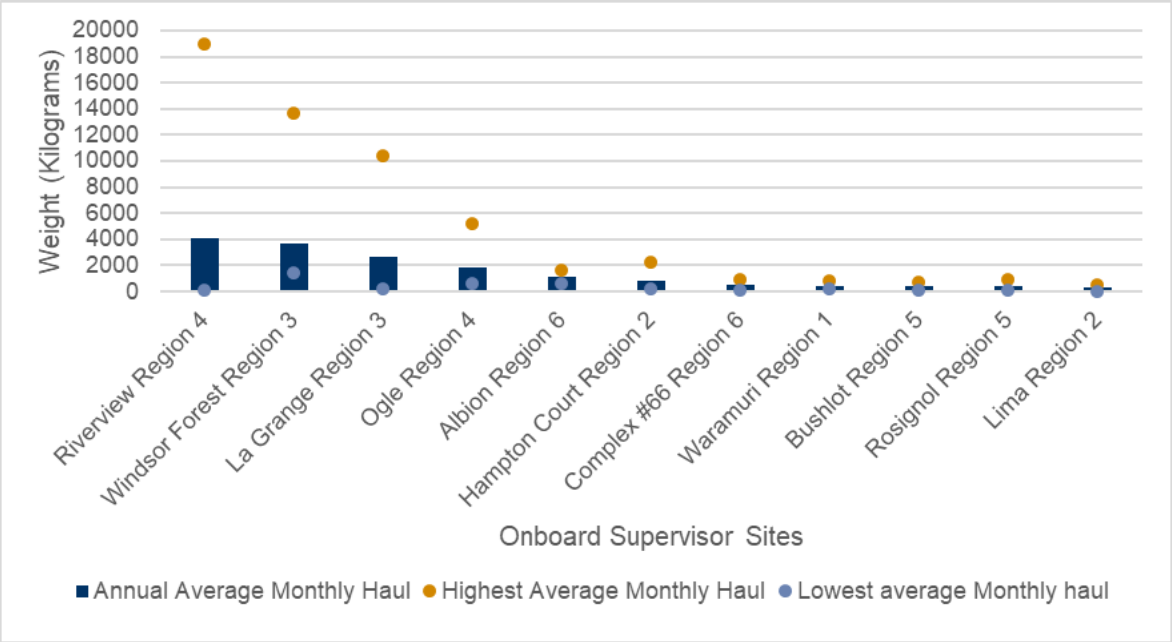

Figure 4-3: Monthly Haul Volumes at the Landing Sites with Onboard Supervisors

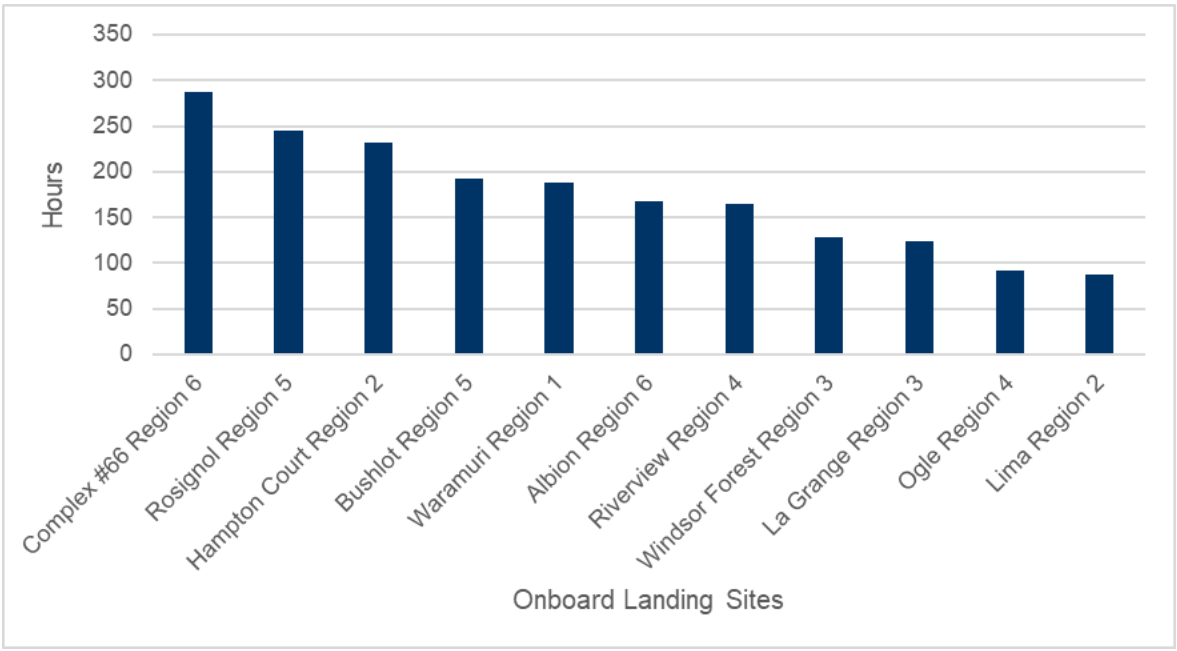

Figure 4-4: Average Monthly Effort Expended by Onboard Supervisors

4.3 Seasonal Productivity

Artisanal fisherfolk in Guyana have a shared belief in the seasonal productivity of fishing activities and this belief also tends to influence their fishing practices and, in particular, effort expended. The peak fishing season, commonly referred to as the “good” season, is believed to occur during periods of the year when waters are warmer (which is believed to lead to an abundance of fishes) and calmer (which is less dangerous and requires less effort to fish). The off-peak season is generally referred to as the “hard” season when waters become colder and rougher. **The good season is generally considered to start in**

May but to peaks from July to September. The hard season is typically considered to be from October to April.

Research suggests that fishes come closer to the shore during the rainy season when river discharges are higher and when the trade winds subside, which means muddy bottoms are not as disturbed (Lowe-McConnell 1962). However, fisherfolk have indicated that fishing productivity does not significantly change among Guyana's wet and dry seasons. The good season is considered to extend from May to September and thus overlaps entirely with the primary wet season (May to July) and partially with the primary dry season (August to October). Similarly, the hard season (October to April) overlaps with the secondary wet season (November to January) and the secondary dry season (February to April).

Fisherfolk have varying beliefs concerning the most productive months for shrimping. Some fisherfolk indicated that shrimp catch generally increases during the closed trawl season, which occurs from August 16 to October 5 annually, and which may allow more shrimp to come closer to shore. Other fisherfolk indicate that the average productivity increases during the dry seasons of February to April and August to September. This intersects with the closed trawl season, and with the spawning season of white belly shrimp that runs from January to April and June to July (Pereira et al. 2017). Spawning seasons may also increase productivity as white belly shrimp may travel closer to shore to spawn in the mangroves.

4.3.1 Regional Supervisor Results

Based on the data collected by the regional supervisors at Charity (Region 2), Zeeburg (Region 3), Riverview (Region 4), and Mahaicony Bridge (Region 5), higher productivity was observed in the good season, as expected (Figure 4-5). However, two landing sites had greater productivity in the hard season than in the good season:

- At Smith's Creek and Morahwanna (Region 1), where no target species are uniformly sought, productivity was higher in the hard season and the highest hauls were in the primary dry season. The most productive month was in October 2019, which is within the hard season and the primary dry season. However, October was also the most productive month at the Mahaicony Bridge landing site (Region 5), where overall productivity was greater in the good season. In addition, fisherfolk from Smith's Creek and Morahwanna share common fishing grounds with fisherfolk from the Charity landing site (Region 2), but the seasonal differences in the haul are starkly different. High fuel prices presented a significant confounding variable that curtailed normal fishing practices in Region 1, particularly in June and July 2019. As a result, the trends that have emerged at Smith's Creek and Morahwanna should be considered with caution and additional data are required to determine whether the trends observed thus far can be representative of practices that generally prevail at Smith's Creek and Morahwanna.
- At the Rose Hall landing site (Region 6), where pin seines are used to target shrimp, hauls were generally consistent over the good and hard seasons and also over the wet and dry seasons. Like Zeeburg, where shrimp is also the target species, the primary and secondary dry seasons were the most productive. However, fishing activities at this landing site were disrupted during the study period as a result of rough tidal conditions which continuously broke down pin seines.

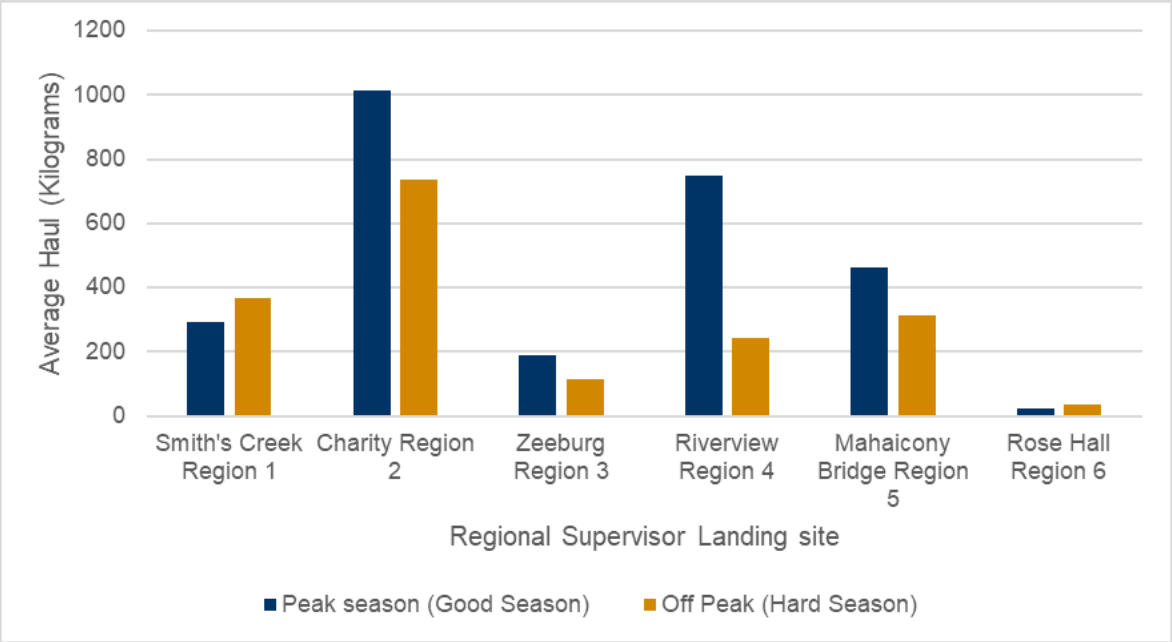

Figure 4-5: Average Productivity of Hauls in the Good and Hard Seasons for Landing Sites with Regional Supervisors

4.3.2 Onboard Supervisor Results

The average productivity of hauls per soaking was higher in the good season for seven of the ten onboard supervisors in Regions 2 to 6 (Figure 4-6). These landing sites were Hampton Court (Region 2), La Grange (Region 3), Windsor Forest (Region 3), Riverview (Region 4), Ogle (Region 4), Rosignol (Region 5), and Complex 66 (Region 6). The difference in productivity was most significant at the La Grange landing site, where productivity was 75 percent greater in the good season. At most of these landing sites, total hauls were also greatest during the primary wet and dry seasons. This is due to the significant periodic overlaps of the good season (May to September), the primary wet season (May to July), and the primary dry season (August to October). However, within the disaggregated timeframes of the good and hard seasons, climatic seasonality was also observed to have influenced haul productivity. Specifically, within the timeframes of the good and hard seasons, greater productivity was recorded during the primary wet season and the secondary wet season for both fishing and shrimping activities. This trend varied at the Zeeburg landing site (Region 3) where data suggest greater productivity for white belly shrimping was associated with the dry seasons.

Within the good season, the productivity of hauls was greatest during the primary wet season for the landing sites in Hampton Court, La Grange, Riverview, and Rosignol. The onboard supervisors at these landing sites all target various species of fishes. Except for Hampton Court, total hauls at these landing sites were also significantly higher during the primary wet season compared to the primary dry season. Moreover, within the hard season (October to April), the productivity of hauls was significantly greater during the secondary wet season than in the secondary dry season at all these landing sites except Hampton Court. The apparent seasonal differences at Hampton Court may be attributed to the numerous challenges that the onboard supervisor encountered and that have hindered data collection (described in detail in Appendix I).

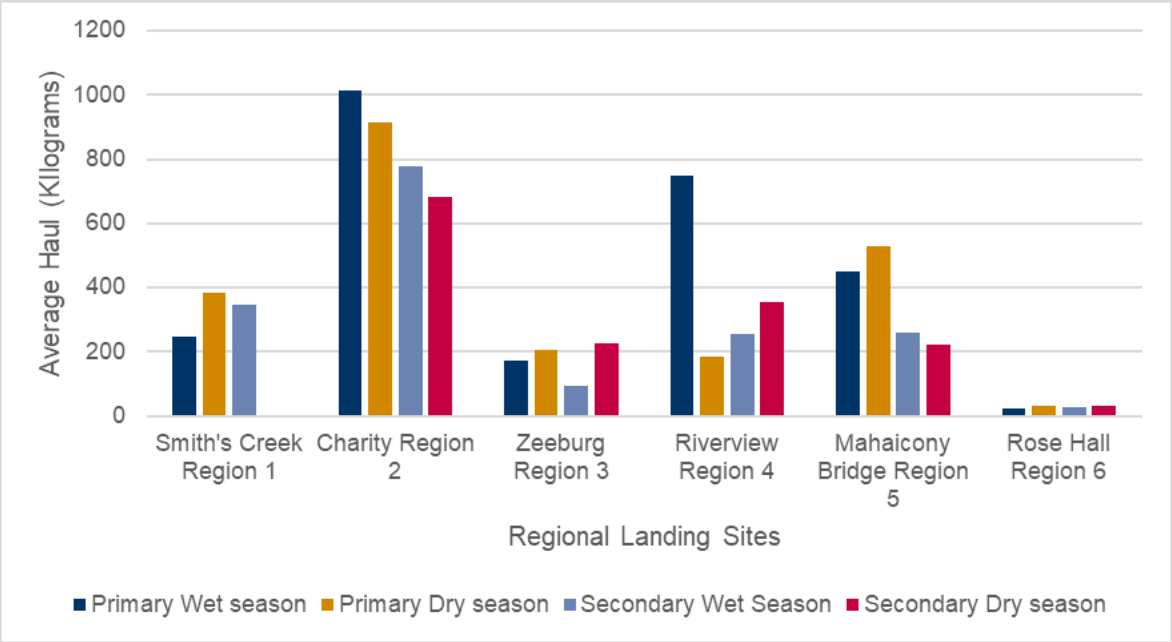

Figure 4-6: Climatic Seasonality of Average Productivity per Haul for Landing Sites with Regional Supervisors

At the Complex 66 landing site, productivity was also higher during the good season as seen on Figure 4-7. However, greater productivity was accompanied by an increase in effort. This is unusual because, at most of the other landing sites, greater effort was expended during the period with lower productivity. In addition, there is a data gap for January 2020 which, if filled, may have narrowed the difference in productivity observed during the good and hard seasons. With the timeframes for the good and hard seasons, the productivity of hauls was greatest during the primary and secondary wet seasons. Based on the supervisor's experience and the total-haul to total-effort ratio, it can be concluded that there is no clearly defined good and hard season for the onboard supervisor's fishing practices.

Within the good season, the productivity of hauls was also greatest during the primary wet season at the landing sites in Windsor Forest and Ogle as seen on Figure 4-8. These onboard supervisors use Chinese seines to target shrimp but, as stated earlier, fishes were the most abundant species caught at the Windsor Forest landing site. At Windsor Forest, total hauls were also significantly higher during the primary wet season. Within the hard season at Windsor Forest, the productivity of hauls was greater during the secondary dry season than the secondary wet season. By contrast, at the Ogle landing site, total hauls were greatest during the secondary wet season because the onboard supervisor expended greater effort at fishing (conducting more fishing trips) than in the primary wet season. Also, the second shrimp spawning season occurs in June to July and therefore intersects both the good season and the primary wet season. The first shrimp spawning season runs from January to April and intersects with the hard season and the secondary dry season. Based on the data available for these two landing sites, it is not clear whether the spawning seasons influenced the productivity of shrimping activities.

Although the data from the onboard supervisors generally corroborated the data from the regional supervisors with respect to the good season being more productive than the hard season (see Figure 4-7), there were outliers in the onboard supervisors' data as well. Three landing sites in Regions 2 to 6 also recorded greater productivity during the hard season:

- At the Lima landing site (Region 2), where the onboard supervisor primarily used Chinese seines to target shrimp, hauls during the good and hard season were relatively uniform, with only a marginal

increase being reported during the hard season. This consistency in haul volumes may be attributed to the supervisor's decision to complement Chinese seine fishing with drift seines and pin seines during the hard season to improve haul. Within the disaggregated timeframes of the good and hard seasons, the greatest productivity of hauls was recorded during the secondary dry season. The greatest total hauls were reported during the primary and secondary wet season. Based on the data available, greater productivity was also associated with the spawning seasons at this landing site. As such, productivity had no clear seasonal trends at this landing site. Additional data are required to draw firm conclusions as to the seasonality of the onboard supervisor's fishing practices.

- At the Bushlot landing site (Region 5), where the onboard supervisor used drift seines with varying mesh sizes to target large fishes like snapper and trout, productivity was significantly greater (65 percent higher) during the hard season. The supervisor indicated that this reversal in seasonality has occurred previously and that this is the second consecutive year in which this was observed; the reasons for this reversal are unknown. In addition, as previously discussed, at this landing site, effort also peaked during the May to September period. Based on the differences observed in the good and hard seasons, productivity based on climatic seasonality also changed. As a result, the average weight of hauls during the primary wet and dry seasons was significantly lower than in the secondary wet and dry seasons. However, within the disaggregated timeframes of the good and hard seasons, productivity was greater during the primary and secondary wet seasons.
- At the Albion landing site (Region 6), where the onboard supervisor targeted bangamary, the productivity of both the average weight of hauls per soaking and total hauls were greater in the hard season as seen on Figure 4-7. However, total effort expended also increased. This is unusual as greater total effort typically occurred and peaked during the season with the lower productivity at other landing sites, including Bushlot. However, increased effort during the more productive period may have been influenced by a deliberate change in fishing practices by the onboard supervisor to access fishing grounds farther offshore. Moreover, total hauls were greater in the hard season than the primary wet and dry seasons. In contrast to other landing sites, the highest total haul was recorded in the primary dry season, and the highest average hauls per soaking were recorded during the primary and secondary dry seasons as shown on Figure 4-8. Based on the ratio of effort to productivity during the good and hard seasons, it may be concluded that there was no clearly defined periodicity of the onboard supervisor's fishing practice. Additional data are required to draw firm conclusions as to the seasonality of the onboard supervisor's fishing practices.

Seasonality of fishing practices of the onboard supervisors from Waramuri and Smith's Creek (Region 1) was not considered in this summary because data are only available from Waramuri for the good season and Smith's Creek for the hard season.

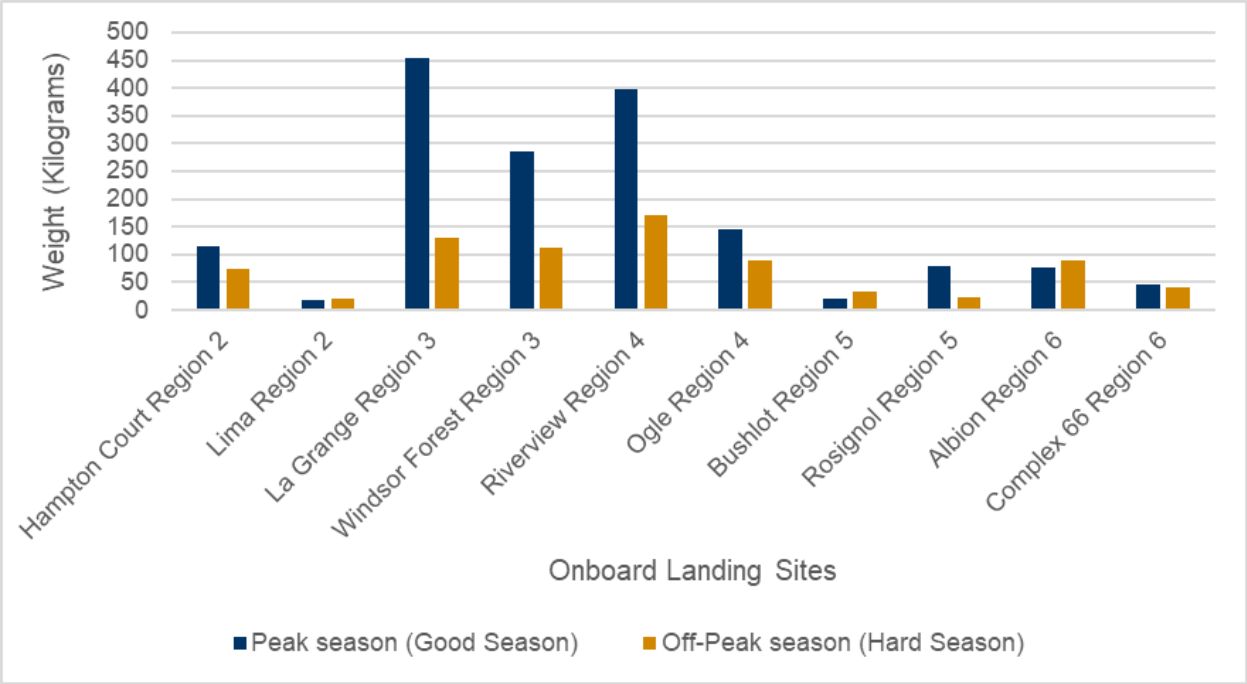

Figure 4-7: Average Productivity of Hauls in the Good and Hard Seasons for Landing Sites with Onboard Supervisors

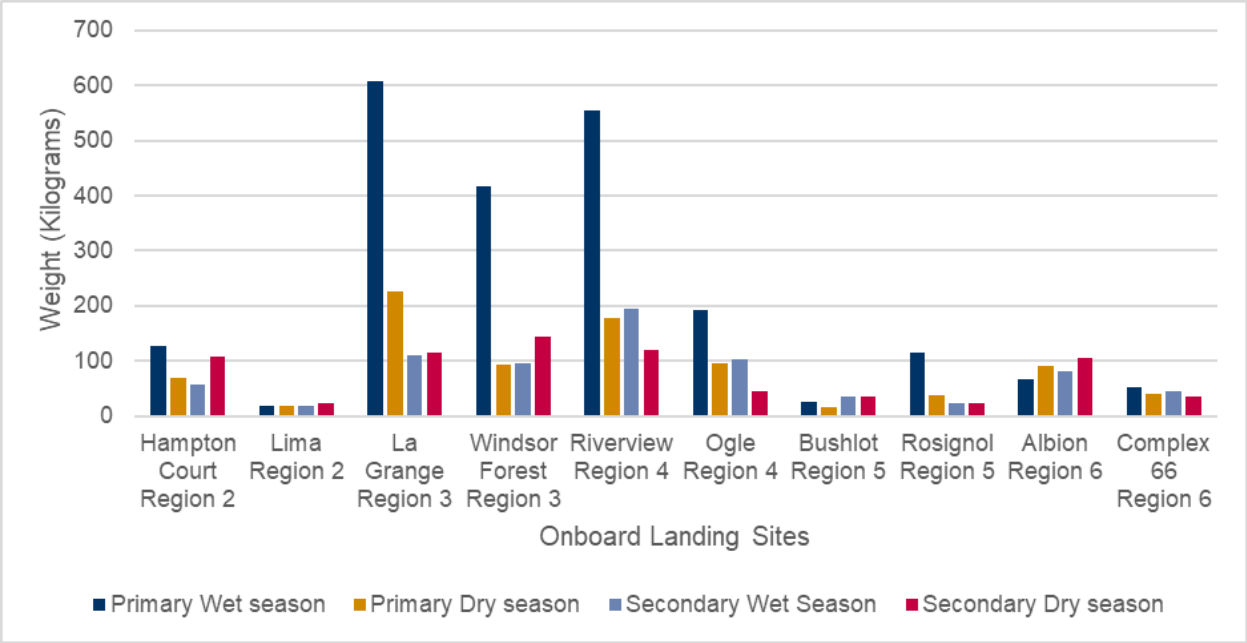

Figure 4-8: Climatic Seasonality of Average Productivity per Haul for Landing Sites with Onboard Supervisors

Figure 4-9 demonstrates the monthly variations in the productivity of hauls for the landing sites. As discussed above, productivity was highest during the primary wet season and this was due to the similar peaks in productivity in May and July 2019. Lowe-McConnell (1962) posited that fishes will be more likely to come closer to shore in the rainy seasons when nutrients are more abundant at the river mouths.

Increased hauls during the good season may also be attributed to the spawning seasons that run from July to September for most of the species caught by the supervisors.

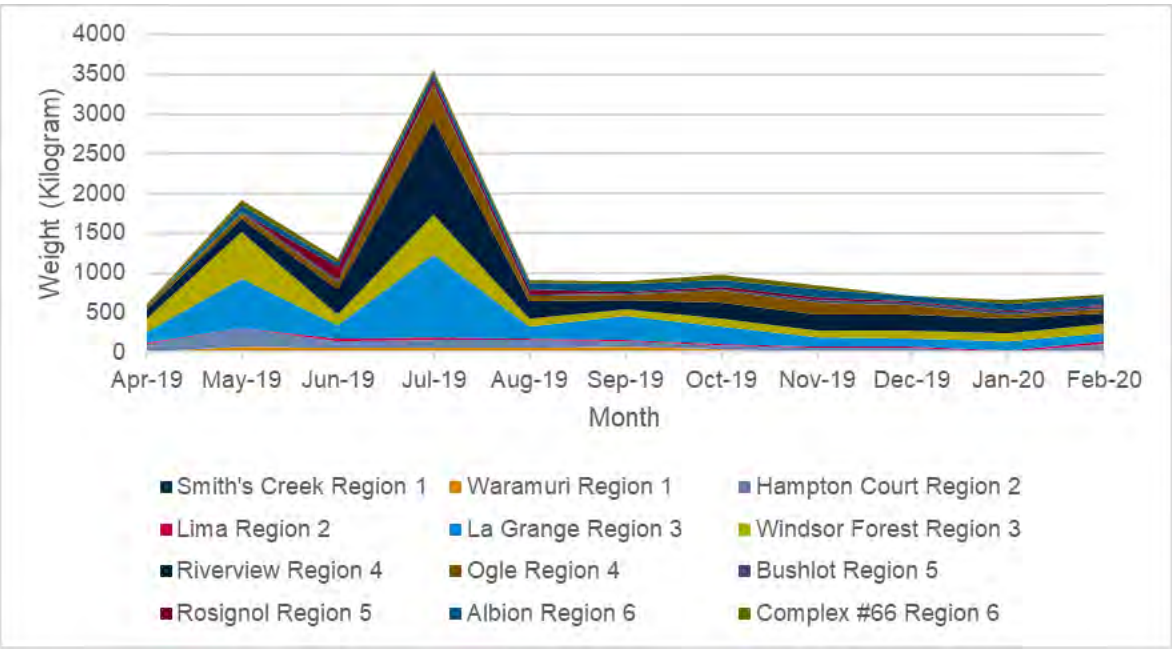

Figure 4-9: Monthly Productivity at Landing Sites with Onboard Supervisors

4.4 Species Diversity

The species diversity of hauls is determined principally by two factors. **The first determinant of species diversity of the haul is the mesh size of the seines used.** In particular, seines with larger mesh sizes typically capture only larger species and larger fishes. Based on data collected by the regional supervisors, the largest mesh sizes were used at the Charity landing site, where a relatively low species diversity of 14 was recorded (see Figure 4-10). Fisherfolk from Charity generally share fishing grounds with fisherfolk from Smith's Creek and Morahwanna, where species diversity was 36. This difference may be partially attributed to differences in gear types because a wide range of seine mesh sizes are used by fisherfolk from Smith's Creek and Morahwanna, while fisherfolk from Charity use snapper seines almost exclusively. Although species diversity of the hauls from seines with smaller mesh sizes are typically higher than from seines with larger mesh, these fishes are typically juveniles and are not considered commercially viable. This is underscored by local consumers' preference for larger species, which results in smaller species of fishes being considered less commercially viable.

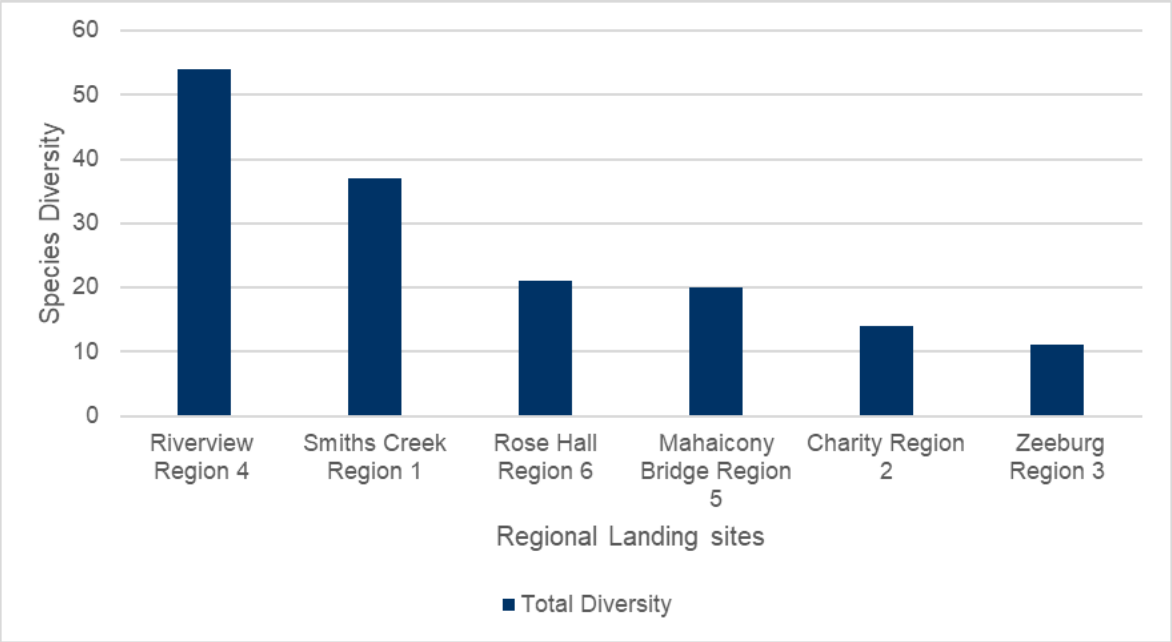

Figure 4-10: Species Diversity at Landing Sites with Regional Supervisors

The second factor that determines the species diversity of the landed hauls is fisherfolk perception concerning what species are likely to be considered commercially viable at their landing sites. In particular, the highest species diversities of 54 and 36 were observed at the landing sites in Riverview (Region 4) and Smith's Creek/Morahwanna (Region 1), respectively. These landing sites were unique because fishes were valued differently compared to other landing sites. For example, bangamary was more highly valued at Smith's Creek/Morahwanna than the other fishing landing sites, while shark species were more highly valued at Riverview than at the other landing sites. However, a wider range of fish and non-fish species were deemed commercially viable by fisherfolk at these landing sites. For example, well developed local and export markets for sea bats and string rays were observed at Smith's Creek, but markets for these species typically do not exist elsewhere in the country. Of the 54 species deemed commercially viable at the Riverview landing site, there were only markets for 50. In particular, although sea bats were sold at Riverview, there were no markets for stingrays. In addition, at the Riverview landing site, species were reported in a disaggregated fashion, and this was not observed at any of the other landing sites. For example, four species each of shark and snapper were reported at Riverview, whereas at most other landing sites these would have been reported as one species each.

The two principal factors influencing species diversity of hauls described above were also observed in the data collected by the onboard supervisors. The lowest species diversity was reported by the onboard supervisors who used drift seines with relatively large mesh sizes to target large species such as snapper, trout, and gillbacker. The onboard supervisors from the Rosignol (Region 5) and Complex 66 (Region 6) landing sites used snapper seines with mesh sizes of 19 centimeters (7.5 inches) and 18 centimeters (7 inches) for fishing and caught 13 and 15 species of fishes, respectively. The onboard supervisor from the Hampton Court landing site (Region 2) used drift seines with mesh sizes of 20 centimeters (8 inches), the largest mesh size used by an onboard supervisor, and recorded a species diversity of only six. In addition, fishing with Cadell lines also produced comparative species diversity. The onboard supervisor from Waramuri who used Cadell lines recorded the lowest species diversity of any survey participant (five species) over a 6-month study period.

Overall, the highest species diversity was reported from fisherfolk using the bangamary seines and Chinese seines. The highest species diversity haul was recorded by the onboard supervisor from the Riverview landing site, where 56 species were caught over the study period. This is consistent with the 54 species reported by the regional supervisor at the Riverview landing site (see Figure 4-11). This was the greatest species diversity recorded by any of the onboard supervisors and was attributed to a larger number of species being considered commercially viable by the onboard supervisor and greater disaggregation of species. The onboard supervisor from the Albion landing site (Region 6) also used bangamary seines and had a high species diversity of 31.

Although the onboard supervisor at the landing site at Windsor Forest (Region 3) also used Chinese seines for fishing, a relatively low species diversity of 12 was recorded. By contrast, onboard supervisors from the Lima (Region 2) and Ogle (Region 4) landing sites had highly diverse hauls, with 28 and 31 species reported. Indeed, species diversity from Windsor Forest is reminiscent of the species diversity reported by the regional supervisor from the Zeeburg landing site (Region 3) where fisherfolk also used Chinese seines and only 11 species were reported. Low species diversity is not typical of Chinese seine fishing and as observed by the study team, more fish species are caught as juveniles and are discarded as bycatch with small mesh nets like the Chinese seine than with other gear types.

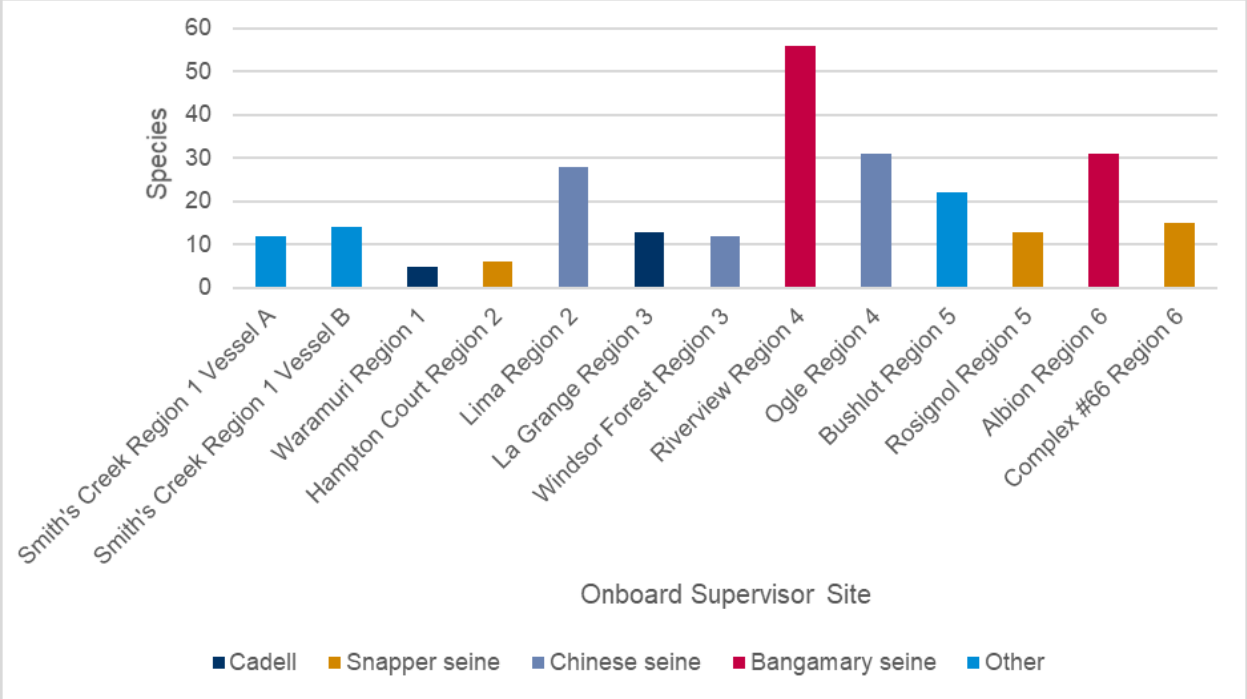

Figure 4-11: Species Diversity at Landing Sites with Onboard Supervisors

4.5 Biometrics

The annual average lengths of the target and most abundant species caught were consistent when fishing gear were similar, even though fishing activities occurred in ecologically different sites. Generally, as seen on Figures 4-12 and 4-13, the annual average lengths of the fishes caught were directly related to the size of the seines used at the landing sites.

Fisherfolk at the Charity landing site (Region 2) and the onboard supervisors from Hampton Court (Region 2), Rosignol (Region 5), and Complex 66 (Region 6) all used large mesh sizes to target larger species like snapper and gillbacker. As a result, the annual average lengths of fish caught at these sites

indicated that most fish had reached maturity. The largest fishes, including snapper, were caught by the onboard supervisor from Hampton Court who also used drift seines with the largest mesh sizes. At the Riverview and Mahaicony Bridge landing sites, the target species was bangamary and at both sites, the annual average lengths of the fishes based on data collected by the regional supervisors were 30 centimeters, which is the length at which this fish is considered sexually mature. Similarly, the annual average length of bangamary caught by the onboard supervisor from the Albion landing site had an annual average length of 31 centimeters, and therefore may also be considered sexually mature. However, the bangamary caught by the onboard supervisors at the Riverview (Region 4) and Albion (Region 6) landing sites had an annual average length of 29 centimeters and did not reach the maturity threshold.

According to data collected by the regional supervisor at Smith's Creek/Morahwanna (Region 1) and the onboard supervisor at Bushlot (Region 5), cuirass was the most abundant species caught and had annual average lengths of 53 centimeters and 58 centimeters, respectively. At both landing sites, the cuirass was sexually mature and most of the other species caught had also reached sexual maturity.

The similarity in sizes was observed for the shrimp caught by fisherfolk at landing sites at Lima (Region 2), Zeeburg (Region 3), Windsor Forest (Region 3), Ogle (Region 4), and Rose Hall (Region 6).

However, a few trends were observed at all the landing sites, as follows:

- All shark species caught are considered juveniles. Although the mesh sizes of most of the seines may be too small to capture mature shark, demand in local markets is for younger sharks. This is because the meat of juvenile sharks is considered more palatable due to its lower ammonia content compared to adult sharks.
- The majority of the fishes caught by the Chinese seines and pin seines were considered juveniles of their species. Some species caught at Lima (Region 2), Windsor Forest (Region 3), Ogle (Region 4), and Rose Hall (Region 6) had reached maturity, but these were only caught in lower quantities. The most frequently caught species of fishes were not sexually mature. At the landing sites in Windsor Forest and Ogle, juveniles of several different species were grouped under the umbrella terms "shine banga" or "flat banga." These fishes were generally discarded as bycatch.

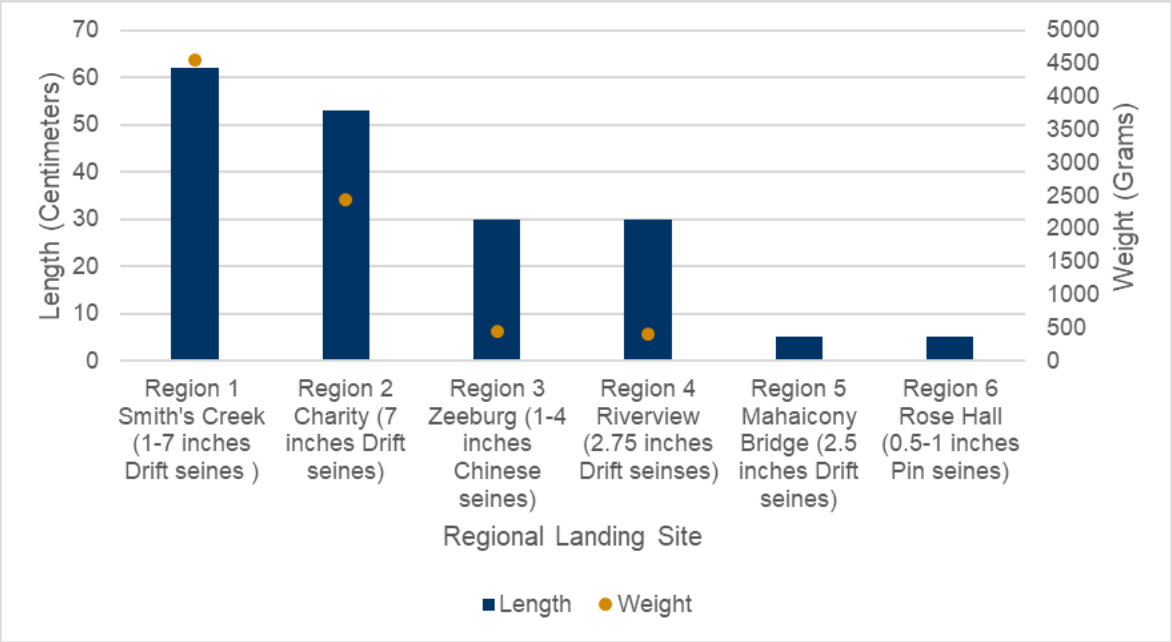

Figure 4-12: Average Lengths for the Most Abundant Species Caught at Landing Sites with Regional Supervisors

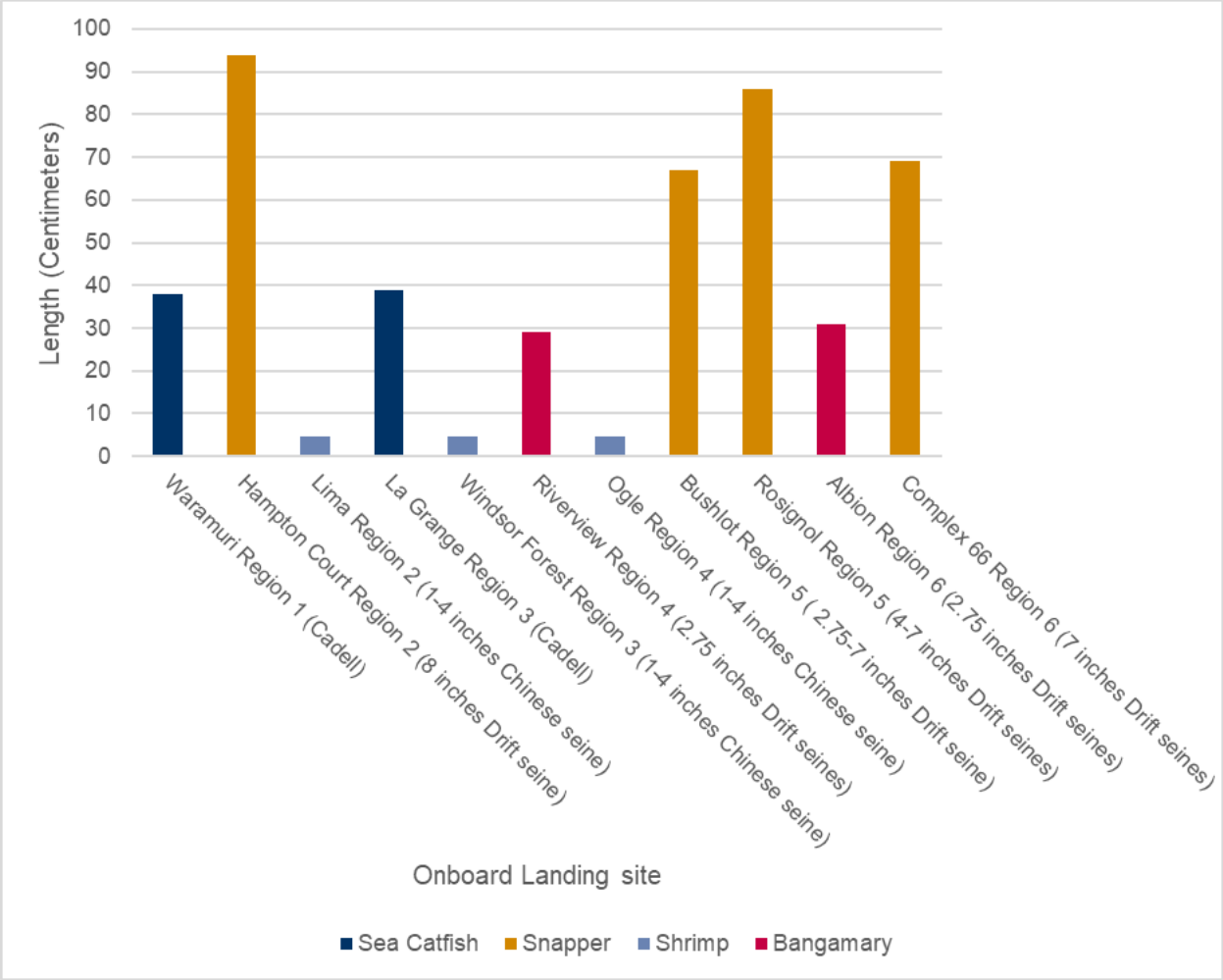

Figure 4-13: Average Lengths of the Most Abundant Species Caught at Landing Sites with Onboard Supervisors

4.6 Prices and Markets

Many factors contribute to the total value of sales per haul, including the species composition of the haul, the total weight of the haul, the size of the fishes that were caught, and bargaining with vendors or other customers. For example, at most of the landing sites where regional supervisors collected data, snapper was the most highly valued species when it was included in the haul and therefore, large hauls in which snapper is the most abundant species caught are likely to be more highly valued. As a consequence, the most valuable hauls were at the Charity (Region 2) landing site, where the target species was snapper and where the largest average weight of hauls was reported. The total value of sales at the Charity landing site was significantly higher than sales at any of the other landing sites (see Figure 4-14). However, the value was likely even higher because the price per kilogram of snapper and trout glue (swim bladders) is equivalent to or higher than the price per kilogram of the flesh of the fishes. However, the price valuation of glue was not part of the data collection effort of this study.

At Riverview (Region 4) and Mahaicony Bridge (Region 5), bangamary was the primary target species. However, unlike the pricing trends at Charity, the target species was not the most highly valued. Instead, bangamary was a medium-value species at these landing sites. This was also observed at Zeeburg (Region 3), where the target species, white belly shrimp, was also a medium-value species. Although not

the target species at Smith's Creek/Morahwanna (Region 1), cuirass was the most abundant species caught and was also a medium-value species at the landing site. In these instances, the value of an average haul is strongly associated with its volume/weight. In particular, when more fishes (hauls are heavier) are caught, earnings are likely to be higher, and when fewer fishes are caught, earnings are likely to be lower.

Fisherfolk also reported that prices are also determined based on the outcomes of bargaining with vendors and other customers. In addition, fisherfolk have reported that there is typically size bias in pricing fishes. For example, bangamary at the Zeeburg landing site was significantly smaller (juveniles) and consequently, significantly cheaper than at other landing sites. At the Rose Hall (Region 6) landing site, where fisherfolk sell hauls directly to consumers in local markets rather than to third party vendors, the prices for most species were significantly higher than those reported by other regional supervisors. The prices per kilogram of target species at other landing sites (snapper, bangamary, and white belly shrimp) were higher at Rose Hall.

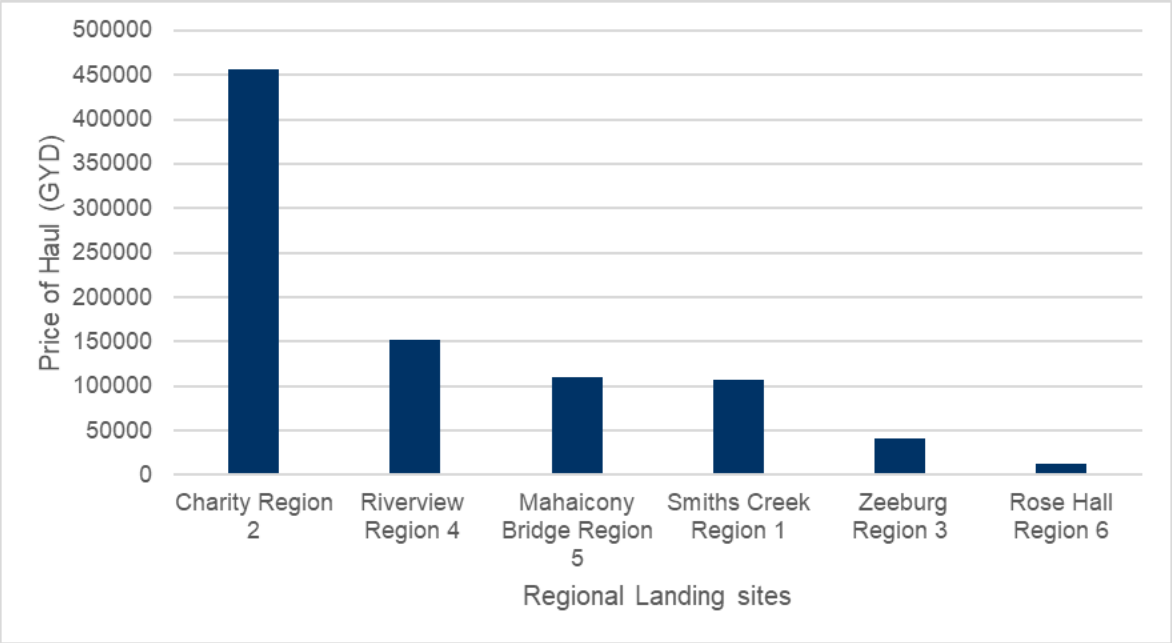

Figure 4-14: Prices of an Average Haul at Landing Sites

4.7 Fishing Grounds

During the study period, the onboard supervisors took GPS waypoints of their fishing points and routes traveling to these fishing points. Generally, **the total distance traveled and the distance offshore at which activities occurred were linked to the supervisor's fishing practices, including the target species and vessel type used.**

The onboard supervisors from Lima (Region 2) and Windsor Forest (Region 3) who used Chinese seines had the smallest traveling range of 20 and 25 square kilometers, respectively. This is due to the static nature of their fishing practices where the pens used to set the Chinese seines are located in a single cluster. However, the pens used by the Windsor Forest onboard supervisor are significantly farther offshore than those used by the onboard supervisor from Lima. Although the onboard supervisor from the Ogle (Region 4) landing site also used Chinese seines for fishing, multiple pens were used in various locations. This resulted in a significantly larger traveling range, and in fishing points also located even farther offshore.

The traveling range of the onboard supervisor from Riverview (Region 4) was significantly different than those of the onboard supervisor from Albion (Region 6). The onboard supervisor from Riverview had a traveling area encompassing 1,041 square kilometers. This was seven times larger than the area covered by the Albion onboard supervisor, who had a 141-square-kilometer traveling area. However, the maximum distance offshore at which fishing occurred was consistent between these landing sites, with both supervisors traveling 32 to 33 kilometers offshore to fish. In addition, the onboard supervisor from Riverview also fished significantly closer to shore (0.4 kilometer) than the onboard supervisor from Albion, whose minimum distance from shore was 2 kilometers. The difference in traveling range and minimum fishing distance may have been related to greater foraging for fishing grounds by the onboard supervisor from Riverview due to the increased competition for fishing grounds. For fisherfolk targeting bangamary, three large landing sites at Hope Canal, Bee Hive, and Enmore are within 10 kilometers of the Riverview landing site.

The onboard supervisor from the La Grange landing site (Region 3) traveled farther offshore (46.5 kilometers) for fishing than any of the other onboard supervisors, almost three times the maximum distance offshore at which the onboard supervisor from Waramuri/Haimokabra (Region 1) fished. Several factors may influence such a large distance to fishing grounds. In particular, the fishing grounds were located at the mouth of the Demerara River, which is a highly traversed area. Traveling farther offshore to fish may have been an attempt to find relatively low-traffic fishing grounds to minimize conflicts and to prevent fishing activity disturbance.

The largest traveling area covered was by the onboard supervisors targeting snapper at Complex 66 (Region 6), with 7,003 square kilometers, and at Rosignol (Region 5), with 6,076 square kilometers (see Table 4-2). These vessels are both licensed to fish in Surinamese waters and fished frequently there during the study period. The snapper vessels generally have larger foraging areas as snapper is a large predator and therefore, more difficult to catch. However, although they have significant traveling ranges, fishing occurs relatively close to shore. Maximum distance traveled offshore by the onboard supervisor from Rosignol (Region 5) is comparable to the farther offshore fishing points recorded by the supervisors from Riverview (Region 4) and Albion (Region 6) who target bangamary. Indeed, the maximum distance traveled by the onboard supervisor from Complex 66 was significantly lower than those of the onboard supervisors from Riverview and Albion. By contrast, the traveling range used by the onboard supervisor from Hampton Court (Region 2) was relatively small and maximum distances fished offshore were even lower than for Rosignol and Complex 66. However, the onboard supervisor indicated that these fishing grounds have been sufficiently productive for years and are not likely to change.

The onboard supervisor from Bushlot (Region 5) uses drift seines with relatively large mesh sizes to target large fishes like snapper and trout. However, the onboard supervisor uses a sailboat and fished closer to shore than any of the snapper vessels from Hampton Court, Rosignol, or Complex 66. Moreover, the haul capacity of the sailboat is lower and this requires the onboard supervisor to take relatively short fishing trips. For example, fishing trips by the onboard supervisor from Hampton Court last for 2 to 8 days, but the onboard supervisor's fishing trips lasted only 12 hours on average. In addition, the onboard supervisor also alternated the seines with different mesh sizes throughout the study period based on success experienced during previous fishing trips in specific fishing grounds. By contrast, the other onboard supervisors targeting snapper consistently used drift seines with mesh size of 17 to 20 centimeters (7 to 8 inches). As a result of these factors, the most abundant species caught was cuirass.

Table 4-2: Distances Covered by Onboard Supervisors

Onboard Landing Site	Traveling Range (square kilometers)	Minimum Distance Offshore (kilometers)	Maximum Distance Offshore (kilometers)	Maximum Distance from Landing Site (kilometers)
Smith's Creek Region 1	1,741	0.22	11	138.41
Waramuri, Region 1	458	0.53	12.5	60.61
Hampton Court, Region 2	272	4	15	21.68
Lima, Region 2	20	0.23	1.37	1.38
La Grange, Region 3	2,226	9.3	46.5	52.69
Windsor Forest, Region 3	25	10.3	10.3	10.3
Riverview, Region 4	1,041	0.4	33	34.3
Ogle, Region 4	151	0.8	14.68	14.68
Bushlot, Region 5	255	0.25	8.5	8.5
Rosignol, Region 5	6,076	1.46	33.06	205
Albion, Region 6	142	2	32.6	36
Complex 66, Region 6	7,003	1.96	23.12	259

Figure 4-15 shows the extent of the fishing grounds used by the onboard supervisors. Although there were only 13 onboard supervisors, significant overlaps were observed in their fishing grounds. For example, fishing grounds were shared by onboard supervisors as follows:

- Smith's Creek and Waramuri overlapped in Region 1
- La Grange overlapped with Windsor Forest in Region 3, along with Ogle and Riverview in Region 4
- Rosignol (Region 5) overlapped with fishing grounds of all onboard supervisors from Regions 5 and 6, La Grange (Region 3), and Ogle and Riverview (Region 4)
- Complex 66 overlapped with Rosignol (Region 5) and Albion (Region 6)

Individual fishing grounds and routes by landing site are shown on Figures 4-16 through 4-27 and discussed in Sections 4.8 and 4.9.

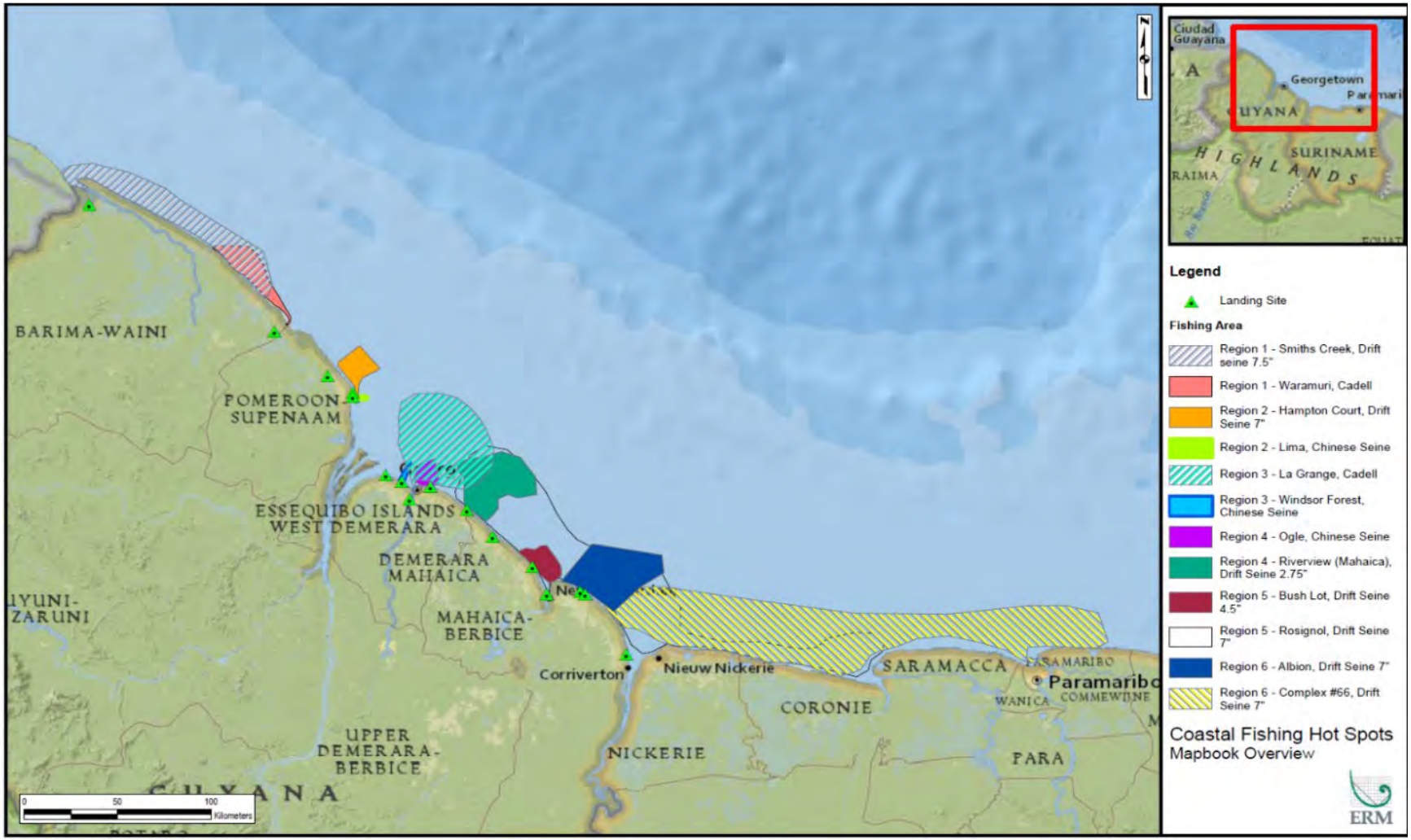

Figure 4-15: Fishing Grounds Used by Onboard Supervisors

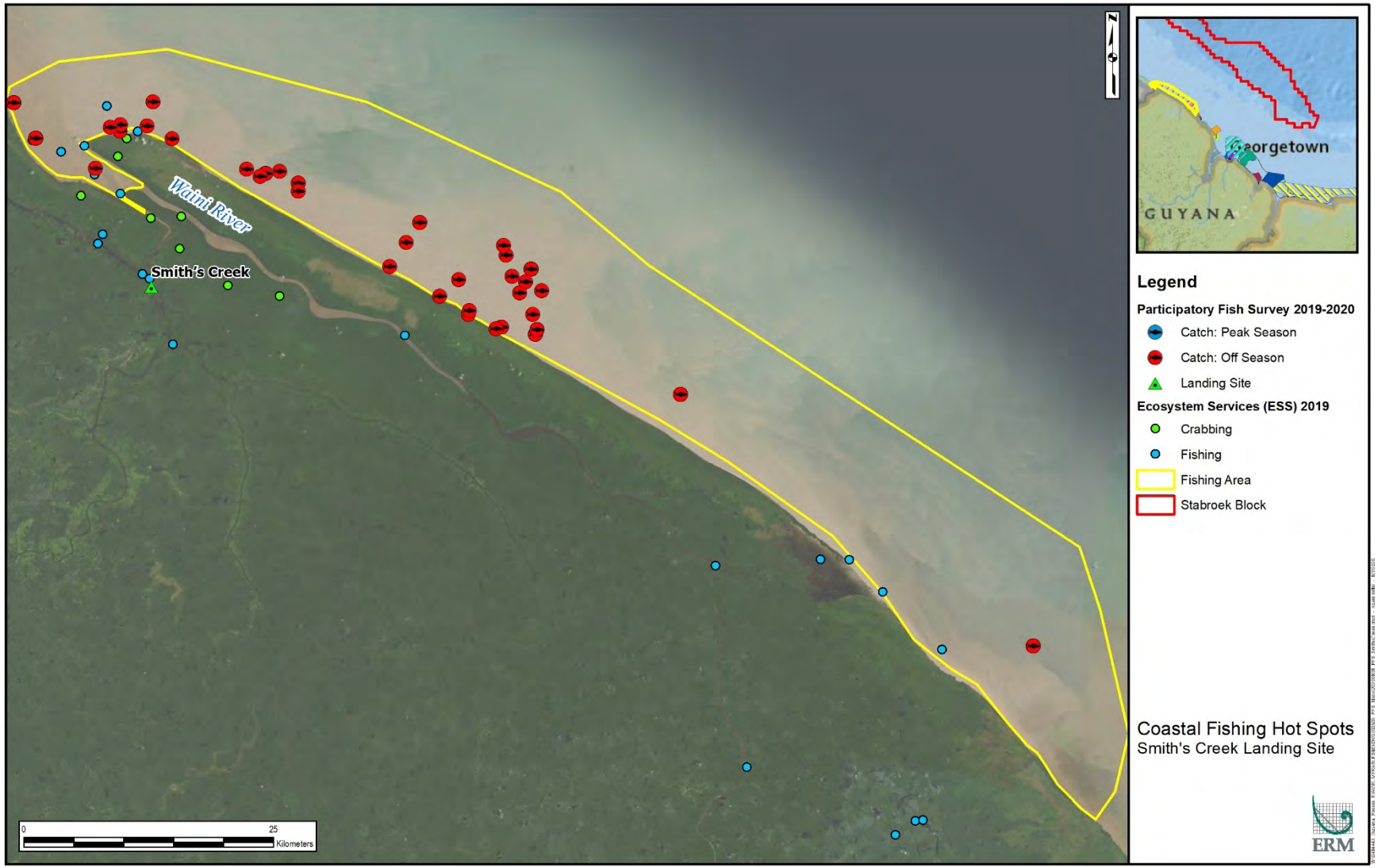

Figure 4-16: Smith's Creek, Region 1

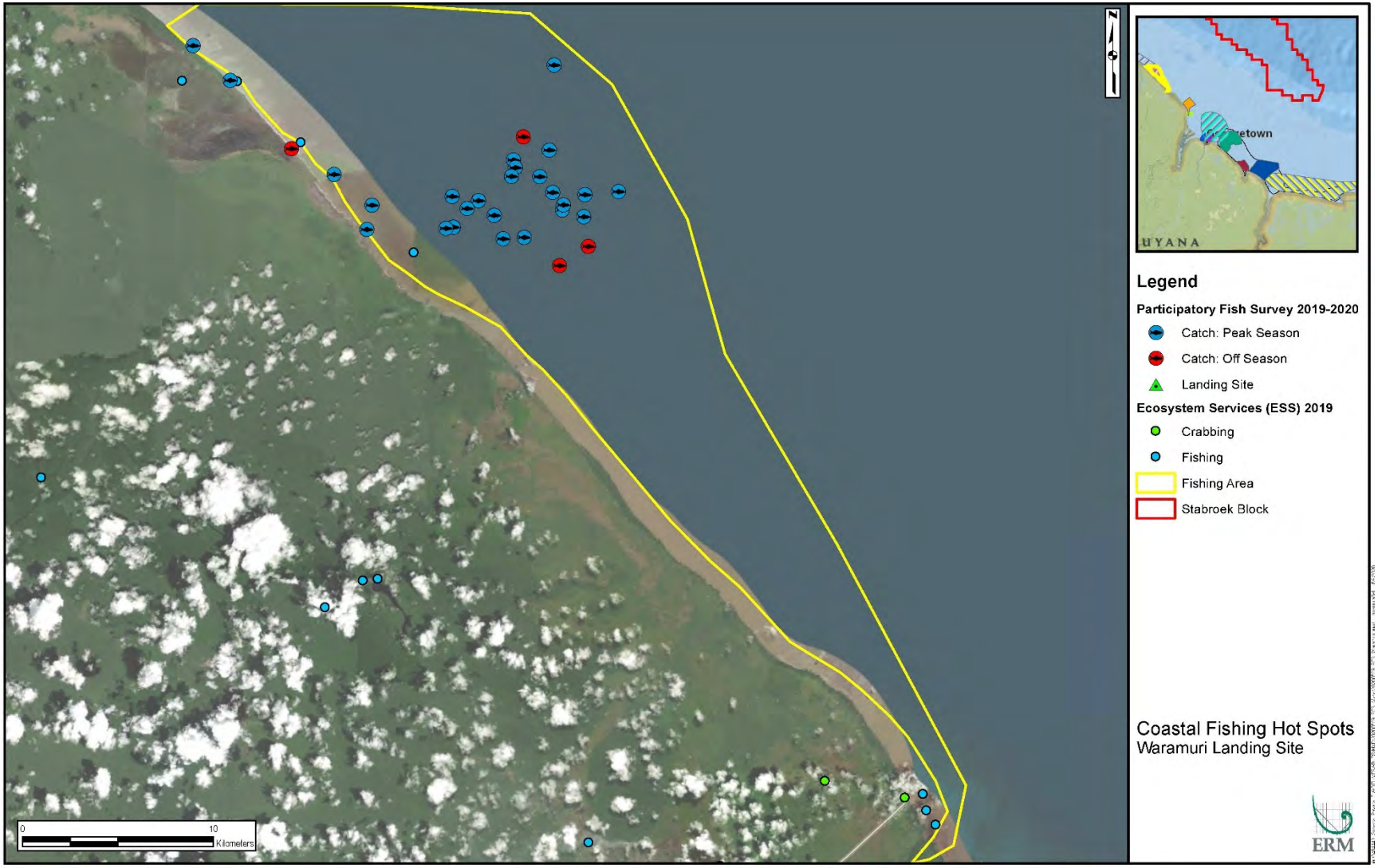

Figure 4-17: Waramuri, Region 1

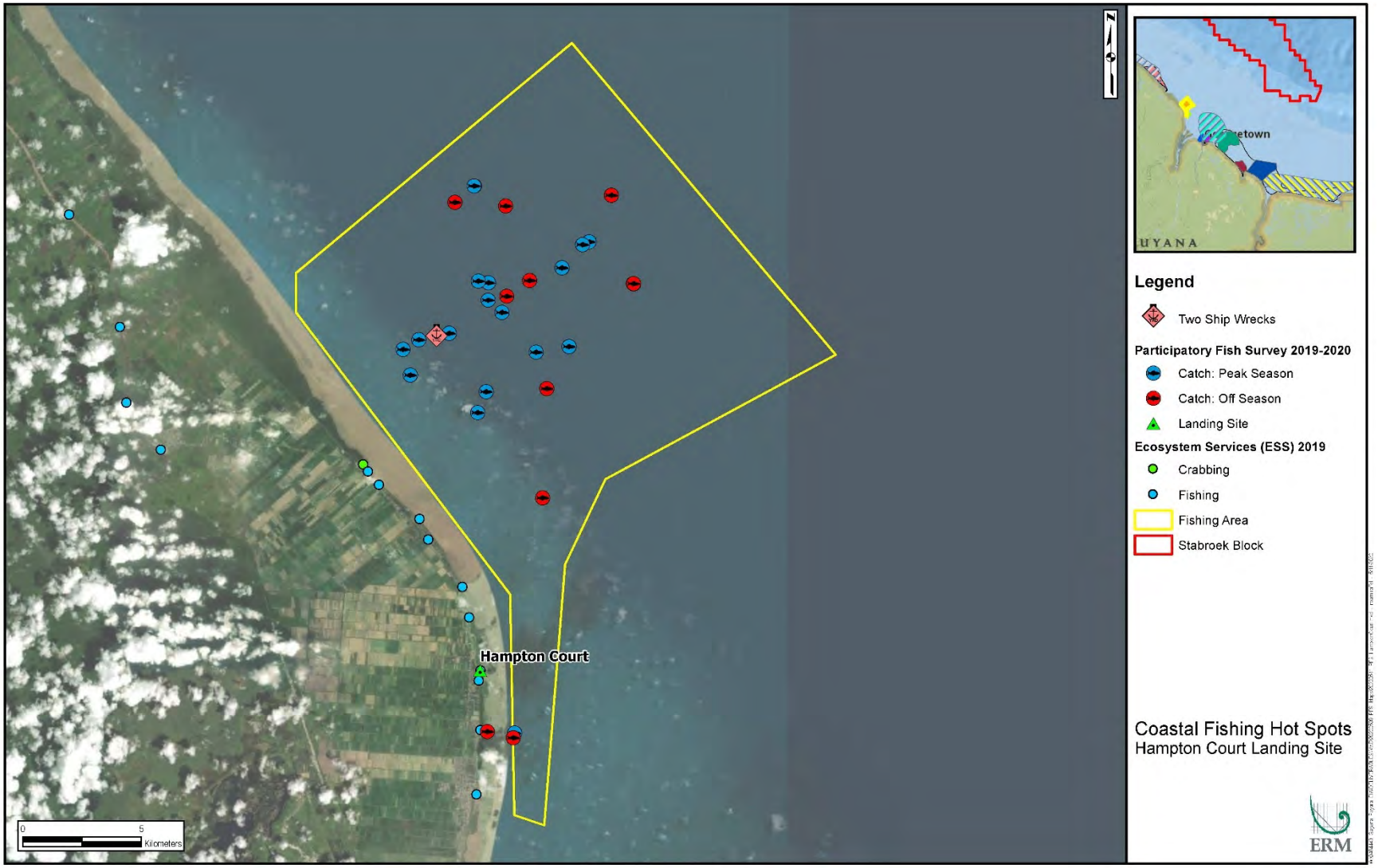

Figure 4-18: Hampton Court, Region 2

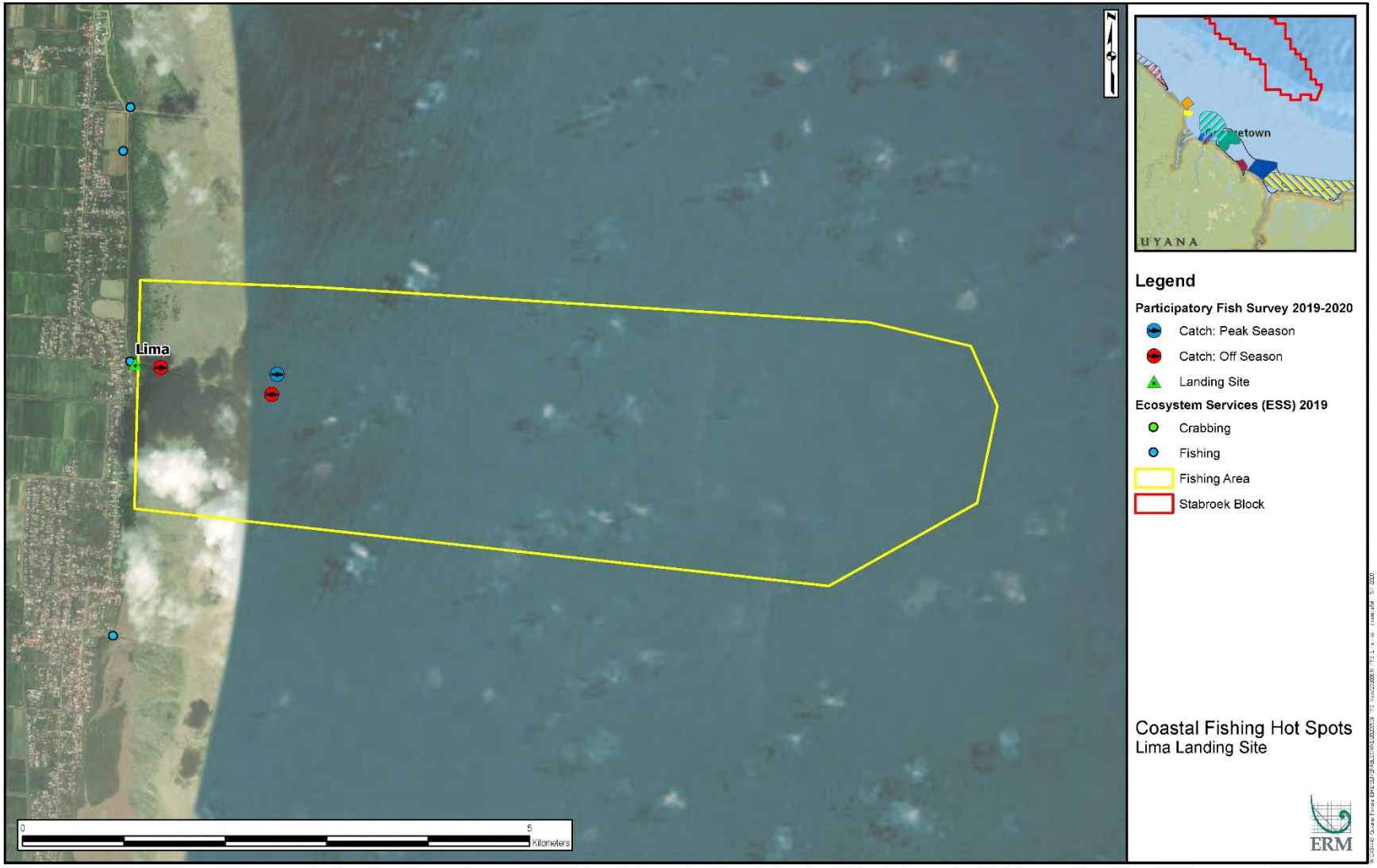

Figure 4-19: Lima, Region 2

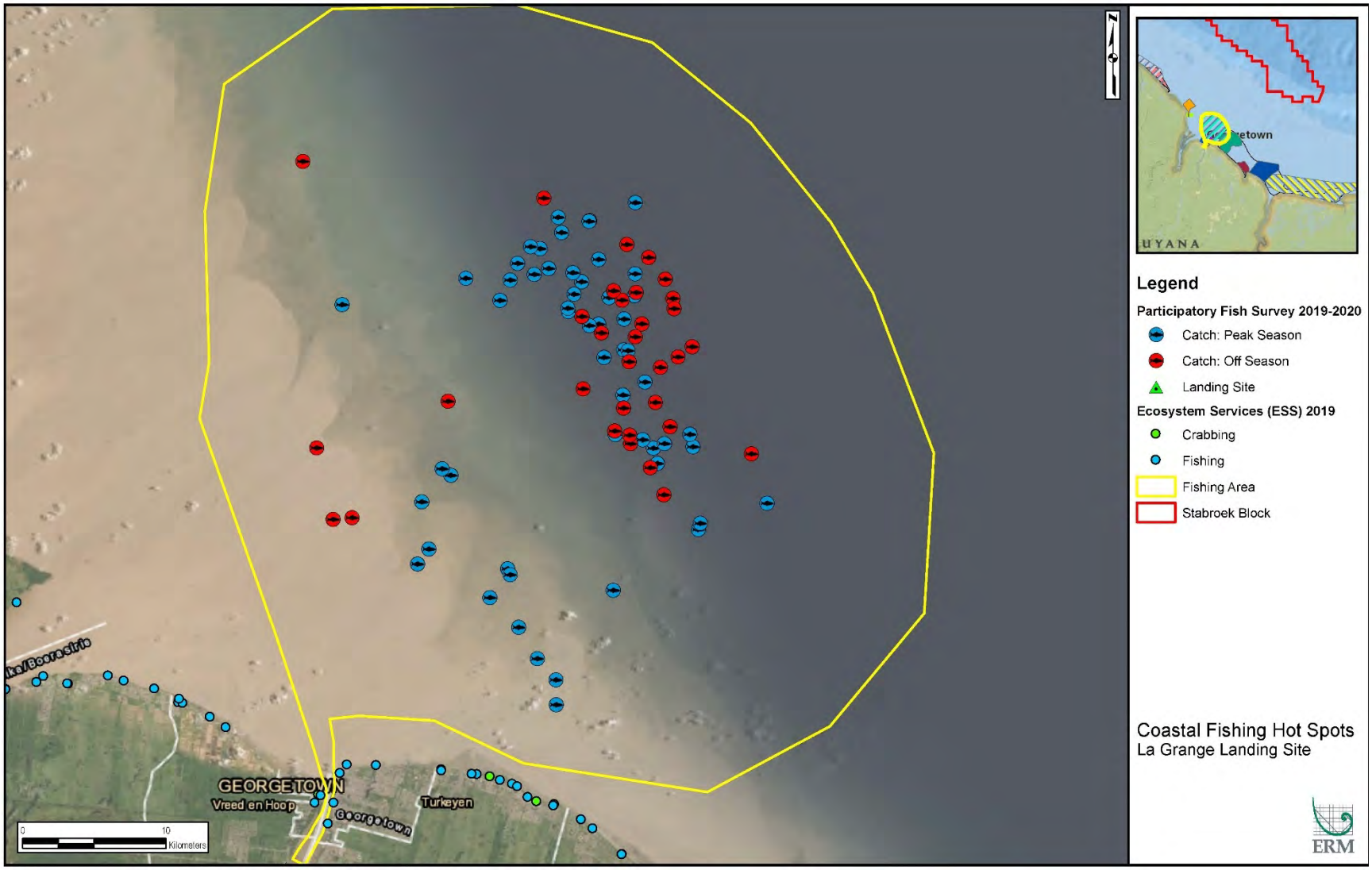

Figure 4-20: La Grange, Region 3

Figure 4-21: Windsor Forest, Region 3

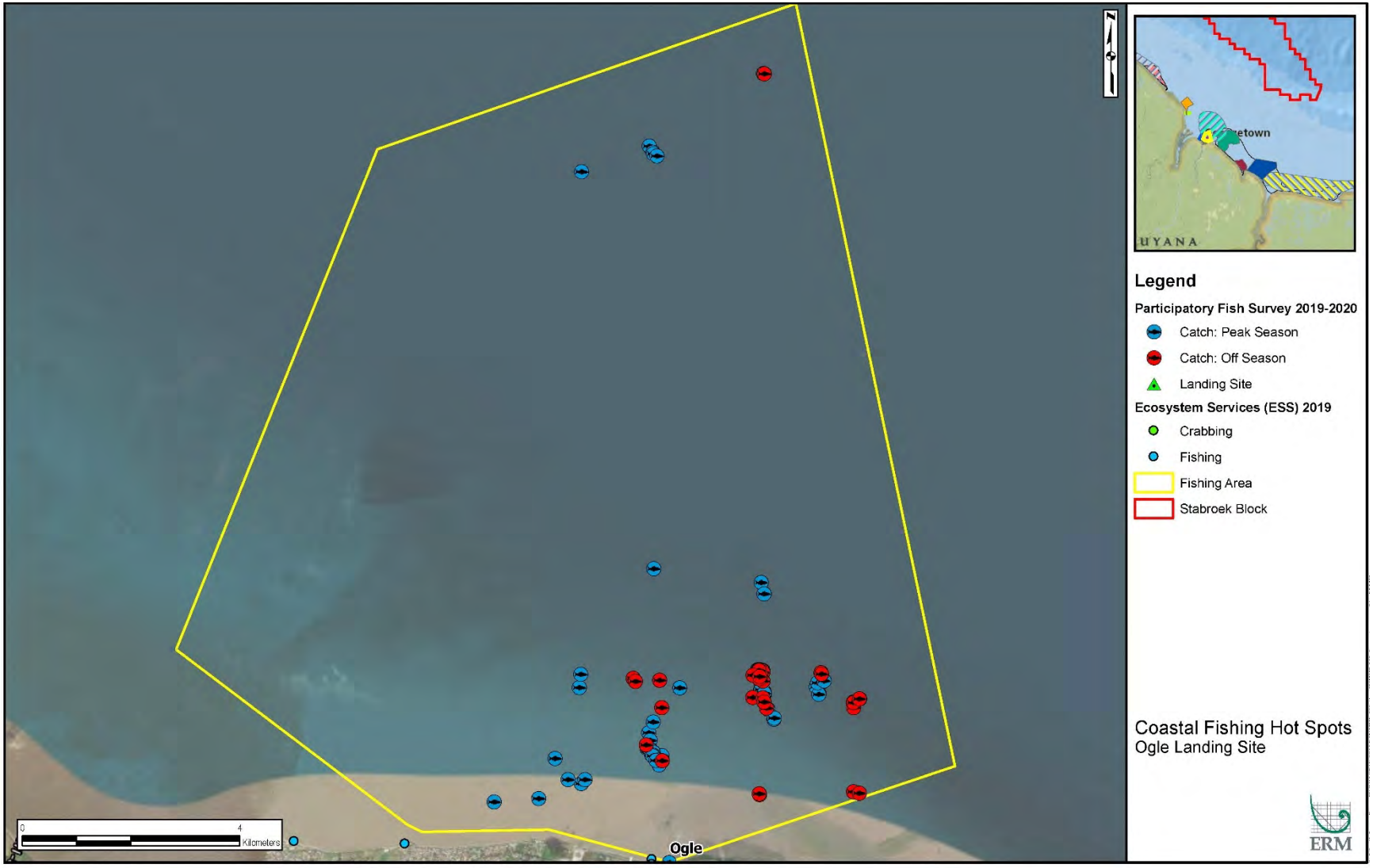

Figure 4-22: Ogle, Region 4

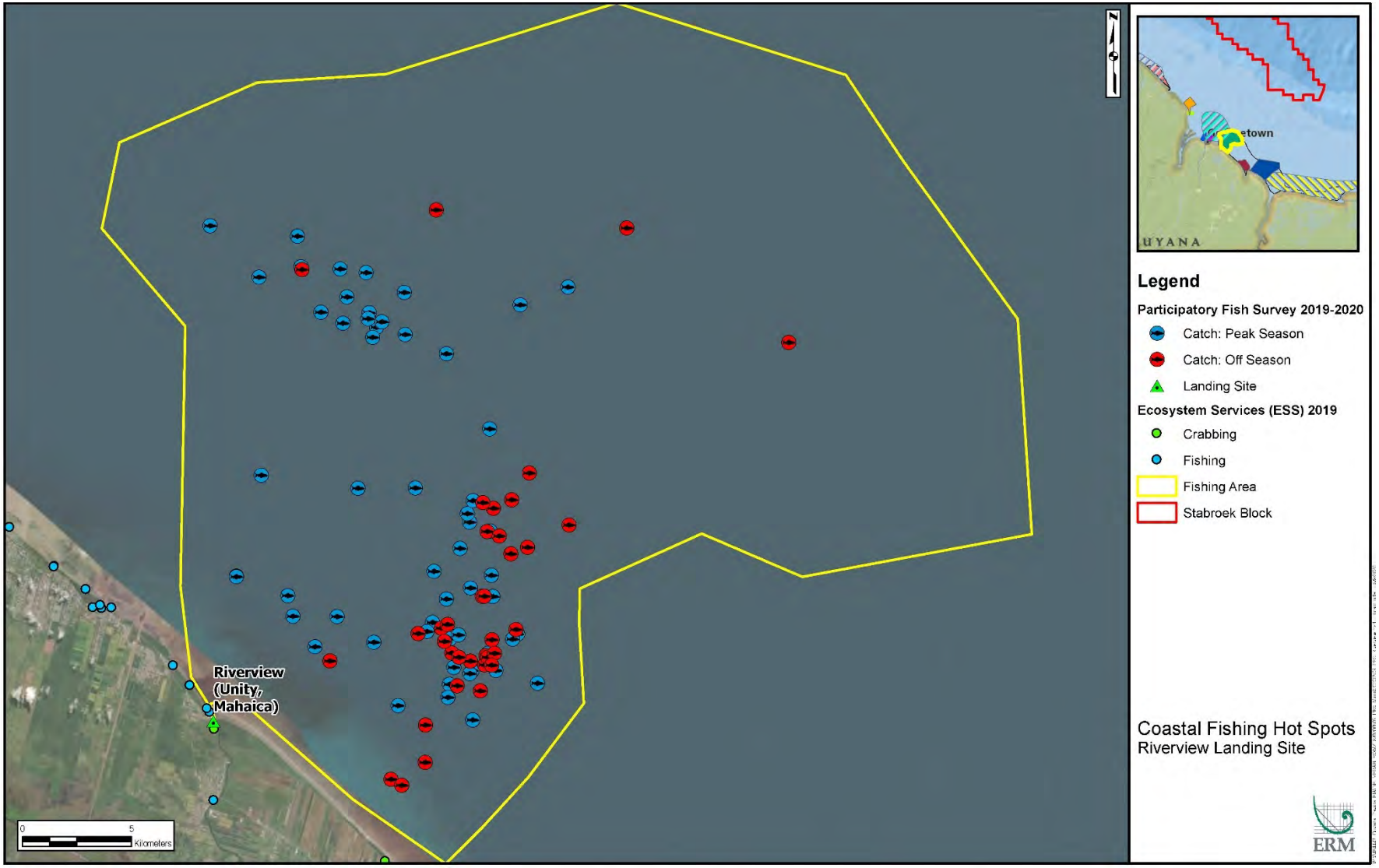

Figure 4-23: Riverview, Region 4

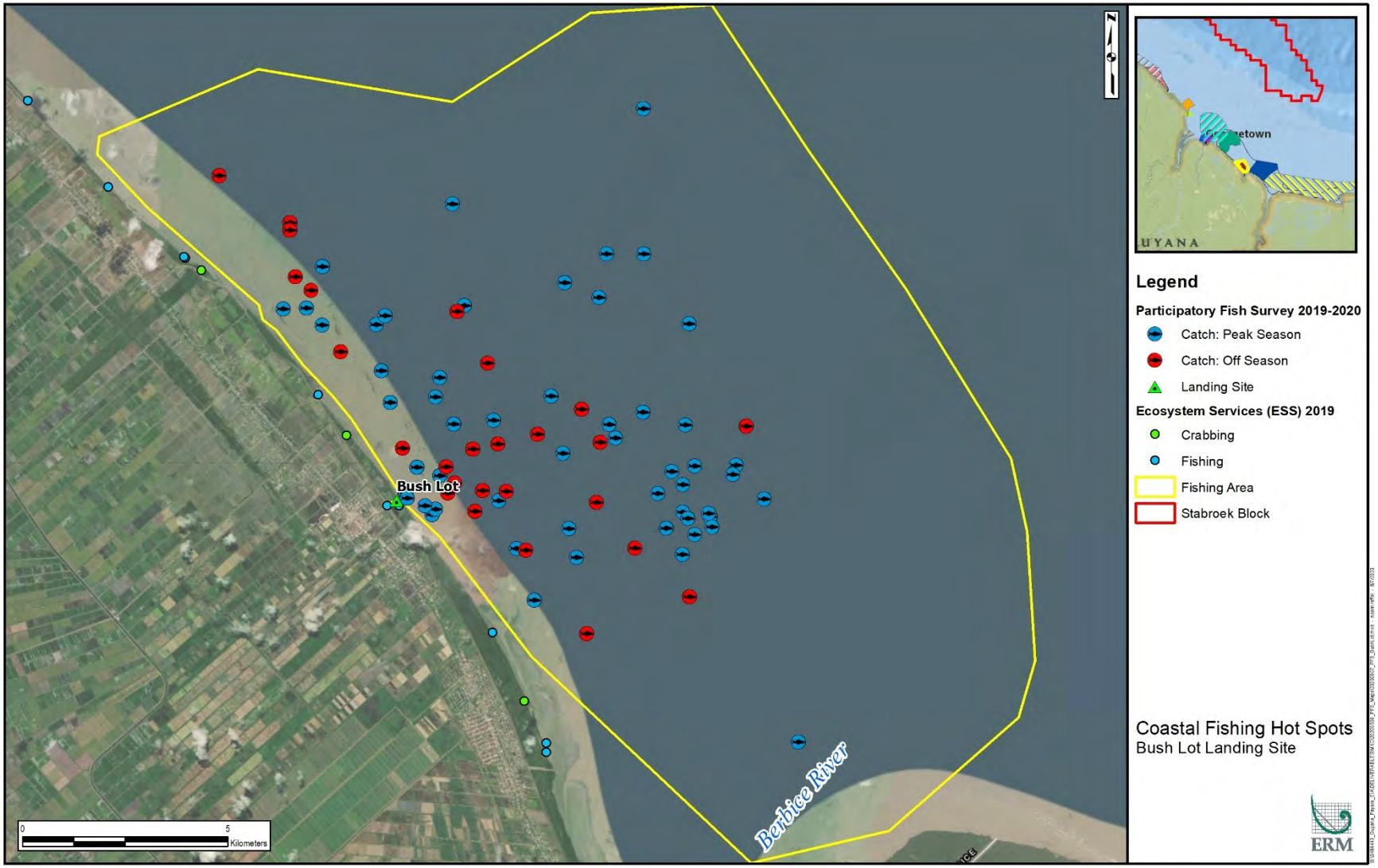

Figure 4-24: Bushlot, Region 5

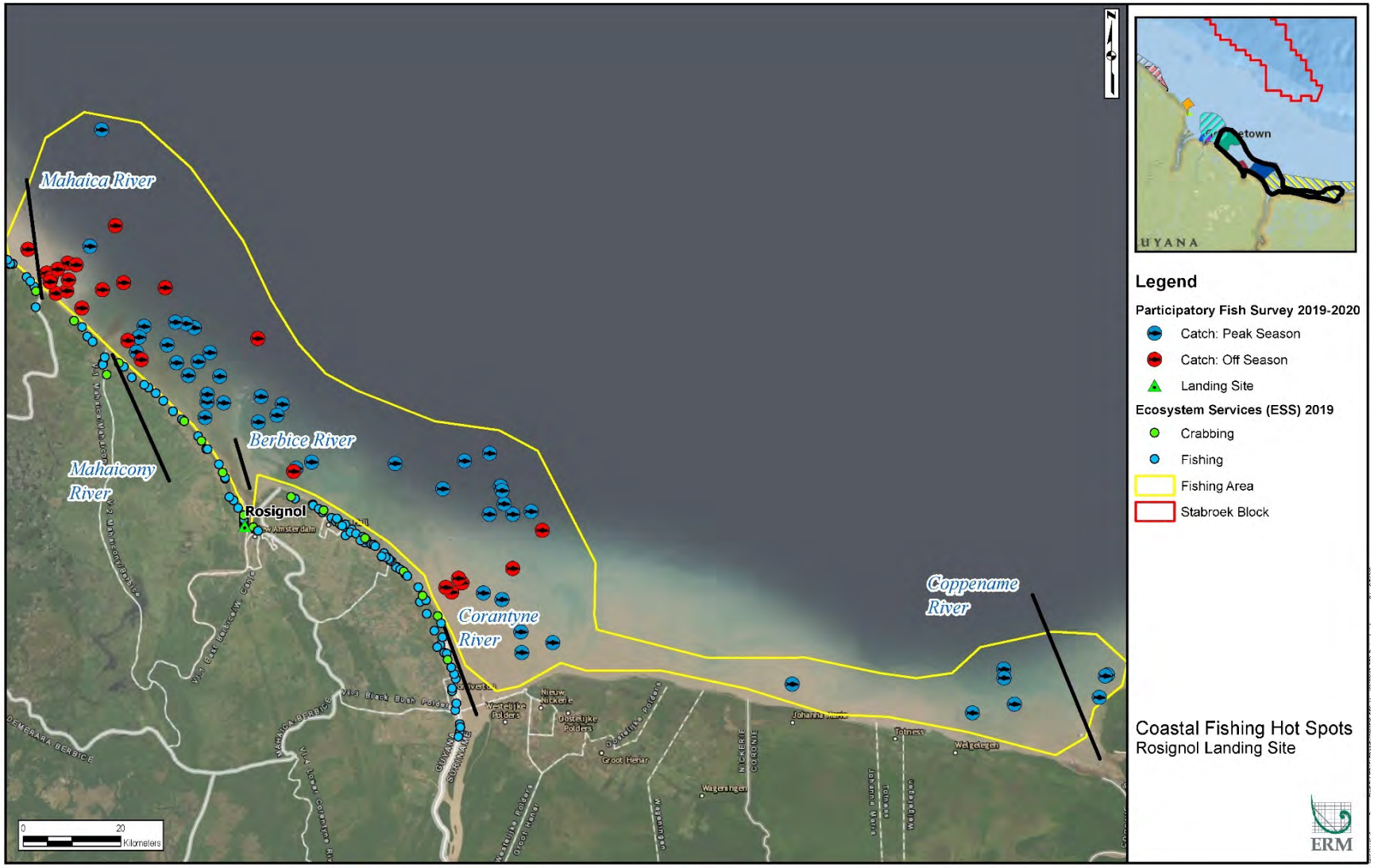

Figure 4-25: Rosignol, Region 5

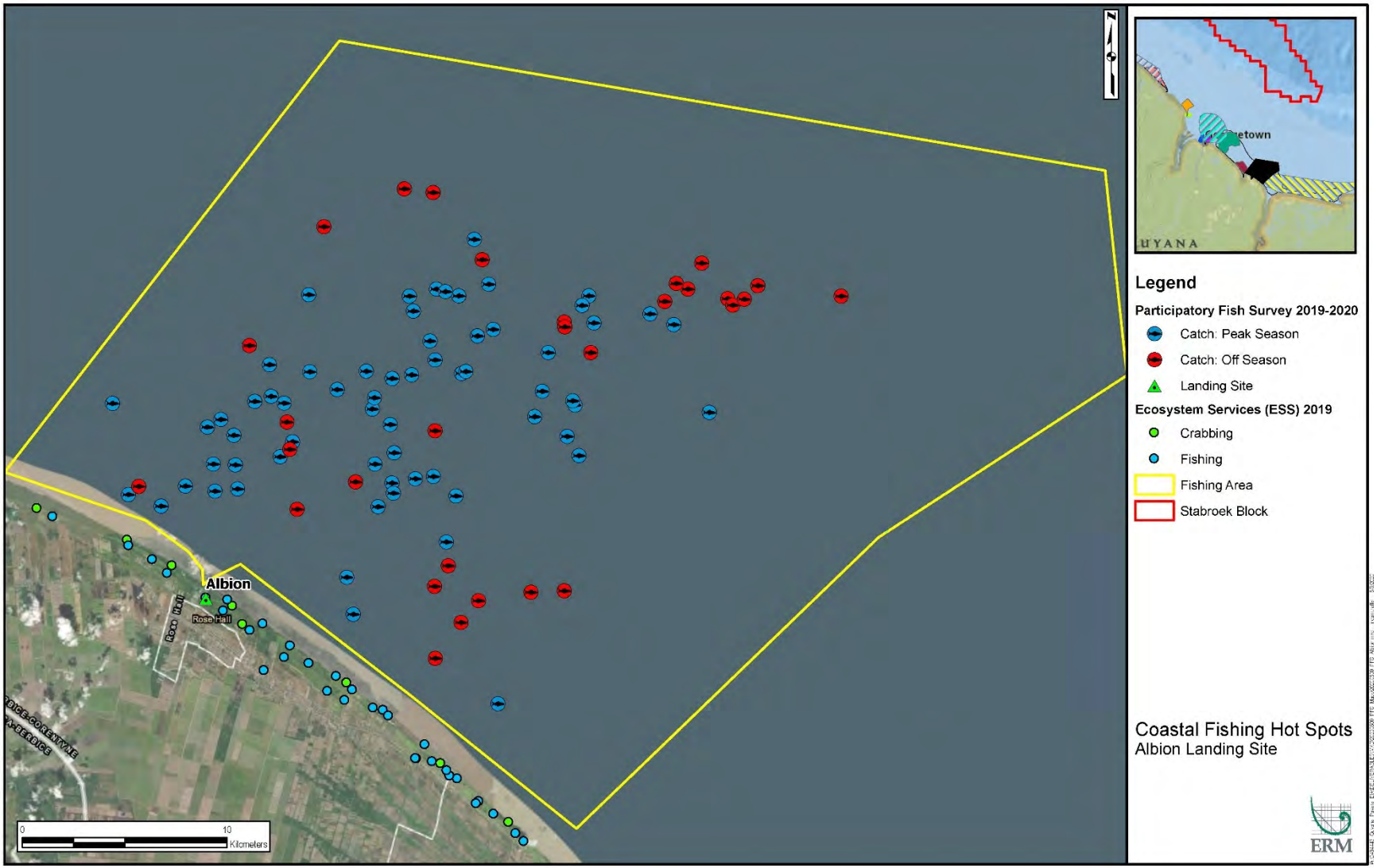

Figure 4-26: Albion, Region 6

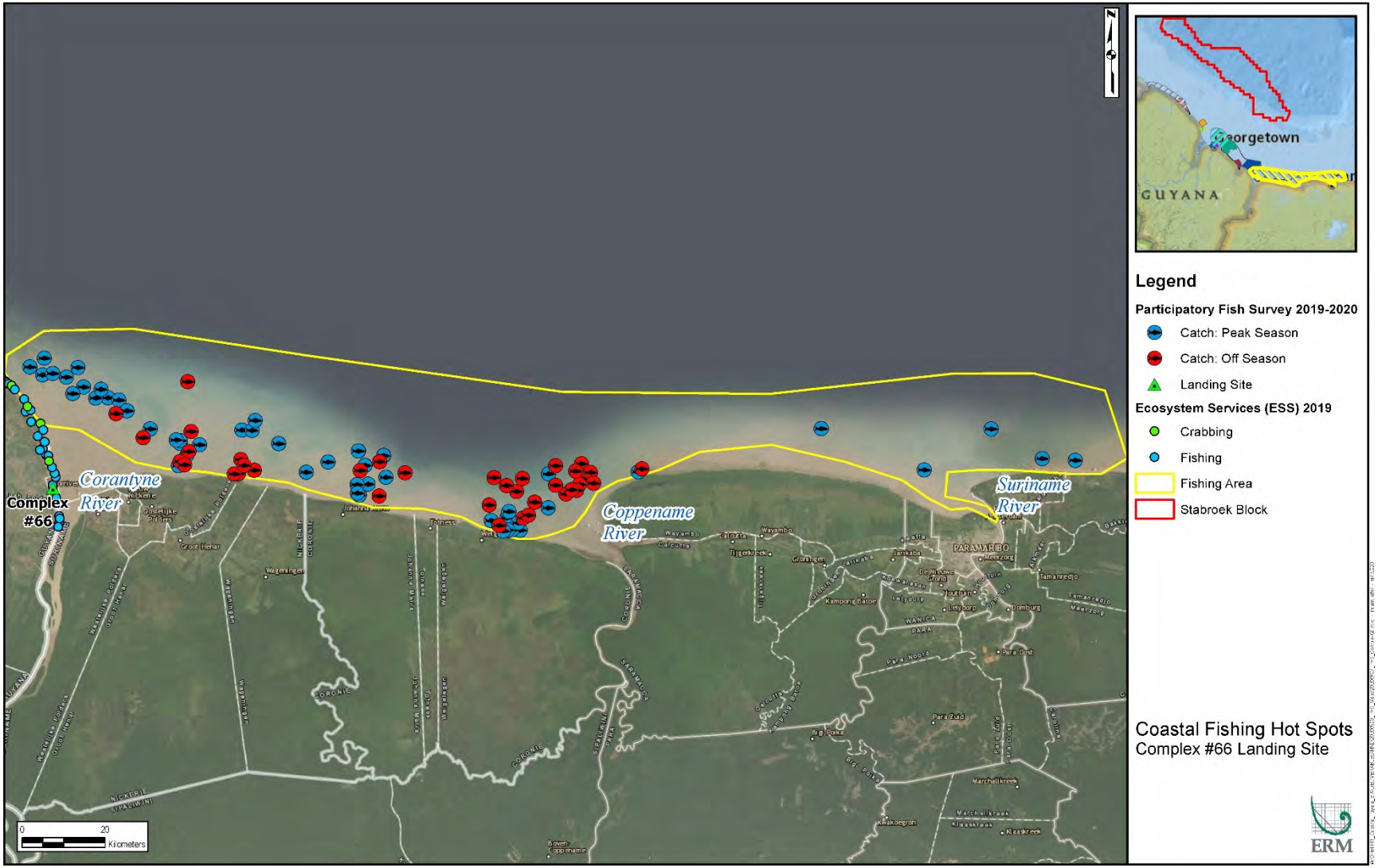

Figure 4-27: Complex 66, Region 6

4.8 Summary of Landing Sites with Regional Supervisors

At the Smith's Creek/Morahwanna landing site (Region 1), the main fishing method was drift seines with mesh sizes ranging from 2.5 to 18 centimeters (1 to 7 inches). As a result of these varied methods, no target species was identified, and the most abundant species caught was cuirass, which can be caught using any of the seine mesh sizes used at this landing site. Hauls also included jewfish and stingrays (endangered, threatened, and protected species), as well as shark species—some of which may be considered endangered, threatened, and protected, or vulnerable species. In total, 36 different commercial species of fishes were caught, with a total weight of 80,830 kilograms (178,200 pounds). During the study period, a fuel shortage, which in turn led to high fuel prices, occasionally made fishing trips economically unfeasible. As a result, fuel prices significantly affected the effort expended by fisherfolk; the increased effort during peak season may have resulted in a greater total haul. In total, sales at this landing site during the study period were $26,721,374 GYD ($127,853 USD) based on data collected. Fishes are valued differently at this landing site and a wide range of species are considered commercially viable. In addition, high fuel prices also affected the prices since the increased expenses borne by fisherfolk were ultimately passed on to the consumers in the form of higher prices. The majority of the fishes measured at this landing site had achieved sexual maturity.

The Charity landing site (Region 2) is one of the largest landing sites for inboard cruisers, the largest artisanal fishing vessels. The landing site has an artisanal vessel fleet of 70. Vessels use drift seines with mesh sizes of 10 to 20 centimeters (4 to 8 inches) to target snapper. These vessels have extended fishing trips averaging 15 days at sea. Hauls also included jewfish (endangered, rare, and protected species) and shark species—some of which may be considered endangered, rare, and protected, or vulnerable species. In total, 14 commercial species of fishes were caught, with a total recorded weight of 105,370 kilograms (232,301 pounds). Snapper was the most abundant species caught and accounted for 60 percent of the total recorded weight at the landing site. The May to September 2019 period was the most productive fishing period at this landing site. In total, sales of fishes at this landing site were valued at $54,725,111 GYD ($263,101 USD) based on the data collected. These were the highest earnings at any landing site at which regional supervisors collected data. In addition, fisherfolk at this landing site sell the glue (swim bladders) of snapper and trout separately and have reported that the price per kilogram of glue is frequently higher than the price per kilogram of the flesh of these fishes. If earnings from the sale of glue were not included, it is likely that the total sale value of fishes would be significantly lower. The majority of the fishes measured at this landing site had achieved sexual maturity.

The Zeeburg landing site (Region 3) is one of the largest landing sites in Guyana for vessels that use Chinese seines to target white belly shrimp. The landing site has an artisanal vessel fleet of 30. The landing site is also used for drying white belly shrimp. Fishing activities were significantly affected by infrastructural works at the landing site and by damage to the landing due to spring tides at the end of September 2019, which caused all activities to temporarily cease in October. In total, 11 commercial species were caught with a total recorded weight of 111,535 kilograms (245,892 pounds). White belly shrimp was the most abundant species caught, accounting for 85 percent of the total haul. The species diversity of the hauls is expected to be greater, but most other species caught would have been considered juveniles. In total, sales at this landing site were valued at $31,295,960 GYD ($150,461 USD) based on the data collected. None of the fishes caught at this landing site were measured as being sexually mature.

The Riverview landing site (Region 4) had an artisanal vessel fleet of 30. Most vessels use drift seines with mesh sizes of 7 centimeters (2.75 inches), known as bangamary seines, to target bangamary. A few vessels use drift seines with mesh sizes of 10 centimeters (4 inches) to target snapper. In total, 54 species were caught at this landing site, with a total haul weight of 133,977.5 kilograms (295,369 pounds). Bangamary, butterfish, and trout were the most abundant species caught, accounting

for 36, 23, and 21 percent of the total haul, respectively. Hauls at this landing site included several species of shark including the blacktip shark (endangered, threatened, and protected species) and hammerhead shark, species that are considered vulnerable. Data are not available for the July to September 2019 period (accurate and reliable data were not collected by the regional supervisor; see Appendix N), and it is likely that the total haul would have been higher had these data been included in the data set. Nonetheless, total recorded haul at this landing site was the highest total haul of any of the landing sites at which regional supervisors collected data. In addition, there was a greater species diversity, which was likely due to more species being considered commercially viable, as well as the disaggregation of species caught. For example, four species of shark and four species of snapper were recorded. In total, sales at this landing site were valued at $45,323,998 GYD ($217,904 USD). Shark species were more highly valued at this landing site than at any other landing site. The majority of the fishes measured at this landing site had achieved sexual maturity.

The Mahaicony Bridge landing site (Region 5) had an artisanal vessel fleet of 15. Most of the vessels use drift seines with mesh sizes of 6.5 centimeters (2.5 inches) to target bangamary. In total, 20 species were caught at this landing site with a total haul weight of 118,702 kilograms (261,693 pounds). Bangamary was the most abundant species caught, accounting for 76 percent of the total haul. The second and third most abundant species caught were butterfish and trout, which accounted for 12 and 5 percent of the total haul, respectively. During the study period, the most abundant hauls were recorded over the July to October 2019 period. In total, sales of fishes at this landing site were valued at $29,997,072 GYD ($144,216 USD). The majority of the fishes measured at this landing site had achieved sexual maturity.

The Rose Hall landing site (Region 6) was the smallest landing site in the study. During the baseline data collection in February 2019, four fisherfolk were actively using the landing site. However, the number of fisherfolk operating at the landing site declined due to migration and by February 2020, only two fisherfolk continued to use the landing site. Both of these fisherfolk use pin seines with mesh sizes of 2.5 to 3.8 centimeters (1 to 1.5 inches), targeting shrimp. High tides and rough waters significantly affected fishing activities at this landing site in September 2019 and in January to February 2020. In total, 21 species were caught at this landing site, with a total haul weight of 5,325 kilograms (11,805 pounds). The most abundant species caught was shrimp, accounting for 78 percent of the total haul. Sales at this landing site were valued at $2,509,451 GYD ($12,065 USD) based on the data collected. In general, prices for most species were significantly higher than those reported by other regional supervisors. Some of the fishes caught were measured as being sexually mature, but the majority was juveniles.

4.9 Summary of Landing Sites with Onboard Supervisors

At Smith's Creek, two onboard supervisors collected data. Both vessels used the 2.5-, 5-, 7.5-, 10-, and 12.7-centimeter (1-, 2-, 3-, 4-, and 5-inch) mesh size drift seines to conduct their respective fishing activities. Vessel A was the larger of the two vessels and targeted sea bats that were sold to vendors who exported the haul to Venezuela. This vessel had a haul capacity of 3,000 kilograms (6,600 pounds) and used a 40 hp engine. The vessel typically fished along the Atlantic Coast in Region 1 and recorded a total haul of 19,813 kilograms (43,680 pounds) from 576 hours of effort from November 2019 to January 2020. In total, 12 different species were caught. Based on the average sizes of the sea bats, most were juveniles.

Vessel B at Smith's Creek had a total capacity of 1,000 kilograms (2,200 pounds) and was powered by a 15 hp engine. This vessel fished close to the mouths of the Barima and Waini rivers. Vessel B recorded a total haul of 3,511 kilograms (7,740 pounds) from 924 hours of effort in November and December 2019. The species diversity was 14, with snapper being the most abundant species caught. However, it accounted for only 7.6 percent of the total haul, which shows a balanced haul, a lack of bias, and no

specific target species. Most of the fishes caught by this vessel were measured as having reached sexual maturity.

Waramuri is an Amerindian community on the west bank of the Moruca River, where approximately 20 vessels normally operate, all equipped with outboard engines ranging from 5 to 48 hp. Cadell lines and drift seines were the principal fishing gear used by fisherfolk at this landing site. The onboard supervisor from this landing site who participated in the study used the Cadell method of fishing. The vessel used a 15 hp engine and had a haul capacity of 500 kilograms (1,100 pounds). The supervisor caught at total of 2,753 kilograms (6,069 pounds) from 1,128 hours of effort from May to October. Sea catfish comprised 75 percent of the total haul, which was expected based on the fishing method. The supervisor fished along the coast of Region 1 and accessed these grounds via the Moruca River. All species caught by the supervisor were mature.

Hampton Court is one of the largest landing sites on the Essequibo Coast (Region 2) and is used by vessels that target both fishes and shrimp. Approximately 22 total vessels use the Hampton Court landing site, all of which are outboard cruisers with engine sizes ranging from 5 to 60 hp. The onboard supervisor at this landing site who participated in the study uses a drift seine with mesh sizes of 20 centimeters (8 inches) to target larger species of fishes, specifically the high-value species, gillbacker and snapper. The vessel used has a haul capacity of 907 kilograms (2,000 pounds) and is powered by two 48 hp engines. The supervisor recorded a total of 7,048 kilograms (15,538 pounds) with a total effort of 2,328 hours from April 2019 to February 2020. The majority of the haul comprised gillbacker and snapper with the two species accounting for 56 and 40 percent of total catch, respectively. Hauls were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. In total, six species were recorded by the supervisor, all of which were mature. The supervisor has a general traveling area of 272 square kilometers.

Lima is a smaller landing site in Region 2 that is used by 15 vessels that target fish and shrimp. All vessels are fitted with small outboard cruisers that have engine sizes of 10 to 25 hp. The onboard supervisor who participated in the study principally used the Chinese seine method, but drift seines and pin seines were also used during the hard season (October 2019 to February 2020). Hauls totaled 2,935 kilograms (6,470 pounds) from 952 hours of effort. Shrimp comprised 71 percent of the haul, which is a mixture of white belly and coarse shrimp. Hauls were marginally greater in the hard season, but this may be attributed to the onboard supervisor augmenting fishing practices to increase total catch. Moreover, the primary and secondary rainy seasons were the most productive for this supervisor. The supervisor caught a total of 28 species of fishes and the annual average lengths of these fishes indicated that 12 individuals from these species were juveniles. The supervisor used a small traveling area of 20 square kilometers.

The La Grange landing site is one of the only landing sites in Guyana where almost all fisherfolk still use Cadell lines for commercial fishing. The landing site is on the western bank of the Demerara River. Although the landing site is more inland than the other landing sites surveyed, fisherfolk traverse along the Demerara River to access fishing grounds along the Region 3 and 4 coastlines. Using Cadell lines, the onboard supervisor who participated in the study caught a total of 30,656 kilograms (67,585 pounds) from 1,367 hours of effort. Sea catfish accounted for 75 percent of the haul. Hauls were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. The supervisor caught a total of 13 species, all of which were measured as being sexually mature. The supervisor traveled in an area of 2,226 square kilometers outside the mouth of the Demerara River and fished farther offshore than any of the other onboard supervisors.

Windsor Forest is a medium-sized landing site on the west coast of Demerara in Region 3. Approximately 12 vessels use this landing site, all of which use Chinese seines with mesh sizes ranging from 2.5 to 10 centimeters (1 to 4 inches) as the principal method of fishing. The onboard supervisor at this landing

site who participated in the study recorded a total catch of 40,727 kilograms (89,787 pounds) using both the Chinese seine fishing method and Cadell lines. Bangamary was the most abundant species caught, representing 24 percent of the total haul. A total of 1,464 hours was expended on fishing activities during the study period. Hauls were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. The supervisor caught a total of 12 species including several species of juvenile fishes. Significant quantities of bycatch were also recorded by the onboard supervisor. The supervisor traveled in an area of 25 square kilometers.

The onboard supervisor at the Riverview landing site used a mesh size of 2.75 inches (7 centimeters) to target bangamary. The supervisor recorded a total of 44,601 kilograms (98,328 pounds) from 1,815 hours of effort during the study period. The onboard supervisor also had the more productive soakings of the seine compared to other onboard supervisors. Bangamary comprised 53 percent of the total haul. In total, 56 species were recorded by the onboard supervisor and this was the most species-diverse haul of any of the regional or onboard supervisors. Hauls were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. Most of the species caught by the onboard supervisor were measured as having reached sexual maturity, but four species of sharks, including blacktip and hammerhead sharks, were all immature. The supervisor had a traveling range covering 1,041 square kilometers.

The Ogle landing site is one of the largest landing sites in Region 4 for vessels using Chinese seines. Fisherfolk estimate that approximately 30 vessels use this landing site, most of which are outfitted with outboard cruisers of 15 hp. The onboard supervisor who participated in the study used Chinese seines to target coarse shrimp and the vessel was fitted with a 30 hp engine. A total of 20,473 kilograms (45,135 pounds) was caught and coarse shrimp accounted for 71 percent of the haul. The supervisor had a total effort of 1,095 hours during the study period. Hauls were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. The supervisor recorded a total of 31 species, several species of which were juveniles. This supervisor also reported significant quantities of bycatch. The supervisor had a traveling range covering 151 square kilometers.

Bushlot is the only landing site at which most of the vessels are sail vessels. Fisherfolk indicated that 20 sail vessels are operational at this landing site year-round, but approximately 40 vessels use the landing site during peak fishing seasons. Although the vessels primarily use sails, some are also fitted with small outboard cruisers of 5 to 15 hp. The onboard supervisor who participated in the study used drift seines with relatively large mesh sizes to target large high-value species like snapper and trout. A total of 4,485 kilograms (9,888 pounds) of fishes was caught, of which cuirass and snapper accounted for 28 and 27 percent of the catch, respectively. During the study period, 1,922 hours of effort was expended. In total, the onboard supervisor recorded a species diversity of 22. There was a stark reversal in seasonality at this landing site where the period—typically considered the good season—had significantly lower productivity than the period typically considered the hard season. According to the onboard supervisor, this is the second consecutive year in which this occurred; the reasons for this shift are unknown. The supervisor had a traveling range covering 255 square kilometers.

Rosignol is the largest landing site in Region 5 and a cooperative called the Rosignol Fishermen's Cooperative Society (RFCS) manages the site. According to the RFCS, more than 40 vessels use this landing site, use a range of fishing gear, and are outfitted with outboard cruisers with engines of 25 to 60 hp. The onboard supervisor at this landing site who participated in the study targeted snapper during the study period. The total haul was 3,949 kilograms (8,706 pounds) from 2,208 hours of effort during the study period. Snapper comprised 50 percent of the haul. Hauls were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. In total, 13 species were caught, all of which were mature. The onboard supervisor contends that the good season is becoming shorter and believes that this may be attributed to offshore oil and gas

activities. The supervisor had a traveling range of 6,076 square kilometers that extended from the east coast of the Demerara River to the coast of Suriname.

Albion is one of the largest landing sites in Region 6 and fisherfolk have indicated that 60 vessels use this landing site. All vessels are fitted with outboard cruisers with engine sizes ranging from 15 to 50 hp, most of which target bangamary. The onboard supervisor at this landing site who participated in the study targeted bangamary. The supervisor recorded a total of 11,472 kilograms (25,291 pounds) from 1,673 hours of effort over the study period. Similar to the Bushlot landing site, hauls were greater during the hard season and unlike most of the other landing sites, hauls were more productive during the primary dry season. In total, the supervisor caught 31 species; only one (jewfish) was a juvenile of its species. The supervisor had a traveling range covering 142 square kilometers.

Complex 66 is the largest landing site for artisanal fishing vessels in Region 6 and one of the largest landing sites in Guyana. The site is also managed by a cooperative called the Upper Corentyne Fishermen Coop Society. Approximately 140 vessels routinely operate at this landing site and more than 200 vessels during the peak fishing seasons. The onboard supervisor who participated in the study at this landing site targeted snappers. The total haul was 5,588 kilograms (12,319 pounds) using a total effort of 3,168 hours during the study period. Hauls and effort were highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons. The supervisor caught a total of 15 species, all of which were sexually mature. The supervisor had the largest traveling range covering an area of 7,003 square kilometers extending from the mouth of the Corentyne River to the mouth of the Suriname River.

5. ADDITIONAL FINDINGS AND INFORMATION

5.1 Glue

In recent years, the demand for glue (swim bladders) of several species of fishes has increased significantly in local markets (see Figure 5-1). Local fisherfolk have indicated that this demand originates primarily from Chinese markets where glue is used as an aphrodisiac and also for making some types of beer. In addition, significant quantities of glue were exported and some fisherfolk also preserve the glue for sale by salting and drying. Fisherfolk who harvest glue also sell the meat of the fishes from which the glue is taken.

Glue is sought primarily from snapper and trout, and from cuirass to a lesser extent. Based on feedback from the fisherfolk and supervisors, the glue from grey snapper is sold for the highest price. The increase in the demand and price for glue has led fisherfolk to make certain operational changes to maximize profits through increased efficiency, such as increased targeting of snapper, longer fishing trips to maximize the volume of snapper caught, and increased de-gutting at sea to allow more fishes to be caught per haul.

Due to the high demand, glue is frequently sold separately from other fish products at prices per kilogram that were occasionally even higher than the prices per kilogram of the flesh of the fishes. Fisherfolk who harvest glue for sale separately have indicated that approximately 50 percent of profits from a fishing trip come from the sale of glue. The increased targeting of snapper and trout is similar to the case of the totoaba (*Totoaba macdonaldi*). Like snapper and trout, the totoaba belongs to the Sciaenidae family and as such, has a large swim bladder relative to its overall body size. The totoaba was overfished in Mexico for export of its glue to China and has since been classified as a critically endangered species.

The prices at which glue was sold varied throughout the year, largely in response to external factors. Glue prices reportedly declined in September and October 2019 due to lower demand for exports to China, which was reportedly related to the protests in Hong Kong. As a result, there was a surplus in the local

marketplace. Fisherfolk at the Charity landing site (Region 2) indicated that the price decline challenged the economic viability of their fishing activities and some opted to store the glue harvested from the fishes for sale until market prices once again increased. Before the decline in prices for glue, it was reported by several supervisors that fisherfolk were increasingly targeting snapper because of the high price of its glue. This resulted in an oversupply on the local markets of the fish, which also resulted in prices per kilogram for the flesh of the fish to decline. This relationship between market prices of different fish products underscores the economic vulnerability of fishing-dependent communities and inter-related nature of the markets for fishing-related commodities.

It is expected that the COVID-19 pandemic may have triggered another decline in demand, thus reducing exports of the glue to China and consequently, the price of glue. The glue industry is one that needs to be studied further to better understand its role in influencing artisanal fishing practices.

Figure 5-1**: Fisherfolk Sorting Glue (Swim Bladder) for Sale**

5.2 Bycatch

Since bycatch was not recorded by all of the supervisors, it could only be quantified for hauls from the onboard supervisors who used Chinese seines for fishing from landing sites at Lima (Region 2), Windsor Forest (Region 3), and Ogle (Region 4). Bycatch was also reported by the onboard supervisor from the Bushlot landing site (Region 5). Based on the data collected, bycatch was 38.5 percent of the volume of the total haul at the Windsor Forest landing site and this was the highest quantity of bycatch reported by any of the onboard supervisors (see Figure 5-2). At the Lima and Ogle landing sites, bycatch was 5 percent and 28 percent of the volume of the total hauls of these landing sites, respectively. The main bycatch species from Chinese seine fishing were jellyfishes. Bycatch was also comprised of several other species that are typically considered non-commercial at these landing sites, such as rockhead, Chinese butterfish, flounder, and some species of herring. At the Windsor Forest and Ogle landing sites, the onboard supervisors caught several species that were classified as “flat banga”’ or “small banga” as an umbrella term for the juveniles of several species of fishes that were considered too small to be marketable. At the Bushlot landing site, bycatch represented approximately 15 percent of the volume of the total haul and was comprised mostly of stingrays.

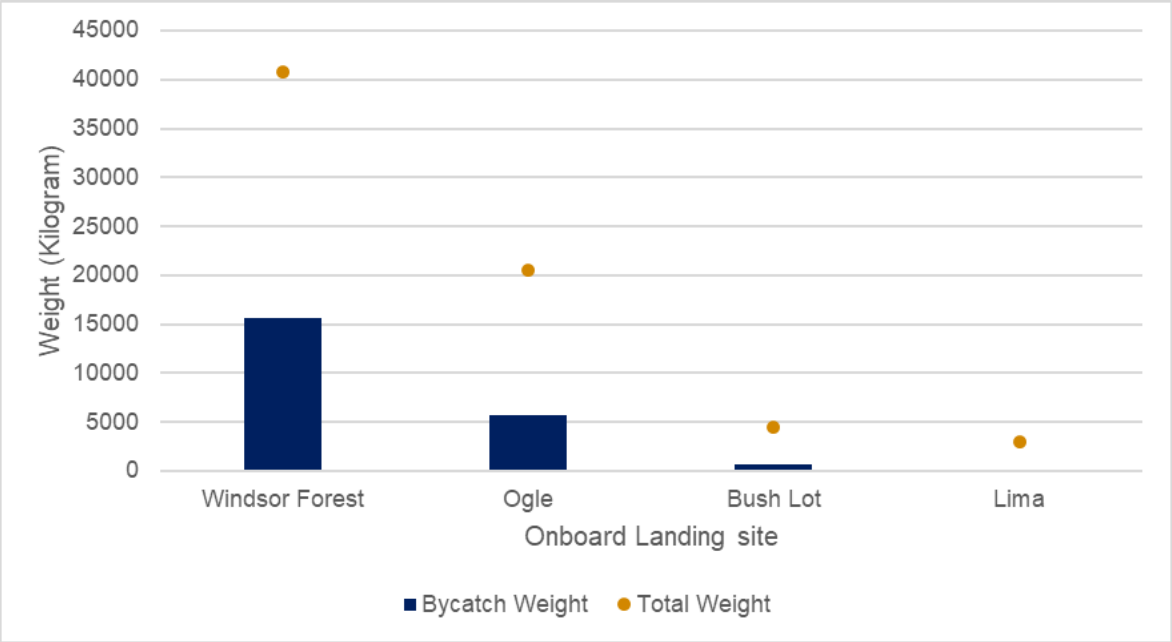

Figure 5-2: Bycatch Weight and Total Haul Weight Recorded by Four Onboard Supervisors

Other onboard supervisors reported bycatch species, but these were not quantifiable, including the following species:

- Marine turtles were caught in seines by the onboard supervisors at Smith's Creek (Region 1), Hampton Court (Region 2), and Complex 66 (Region 6). The main species caught were adult leatherback turtles. All of the supervisors indicated that the turtles were removed from the seines due both to the awareness of the important special status of sea turtles and to superstitions held by the fisherfolk. Some fisherfolk believe that catching turtles leads to lower future hauls while others believe that the turtles are crying (as a result of excretion from the turtle's eyes). In general, the majority of artisanal fisherfolk in Guyana are thought to release any turtles they may catch.
- A nurse shark was captured but released from a Cadell line by the onboard supervisor from the La Grange landing site (Region 3) (see Figure 5-3). Generally, artisanal fisherfolk who catch large sharks release them because it is not deemed commercially viable and would also account for a significant percentage of the haul capacity of the vessel.

No marine mammals were recorded as bycatch by any of the supervisors.

Figure 5-3: Nurse Shark Hooked and Released by the La Grange Onboard Supervisor

5.3 Sargassum

Sargassum is a type of floating seaweed, as shown on Figure 5-4. It is brown in appearance and occupies large areas on the surface of the ocean. During the February to May 2019 period, supervisors reported that significant quantities of sargassum had entered Guyanese waters and created serious impediments to their fishing activities. In the first instance, sargassum became easily entangled in the seines and in so doing, occupied space in the seine that otherwise could be taken up by commercial hauls. Sargassum also blocked the mesh of the seines and thereby prevented fishes from entering and being captured. The onboard supervisor from the Ogle landing site (Region 4) reported that up to 227 kilograms (500 pounds) of sargassum were caught on a single fishing trip. In addition, sargassum was an even greater nuisance when fisherfolk returned to shore; they had to clean the seaweed out of the seine, which meant losing up to a day of fishing activity just to clean the seine according to some supervisors.

The prevalence of sargassum subsided with the onset of the primary rainy season. However, the proliferation of sargassum resumed in early 2020 when the waters began to warm. Fisherfolk will continue to experience challenges and losses when sargassum is prevalent, but this may be mitigated if there is consumer-based demand for this seaweed.

Figure 5-4: Sargassum Pulled Up in an Onboard Supervisor's Seine

5.4 Interactions with Endangered, Threatened, and Protected Species

Fisherfolk reported interactions with several endangered, threatened, and protected species during the study period, including the following interactions:

- Leatherback and green turtles were seen or caught by onboard supervisors in Regions 1, 2, 5, and 6. In addition to the turtles caught in the seines by fisherfolk in Regions 1, 2, and 6, a dead turtle washed up to the Bushlot landing site (Region 5) during the July to September period, as seen on Figure 5-5. The carcass had cuts on its body and fisherfolk believed that the turtle was injured by the propeller of an industrial fishing vessel.
- Manatees, also commonly called sea cows, were observed in the Demerara River outside the koker (sluice) at the La Grange landing site (Region 3) (see Figure 5-6). Fisherfolk from the Riverview (Region 4) landing site also reported sightings of manatees.
- Jewfish was included in the hauls from three landing sites namely Smith's Creek (Region 1), Charity (Region 2), and Albion (Region 6). Catches of jewfish in the hauls were reported across several months during the study period for these landing sites. It was not targeted by any of these fisherfolk, but was considered a commercial species when caught. At the Smith's Creek and Charity landing sites, jewfish was a medium-value species. The jewfish caught at Smith's Creek and Albion were juveniles, but the fish caught at Charity had reached sexual maturity.
- Stingrays were reported in the hauls at landing sites in Smith's Creek (Region 1), Riverview (Region 4), Ogle (Region 4), and Bushlot (Region 5). Commercial markets for string rays were only available at the Smith's Creek landing site where it was a lower-value species. Some fisherfolk at the Riverview landing site also considered string rays as a marketable species, but there were no commercial markets. At Ogle and Bushlot, stingrays were either released or discarded as bycatch. However, similar to the superstitious beliefs about catching turtles, many fisherfolk believe that catching stingrays is taboo because it will reduce total hauls over the long term.

Figure 5-5: Turtle Carcass Washed up at Bushlot.

Figure 5-6: Photo of Manatees taken at the La Grange Landing Site

- For this study, sharks were not disaggregated by species at most of the landing sites. However, based on the prior experience of the study team and observations made, the majority of shark hauls comprised blacktip shark. In particular, blacktip shark was caught in abundance at landing sites in Smith's Creek (Region 1), Charity (Region 2), La Grange (Region 3), Riverview (Region 4), and Albion (Region 6). All of these were juveniles of the species.

- Other species of sharks were caught by fisherfolk from the Riverview landing site. At this landing site, several species of sharks were recorded including the green shark, hammerhead shark, and sand shark.

5.5 Other Marine Species Observed

During the study, several marine birds were observed by the onboard supervisors. These include pelicans, egrets, frigate birds, and ibises. Marine birds have a symbiotic relationship with the fisherfolk where they have become very dependent on mainly Chinese seine fisherfolk to provide food that comes from their bycatch (see Figure 5-7). The birds typically wait until the fisherfolk commenced hauling in their seine, and feed on the bycatch that the fisherfolk would discard into the water. A similar scenario occurs onshore, where egrets clear all scraps of shrimp from the vessels.

Figure 5-7: Birds Feeding on Bycatch from Chinese Seine Haul

6. CONSIDERATIONS FOR FUTURE RESEARCH AND REPORTING

This study has collected critical information on Guyana's artisanal fishing sector in a short period. This was the first study of its kind in Guyana, covering the entire coast of Guyana; the type of information collected is unprecedented. In addition, the methodology and approach of using locals within the fishing community to implement the project has allowed for capacity and relationship building at the selected landing sites. The data collected have been compiled into a comprehensive database comprising copies of the data sheets, images taken by the supervisors, footage of fishing trips from video monitoring of some of the onboard supervisors' fishing trips, and GPS tracks and waypoints marked by the onboard supervisors. The data were also analyzed and presented in reports including quarterly reports and this final report.

Against this backdrop, continuing and expanding the study is strongly recommended in order to:

- Allow for additional data to be collected to fill data gaps for landing sites where external factors significantly disrupted fishing activities or the quality of data collected (for example, a full 12-month data set was not able to be collected for this study due to the challenges associated with COVID-19).

Analysis based on complete data sets will enhance understanding of the seasonal productivity of the artisanal fishing sector including whether anomalous trends observed in this study may be attributed to factors unique to the landing sites at which they occurred, or whether they are part of more regional patterns. Continuation of the study over the short and medium term will also serve to provide current information on how the artisanal fishing sector is evolving and critical issues occurring.

- Contribute to local content by providing capacity building for artisanal fisherfolk. As a result of the study, 19 supervisors have been trained in using digital cameras, measuring basic biometrics of marine species, and recording disaggregated data pertaining to their livelihood. The 12 onboard supervisors were also trained in the use of GPS units that they have integrated into their fishing practices for trip planning and navigation. Cameras, scales, and GPS units, as part of the project's arrangements, were left with the supervisors when the project ended. If the study is expanded to other landing sites, capacity building could also be provided to additional fisherfolk as well as an opportunity to provide additional equipment that could enhance the project's credentials and promote health and safety through assistance with equipment such as first aid kits, life vests, and flares.
- Contribute to local content as many supervisors indicated that the stipend provided for volunteering to collect data contributed to appreciable improvements in their quality of life and consequently their goodwill toward the oil and gas industry. These benefits could continue and expand if the study is extended and/or expanded.
- Maintain an active network of fisherfolk who can aid in the dissemination of information and, if required, could be called upon to assist with responding to unplanned events.
- Enhance the valuation of artisanal fishing activities particularly if additional landing sites are included in the study. This will allow for more robust analysis of fishing activities and could aid in understanding the overall economic value of fishing in Guyana.
- Continue to provide a clearer understanding of the artisanal fishing sector. While fisherfolk, and to a lesser extent national institutions, have a good understanding of the sector in terms of species targeted, pricing, seasonal variations, fishing grounds, etc., the analyses and presentation of the data collected have provided a clearer picture of the sector in a more organized and scientific manner, which can be improved upon with the continuation and expansion of the study.

Continuation and expansion of the study presents the following opportunities:

- Augment data collection for other studies focusing on turtles, marine birds, marine mammals, and any other endangered, threatened, and protected species that fisherfolk have observed.
- Include data collection from industrial fishing activities (trawlers).
- Considering that fisherfolk are perhaps the most direct stakeholders for offshore oil and gas activities, conduct continuous engagement with this stakeholder group, as it allows for immediate and proactive action to be taken related to fisherfolk concerns on the potential impacts on artisanal fishing.
- Communicate the findings of the study to a wider national and international audience using various media such as articles, posters, booklets, and presentations.
- Publish the findings of the study in scientific publications.

In addition, continuation and expansion of the study presents an opportunity to collect data on important topics and gaps in the study's analysis, such as:

- Over the months of April, May, and June 2019, sargassum continued to significantly affect the coast of Guyana. Fisherfolk were in a constant battle with this phenomenon and it caused significant downtime for the fisherfolk since entire days were dedicated to cleaning sargassum from seines.

- The start of the rainy season in May to June led to a change in species diversity in catch at the landing sites. In addition, some fisherfolk became sick with flu-related illnesses that caused them to not go to sea for a number of days.
- The price for “glue” from several species was reduced at many landing sites. Fisherfolk have shared their views on the reasons for the decline. Some fisherfolk believe that supply exceeded demand and drove down the price. Other fisherfolk assert that exports of “glue” to European markets have been banned and this has resulted in the drop in demand. Other fisherfolk believe that the buyer of “glue” on the local market illegally exports it to China via Hong Kong and the unrest in Hong Kong made exports using this route more difficult.

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APPENDIX A FISH SPECIES LIST

Species Name	Common Name	Photograph of Fish
Micropogonias furnieri	basher, basha [a]	
Cynoscion acoupa	grey snapper	
Cynoscion virescens	trout	
Cynoscion leiarchus	shine eye	

Species Name	Common Name	Photograph of Fish
Nebris microps	butterfish / butterhead	
Carcharhinus limbatus	blacktip shark [b]	
Carcharhinus porosus	san shark	
Sphyrna lewini	hammerhead shark	

Species Name	Common Name	Photograph of Fish
Rhizoprionodon porosus	green shark	
Chaetodipterus faber	spadefish / donkey fish	
Sciades props	kukawri [c]	
Batrachoides surinamensis	pacu	

Species Name	Common Name	Photograph of Fish
Macrodon ancylodon	bangamary [d]	
Stellifer rastrifer	Rockhead / white / rat mouth	
Ctenosciaena gracilicirrhus	brickhead / rock head	
Scomberomorus cavalla	kingfish	

Species Name	Common Name	Photograph of Fish
Scomberomorus brasiliensis	mackerel	
Xiphopenaeus kroyeri	coarse shrimp / seabob	
Cynoscion sp.	bangamary [d]	
Odontognathus mucronatus	netly	

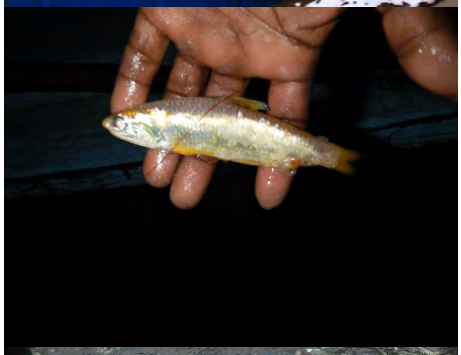
Species Name	Common Name	Photograph of Fish
Trichiurus lepturus	silverbelt	
Lonchurus elegans	Chinese butterfish	
Nematopalaemon schmitti	white belly shrimp	
Achirus achirus and Symphurus plagusia	flounder	

Species Name	Common Name	Photograph of Fish
Centropomus undecimalis	snook	
Farfantepenaeus sp. and *Litopenaeus* sp.	prawn [e]	
Bagre bagre	sea catfish	
Lobotes surinamensis	paggie / sea congo	

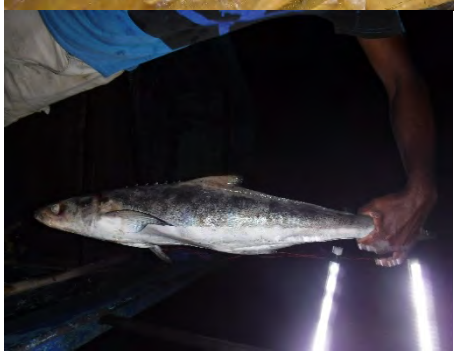
Species Name	Common Name	Photograph of Fish
Cathorops spixii	spring cuirass	
Cathorops sp.	round head	
Cathorops sp. and *Sciades* sp.	cuirass	
Sciades parkeri	gillbacker	

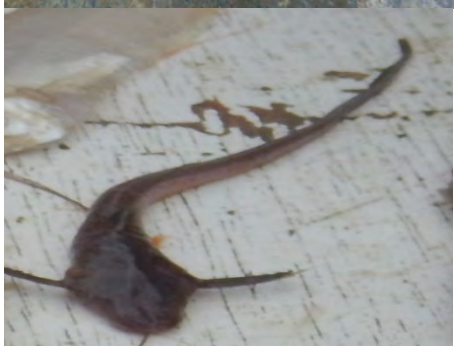
Species Name	Common Name	Photograph of Fish
Megalops atlanticus	cuffum / tarpon	
Genyatremus luteus	annafoke / old wife	
Mugil cephalus	Suriname mullet	
Anchoa spinifer	small herring	

Species Name	Common Name	Photograph of Fish
Elops saurus	long john	
Pomatomus saltatrix	salmon	
Harengula humeralis	shad	
Brachyplatystoma vaillantii	lau lau	

Species Name	Common Name	Photograph of Fish
Sciades couma	cuma cuma / blinka	
Cetengraulis edentulus	big eye herring	
Echiophis punctifer	mud eel	
Cynoscion similis	black tail basha	

Species Name	Common Name	Photograph of Fish
Pellona harroweri	mail boy	
Isopisthus parvipinnis	flat banga	
Mugil curema	quirman	
Penaeus monodon	tiger shrimp	

Species Name	Common Name	Photograph of Fish
Prionotus punctatus	sea robin / flying fish	
Katsuwonus pelamis	bonito / tuna	
Anableps anableps	four eye	
Rachycentron canadum	cabio	

Species Name	Common Name	Photograph of Fish
Physalia physalis	man O war	
Callinectes sapidus	crab	
Amphiarius rugispinis	twee twee	
Bunocephalus sp.	banja man	

Species Name	Common Name	Photograph of Fish
Mugil sp.	cannapa	
Selene vomer	chiny man / moonfish	
Sphyraena guachancho	barracuda	
Diapterus rhombeus	deep sea fish	

Species Name	Common Name	Photograph of Fish
Pseudauchenipterus nodosus	sweet man	
Oligoplites saliens	copper fish / thing bad	
Epinephelus itajara	jewfish	
Cynoscion sp.	bright eye	

Species Name	Common Name	Photograph of Fish
Caranax hippos	crevalle	
Rhinoptera bonasus	sea bat	
Notarius grandicassis	Thomas	
Trachinotus sp.	pampano	
Hypanus sp. *Frontitrygon* sp.	stingray	

Species Name	Common Name	Photograph of Fish
Narcine bancroftii	shocking fish, electric ray	
Menticirrhus americanus	crooker	

APPENDIX B LANDING SITE ASSESSMENT QUESTIONNAIRE

Landing site Assessment

Landing Site: _____ **Date:** __/ __/2019

Interviewer: _____

Name of Fisherman: _____ **Telephone Number:** _____

1. What is the best/quickest way to make contact with you again?

   _____

2. How long have you been a fisherman? _____
3. Type of vessel and engine size: _____
4. Where do you live? _____
5. Is fishing the most important livelihood in your village or town? □Yes □ No

   _____

6. How many hours (soak time) a day do you spend fishing? _____
7. Number of fishing trips per day/ per week/ per month: _____
8. Number of days per week spent fishing: _____
9. Location(s) fished/preferred fishing zones:

   _____

10. Do you travel directly to your preferred fishing zone from the landing site?

    _____

11. What type and size of seine do you use to fish? _____,_____
12. How many crew members participate in an average fishing trip? _____
13. During this fishing season how much catch (lb., kg or basket) have you been obtaining per fishing trip?

    _____

    _____

14. What species do you frequently catch in your fishing zones?

    _____

    _____

15. If possible, indicate the point of sale of your catch? _____
16. During this season what are the prices of the main commercial species you catch?

    _____

    _____

17. What would you say are your main expenses per fishing trip?

    _____

18. Have you observed any important variation in fishing landings among seasons? and years?

    _____

    _____

19. Do you think that the average size of main species have changed?

_____

20. Which are the months of the year when the best catches are recorded?

_____

21. What factors do you think contribute to this?

_____

22. What are the main challenges that affect your fishing?

_____

23. Do you participate in any other income providing activities to supplement fishing?

_____

24. Will you be willing to being contacted in the event of an oil spill?

_____

25. Are there any women who fish at this landing site? □Yes □ No
26. What role if any do women play in the fishing industry in your community? Eg. selling, cleaning shrimp, etc

_____

_____

27. Do you belong to a fishing co-op or union? □Yes □ No
    If yes, please indicate the name of co-op or union? Do women belong to the co-op?

_____

Participatory Fish Survey

1. Is there anyone, including former fishermen with knowledge of this landing site's fishing activity who would be willing to help with daily surveys?

_____

2. Are they unemployed currently? _____
3. Are they respected by the fishermen at the landing site?

_____

4. Would the fishermen be willing to give fishing data for research purposes?

_____

5. For sites selected for Component 2, would you allow one of your crew members to facilitate onboard data collection? This will involve recording your location, the types of fish caught and taking pictures.

_____

6. Are you willing to allow a video camera on-board? □Yes □ No

7. How many boats operate at this landing site?

   _____

8. What types of vessels operate at the site?

   _____

   _____

Multi-Year Turtle Research Programme

1. Do you or other fishers ever see marine turtles surfacing during your fishing activities? □Yes □ No

   If so, which species and what approximate size (small, dinner plate size; medium; or large)?

   _____

2. Do you or other fishers ever catch them in your fishing gear? □Yes □ No

   If so, which species and what approximate size (small, dinner plate size; medium, or large)? Are they usually alive or dead?

   _____

   _____

3. Is there a particular season, time of day, tidal cycle or prevailing wind when turtles are seen/caught? □Yes □ No _____
4. Is there a particular type of area (rocks, mangroves, islands, beach, river mouth etc.) and/or water depth where the turtles are usually found?

   _____

   _____

5. Are there any locations in your fishing zones where you frequently encounter turtles?

   _____

6. Would you be willing to help in catching turtles for research activities? □Yes □ No
7. What do you do if you accidentally catch a turtle?

   _____

8. Do the turtles appear injured/harmed after being trapped? □Yes □No
9. Can you recall in the past five years (2013 to present) if the number of turtles encountered?
   increased or decreased? □Yes □No □Unsure
   10 years? □Yes □No □Unsure

APPENDIX C SUPERVISOR SELECTION QUESTIONNAIRE

Interview Questionnaire for Selection of Supervisors

Landing Site OR Vessel Name:_____ Date:__/___/2019

Name: _____ Telephone No: _____

1. How old are you?
   □ ≤17 □18-29 □30-39 □40-49 □ 50-59 □≥60
2. What is your highest level of education?
   □ Primary □ Secondary □ Tertiary
3. Are you currently employed? □Yes □ No
4. What is your occupation? _____
5. What is your current address?
   _____
6. Do you have any experience working in the fishing industry? □Yes □No
7. Please describe your experience in the industry:
   _____
   _____
   _____
8. Are you familiar with the fishermen working at this site? □Yes □No
9. Are you able to identify the different types (species) of fish? □Yes □No

   Can you identify these fishes?

_____

10. Do you have any physical problems that would prevent you from doing the work?

11. Have you ever used a camera before? □Yes □No

12. Are you willing to help in collecting data on fishing activities for which you will be trained and given a stipend? □Yes □No

13. Will you be available to do this for at least 6 months? □Yes □No

APPENDIX D COPY OF DATA SHEETS

Data Collection Sheet for Regional Supervisors

Data Sheet for Regional Supervisors

Name: _____ Landing Site: _____ Date: _____ Start Time: _____ End Time: _____

Name of the Boat/ Captain's name	Type of engine + HP	Seine Type and mesh size	Fishing area	Time spent at sea	No. of times seine was soaked	Type of fish	Quantity (lb, kg, basket, bucket)	Price ($/lb, kg, basket, bucket)	Observations

Data Collection Sheet for Onboard Supervisors

Data Collection Sheet for On-Board Supervisors

Landing site :_____ Name:_____ Name of the boat:_____ Date: _____

Name of Co-op, if any:_____ Start time:_____ End time:_____ Type of Engine: _____ HP: _____

No. of Soakings	Time of Soakings	Fishing area (GPS coordinates) at deployed area		No. of crew	Seine Type	Time of Shake/ Pull-up	Type of fish	Quantity (lb, kg,basket)	Observations and By-catch quantity

Data Collection Sheet for Biological Data

Data Sheet for Fish Size

No.	Common name	Standard Length (cm)	Total Weight (g)	Code/Date of the photograph
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
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30				

APPENDIX E DATA COLLECTION PERIODS FOR THE LANDING SITES

Table E-1: Schedule of Data Collection Visits

Landing Type	Type of Supervisor	Data Collection Starting Date	Data Collection Ending Date
Region 1 – Smith's Creek/Morahwanna	Regional Supervisor	May 7, 2019	January 27, 2020
Region 1 – Smith's Creek	Onboard Supervisor	November 2, 2019	January 2, 2020
Region 1 – Waramuri/Haimokabra	Onboard Supervisor	May 25, 2019	October 9, 2019
Region 2 – Charity	Regional Supervisor	April 18, 2019	February 19, 2020
Region 2 – Hampton Court	Onboard Supervisor	April 23, 2019	February 28, 2020
Region 2 – Lima	Onboard Supervisor	April 23, 2019	February 29, 2020
Region 3 – Zeeburg	Regional Supervisor	April 16, 2019	February 29, 2020
Region 3 – Windsor Forest	Onboard Supervisor	April 16, 2019	February 28, 2020
Region 3 – La Grange	Onboard Supervisor	April 17, 2019	February 11, 2020
Region 4 – Riverview (Unity, Mahaica)	Regional Supervisor	April 11, 2019	February 28, 2020
Region 4 – Riverview (Unity, Mahaica)	Onboard Supervisor	April 27, 2019	February 28, 2020
Region 4 – Ogle	Onboard Supervisor	April 10, 2019	February 26, 2020
Region 5 – Mahaicony Bridge	Regional Supervisor	April 27, 2019	February 29, 2020
Region 5 – Rosignol	Onboard Supervisor	June 2, 2019	February 11, 2020
Region 5 – Bushlot	Onboard Supervisor	May, 2019	February 29, 2020
Region 6 – Rose Hall	Regional Supervisor	April 26, 2019	December 31, 2019
Region 6 – Albion Region 6 – Complex 66	Onboard Supervisor Onboard Supervisor	May 11, 2019 April 30, 2019	February 29, 2020 February 28, 2020

Table E-2: Schedule of Quality Assurance and Quality Control Visits

Landing Type	Type of Supervisor	Date of First QA/QC Exercise	Date of Second QA/QC Exercise
Region 1 – Smith's Creek	Regional Supervisor	October 30, 2019	January 28, 2020
Region 1 – Waramuri/Haimokabra	Onboard Supervisor	November 23, 2019	
Region 2 – Charity	Regional Supervisor	September 29, 2019	January 13, 2020
Region 2 – Hampton Court	Onboard Supervisor	September 27, 2019	January 13, 20202
Region 2 – Lima	Onboard Supervisor	September 29, 2019	January 13, 2020
Region 3 – Zeeburg	Regional Supervisor	September 19, 2019	January 16, 2020
Region 3 – Windsor Forest	Onboard Supervisor	September 24, 2019	January 17, 2020
Region 3 – La Grange	Onboard Supervisor	September 24, 2019	
Region 4 – Riverview (Unity, Mahaica)	Regional Supervisor	September 25, 2019	January 02, 2020
Region 4 – Riverview (Unity, Mahaica)	Onboard Supervisor	September 25, 2019	January 02, 2020
Region 4 – Ogle	Onboard Supervisor	September 23, 2019	February 06, 2020
Region 5 – Mahaicony Bridge	Regional Supervisor	September 20,2019	January 09, 2020
Region 5 – Rosignol	Onboard Supervisor	October 09, 2019	January 07, 2020
Region 5 – Bush Lot	Onboard Supervisor	October 07, 2019	January 07, 2020
Region 6 – Rose Hall	Regional Supervisor	October 08, 2019	January 07, 2020
Region 6 – Albion	Onboard Supervisor	October 10, 2019	January 07, 2020
Region 6 – Complex 66	Onboard Supervisor	October 09, 2019	January 08, 2020

APPENDIX F SMITH'S CREEK AND MORAHWANNA (REGION 1)

1 LANDING SITE OVERVIEW

Smith's Creek is a village along the Barima River approximately 14 kilometers from the town of Mabaruma. The primary livelihood activity is fishing. The neighboring village of Morahwanna is one of the largest fishing landing sites in Region 1 and has docking capacity for large fishing vessels.

Fisherfolk estimate that approximately six artisanal vessels operate regularly from this site, although up to 20 vessels from both Smith's Creek and the neighboring community of Morahwanna dock at both sites at any one time. All vessels are equipped with outboard engines ranging in size from 15 to 48 horsepower (hp). Drift seines are used by the two vessels with engine sizes of more than 40 hp. Mesh sizes range from 2.5 to 18 centimeters (1 to 7 inches). Vessels operating the 15 hp engines use pole seines with mesh sizes of 9 centimeters and 20 centimeters (3.5 and 7.9 inches). A few fisherfolk also use pin seines and Cadell lines.

As a result of these varied methods, no target species was identified during the study, and the most abundant species caught was cuirass, which can be caught using any of the seine mesh sizes used at this landing site. Hauls also included jewfish and string rays (endangered, threatened, and protected species), and shark species, some of which may be considered endangered, threatened, and protected, or vulnerable species. In total, 36 different commercial species of fishes were caught with a total weight of 80,830 kilograms (178,200 pounds).

Vessels with engines of more than 40 hp generally make one trip per week, spending 5 to 6 days at sea per trip. Fishing occurs at 11 meters (36.1 feet) depth with soak time for fishing activities lasting approximately 3 to 5 hours. The 15 hp vessel also makes one trip per week spending up to 5 days fishing in the Waini region.

According to the fisherfolk at the landing site, the main challenge they experienced during the study was high fuel prices that occasionally made fishing trips economically unfeasible. High fuel prices reduced the economic viability of fishing as a livelihood activity for villagers of Smith's Creek. The regional supervisor indicated that fishing activities were significantly curtailed particularly in the May to July 2019 period. The regional supervisor explained that fuel used by fisherfolk in Smith's Creek was imported from Venezuela. As a result of the socioeconomic crisis in Venezuela, fuel imports declined resulting in a shortage that in turn significantly increased prices. Before the shortage, expenses per fishing trip were mainly related to purchasing fuel typically costing approximately $20,000 GYD ($96 USD). During the shortage, fuel prices were reported to be routinely at least twice as high as before the fuel shortage. In response to the shortage, the government-owned Guyana Oil Company Limited (GuyOil) increased the sale of fuel in Mabaruma. However, fisherfolk reported that these prices were also higher than prices before the shortage and that supply is often inadequate to satisfy all consumers. As of January 2020, many fisherfolk had resumed fishing, but fuel prices remained high.

Fisherfolk at this location indicated that they are affected by pirates from Venezuela and allegedly are victims of theft. When pirates attack fisherfolk at sea, the pirates rob them of engines, seines, hauls, and in some cases vessels. In extreme instances, pirate attacks result in loss of life. During the study period, neither the regional nor the onboard supervisors reported any piratical attacks.

2 REGIONAL SUPERVISOR RESULTS

One regional supervisor was selected to participate in the study. Due to the fact that Smith's Creek is an Amerindian community, the Toshao (local Amerindian leader) was engaged to assist in selecting the supervisor.

2.1 Effort and Haul

Over the May 2019 to January 2020 period, the regional supervisor collected data from 45 hauls from Smith's Creek and 164 hauls from the Morahwanna landing sites. In addition, data were also collected from 42 hauls at the Kumaka Wharf in Mabaruma as vessels from Smith's Creek and Morahwanna villages travel directly to that site on market days to sell their haul. A very high diversity of commercially viable fishes are caught and there are markets for all species, including stingrays that are sold locally or exported to Venezuela. At most other landing sites in the study, species like stingrays would not be considered commercial catch and are likely classified as a bycatch and released at sea or discarded. The majority of fishes caught by the fisherfolk from the Smith's Creek village are sold at the Kumaka Market in Mabaruma.

Vessels typically fish at the mouths of Waini River and Barima River at depths of approximately 8 meters. The effort expended on fishing activities, measured by the average number of days spent at sea, varied throughout the year (Figure F-1). August, November, and December 2019 were the months during which the greatest effort was expended with fishing trips lasting, on average, for 5 days in August, and more than 5 days in November and December. The regional supervisor indicated that fisherfolk undertook longer fishing trips, instead of several shorter trips, in response to the increased fuel prices as a measure to reduce fuel consumption. The greatest effort expended in November and December may also be associated with fisherfolk beliefs that this period is part of the off-peak fishing season, referred to locally as the hard season, in which fishes are least abundant and therefore greater effort is required to catch economically feasible hauls. According to the regional supervisor, preferred fishing grounds change seasonally and during off-peak seasons, fisherfolk are likely to travel farther offshore to fish.

In May 2019, fisherfolk expended the lowest level of effort and this may also be linked to fewer fishing trips due to the increased fuel prices. In addition, the variances in the duration of fishing trips on a monthly basis were likely influenced by a variety of factors including fishing practices, based on engine size and gear type, and increased fuel prices. For example, in June and July 2019, the months with the lowest average productivity, the longest fishing trip duration was 10 days. By contrast, in October 2019, the month with the highest average productivity, the longest was 8 days.

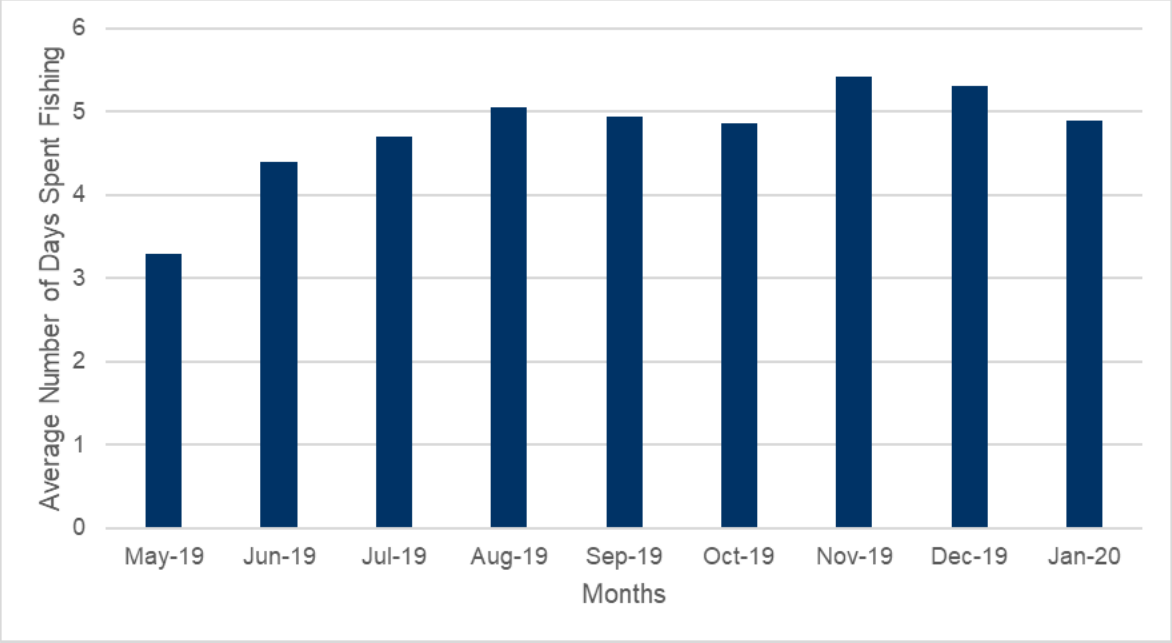


Figure F-1: Average Fishing Effort per Month at Smith's Creek and Morahwanna

2.2 Target Species and Diversity

Based on the data collected, 36 different commercial species of fishes were caught with a total weight of 80,830 kilograms (178,200 pounds). When fuel prices are consistently lower, the total weight of landed fishes would likely be even greater because more fisherfolk are expected to conduct fishing activities more frequently. As seen on Figure F-2, cuirass was the most abundant fish caught by weight with 9,875 kilograms (21,771 pounds). This may be because cuirass stays relatively close to estuaries where the fishing activities are carried out and can be caught by all seine types used. Bangamary, snook, and trout were the second to fourth most abundant species caught by weight with 8,618, 7,813, and 7,071 kilograms (18,999, 17,225, and 15,589 pounds), respectively. These were the only four species for which total haul weights exceeded 6,000 kilograms (13,228 pounds). Some fisherfolk from whom data were collected target bangamary by using drift seines with mesh sizes of 2 inches (5 centimeters) to 4 inches (10 centimeters). Trout and butterfish were also caught in relatively large numbers by individuals targeting bangamary; this phenomenon was also observed at other landing sites where bangamary is targeted such as Riverview (Region 4) and Mahaicony Bridge (Region 5).

Snapper, one of the highest-value species in Guyana, was the fifth most abundant species caught by weight with 5,890 kilograms (12,985 pounds). Snapper is targeted by some fisherfolk at Smith's Creek who use drift seines with larger mesh sizes in particular with mesh sizes of 7 inches (18 centimeters). Snapper is sold primarily for meat and unlike other landing sites, the glue (swim bladder) is not high value as there is no local demand or easy access to other markets. However, fisherfolk were aware of the value of the glue at other landing sites and some indicated that they have traveled to the Charity landing site in Region 2 to sell the glue harvested from snapper and trout.

This landing site is one of only three landing sites at which jewfish were caught. Hauls including jewfish were reported in May, September, October, and December 2019 and January 2020 by fisherfolk who were fishing at the mouths of the Waini and Barima rivers. In total, 58 kilograms (128 pounds) of jewfish were caught, although fisherfolk do not target this species. It is not known whether jewfish is typically caught in these waters during these months and further research is needed to determine whether this may be linked to any particular behaviors, such as spawning or feeding behaviors, of this fish. Shark were caught in greater abundance than jewfish, but were not identified by species and as such, it cannot be determined whether any of the fishes caught are endangered, threatened, or protected species.

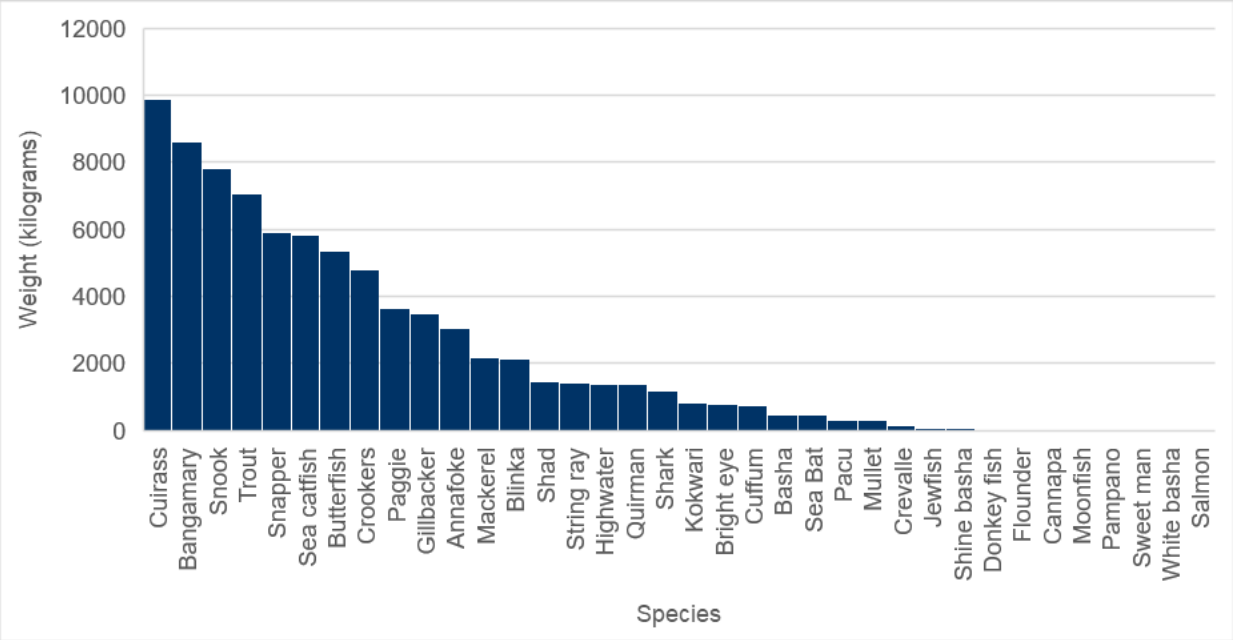


Figure F-2: Total Weight of Species Caught at the Smith's Creek and Morahwanna

Diversity of commercially viable species recorded at this landing site was the second highest compared to data collected by the other regional supervisors. Species diversity of hauls varied throughout the year and October had the highest diversity of commercially viable species with 32 different species caught (Figure F-3). One of the reasons for this high diversity may be the result of fisherfolk intersecting migratory fish species such as pampano and moonfish that migrate from North America in the months of September and October. May was the second most diverse month with 31 species caught; this may be due to increased nutrient flow at the mouth of the Waini and Barima rivers where more fishes come to feed and therefore are the preferred fishing grounds at this time of year. By contrast, June and August were the months in which the lowest species diversity was recorded.

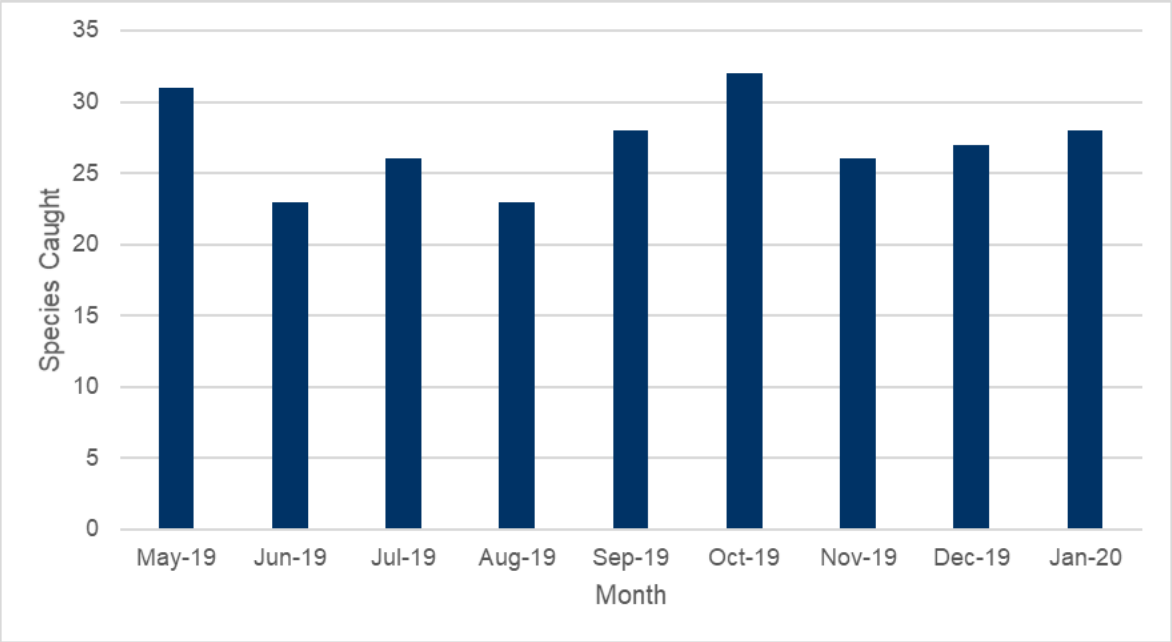


Figure F-3: Species Diversity at the Smith's Creek and Morahwanna

2.3 Seasonal Productivity

Average monthly productivity of fishing trips, measured as total monthly haul weights divided by the number of fishing trips, also varied on a monthly basis (Figure F-4). Artisanal fisherfolk in Guyana have a shared belief of the seasonal productivity of fishing activities, which influenced their fishing practices, in particular the effort expended. The peak fishing season, commonly referred to as the good" season, is believed to occur during periods of the year when waters are warmer (which may lead to an abundance of fishes) and calmer (which is less dangerous and requires less effort to fish). As such, the good season purportedly starts in May but peaks during the July to September. The hard season is typically considered the October to April period when waters become colder and rougher. However, these expected seasonal trends were not observed in the data collected by the regional supervisor. Instead, haul volumes appeared to be related to Guyana's wet and dry seasons. Specifically, seasonal variations in haul were observed along the following pattern:

- The May to July period, the primary wet season, had the lowest combined average monthly productivity of 247 kilograms (545 pounds). Overall, June and July were the least productive months and this may be attributed to a variety of factors including high fuel prices, rougher waters, and less abundance of fishes closer to the shorelines.
- The August to October period, the primary dry season, had the highest combined average monthly productivity of 382 kilograms (842 pounds). Overall, October (the month during which the hard season is expected to start) was the most productive of the study period.
- The November to January period, the secondary wet season, had a combined average monthly productivity of 347 kilograms (765 pounds). This productivity is significantly higher than what was observed during the May to July period. However, fisherfolk expended more effort in the November to January period (as seen on Figure F-1) that may partly account for the increased productivity.
- The secondary dry season occurs over the February to April period.

By comparison, in the May to September 2019 good season, the combined average productivity was 291 kilograms (483 pounds) while in the October 2019 to January 2020 hard season, the combined average productivity was higher with 369 kilograms (813 pounds).

However, these seasonal trends should be considered with caution. High fuel prices presented a significant confounding variable that curtailed normal fishing practices, particularly in June and July 2019. Further data are required to determine whether the trends observed thus far can be representative of practices that generally prevail at Smith's Creek and Morahwanna.

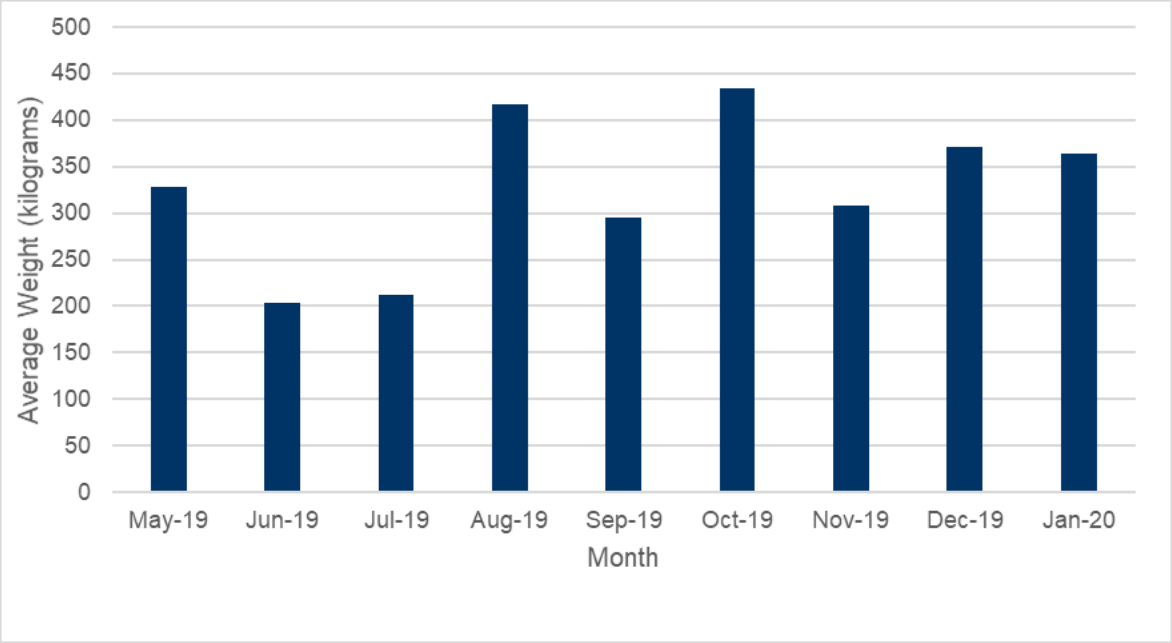


Figure F-4: Average Monthly Productivity of Fishing Trips at Smith's Creek and Morahwanna

2.4 Prices and Markets

Cannapa was the highest-value fish during the study with an annual average price per kilogram of $551 GYD ($2.6 USD) per kilogram as seen on Figure F-5. Cannapa is rarely caught and was only recorded for one landed vessel at Morahwanna in January 2020 and this may have accounted for the high price at which it was sold. Gillbacker and snapper were the second and third highest-value fishes with annual average prices per kilogram of $544 GYD ($2.60 USD). Gillbacker and snapper are typically the highest-value commercial species and this is similar to trends at other landing sites included in the study. However, unlike most landing sites, annual average prices of gillbacker were higher than those of snapper. At most other landing sites, snapper was consistently more highly valued than gillbacker due largely to the loss of the U.S. export market for gillbacker in 2018 after the United States Department of Agriculture (USDA) banned the import of catfishes and catfish products from Guyana because local food safety inspection systems were not equivalent to U.S. inspection systems. Annual average prices per kilogram for all other species, including trout, were less than $500 GYD ($2.39 USD). Based on the data collected by the regional supervisor, fish sales from this landing site totaled $26,721,374 GYD ($127,853 USD). The jewfish was an upper middle-value fish with a cost of $331 GYD ($1.60 USD) per kilogram.

By contrast, the annual average price per kilogram was less than $100 GYD ($0.48 USD) for four species, namely flounder, sweet man, moonfish, and donkey fish. These species are not high value and do not have a high demand.

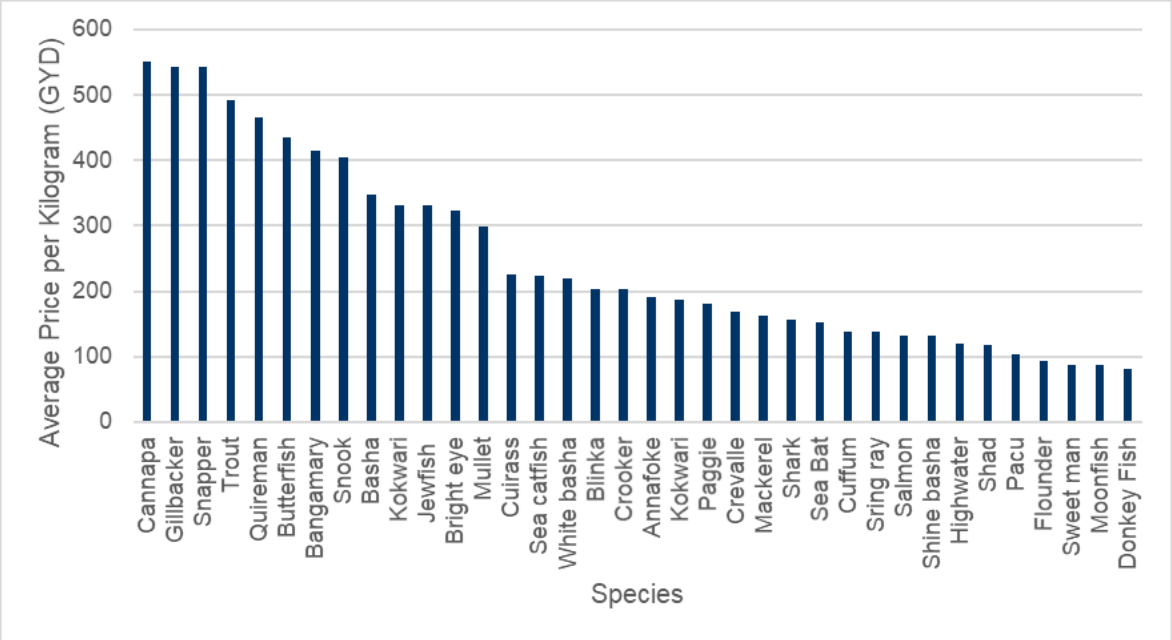


Figure F-5: Annual Average Prices per Kilogram of Fishes at Smith's Creek and Morahwanna

Three of the most abundant species caught, bangamary, snook, and trout, were priced in the upper mid-range value with annual average prices per kilogram of $415 GYD ($2 USD), $405 GYD ($1.90 USD), and $492 GYD ($2.40 USD), respectively. Cuirass, which was the most abundant species caught, was priced in the lower mid-range value with an annual average price per kilogram of $225 GYD ($1 USD). However, there were variations in prices for all species based largely on the interplay of demand and supply. Figure F-6 shows the minimum, maximum, and average monthly prices for the four most abundant species caught. Over the course of the study, maximum prices for cuirass, snook, and trout peaked in August and September 2019 and this was attributed primarily to the concomitant peak in fuel prices. The increase was most drastic for cuirass for which maximum prices rose two-fold from the typical maximum prices. Similarly, minimum prices were highest in August and September 2019 and the December 2019 to January 2020 periods. In some instances, the difference between the minimum and maximum prices for these periods was negligible. The higher minimum prices in August to September 2019 were also attributed to the high fuel prices. These trends demonstrate that the increased expenses borne by fisherfolk were ultimately passed on to the consumers in the form of high prices and it is likely that this practice also holds true for other high-demand species such as snapper, gillbacker, and butterfish.

Higher prices were also observed for bangamary, cuirass, and snook in December 2019 and January 2020. However, it should be noted that some fishes are more highly valued at this landing site than other landing sites included in the study. For example, maximum prices for bangamary were consistently greater than $600 GYD ($2.90 USD) per kilogram at Smith's Creek, which is higher than maximum prices reported by other regional supervisors and more than twice the maximum prices reported at Riverview (Region 4) and Mahaicony Bridge (Region 5) where bangamary is the target species. Similarly, at this landing site the maximum price for trout was greater than $1,200 GYD ($5.74 USD) per kilogram and was

significantly higher than other landing sites where trout is one of the primary target species like Charity (Region 2), Riverview (Region 4), and Mahaicony Bridge (Region 5).

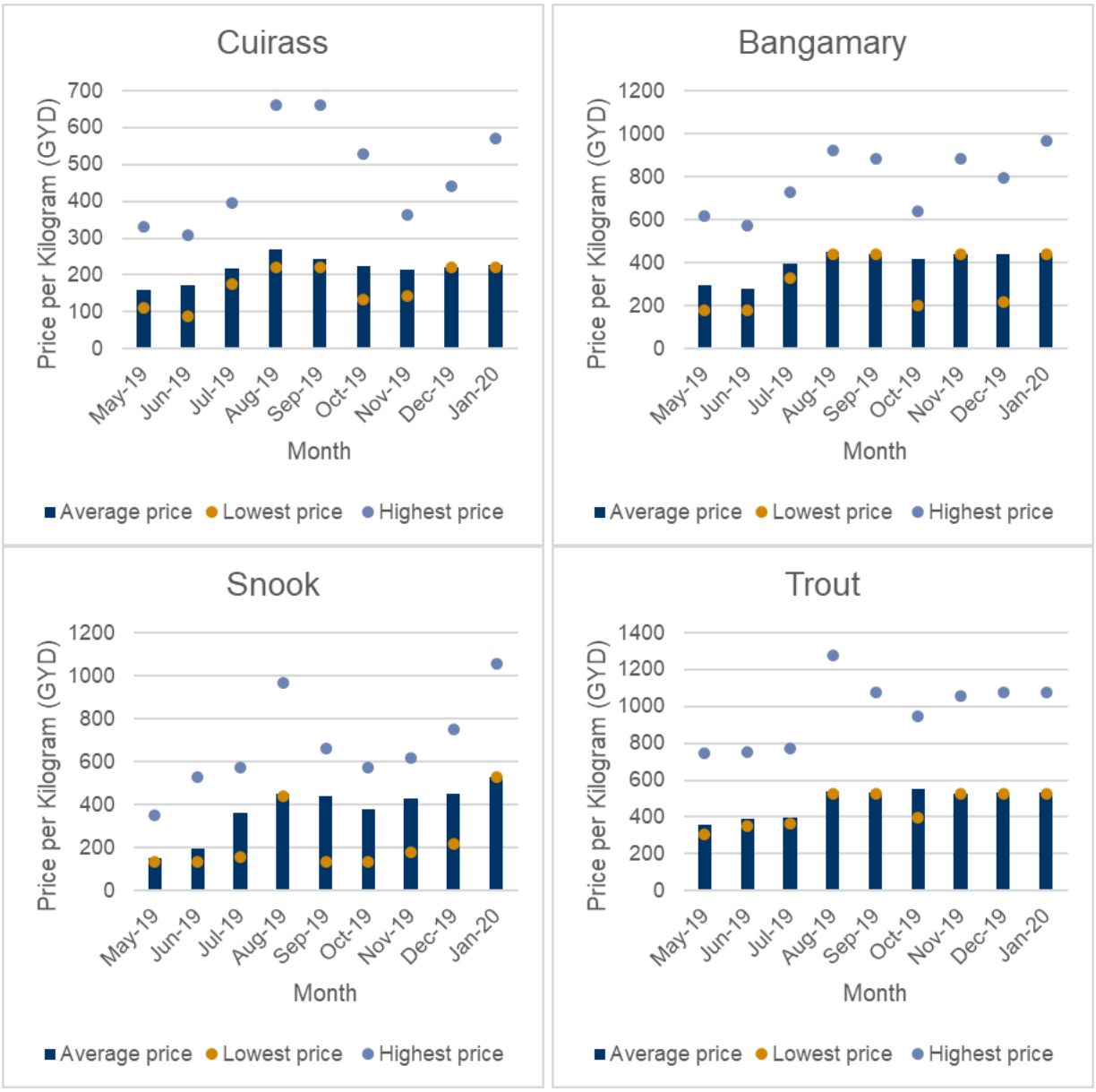


Figure F-6: Monthly Price Variations of the Four Most Abundant Species Caught

2.5 Biometrics

The regional supervisor measured the lengths and weights of fishes that were representative of hauls for which data were collected. Due to the large diversity of fishes, it was difficult for the supervisor to take the biometric data from all species per haul. Figure F-7 shows the annual average lengths and weights of fishes that were measured during the study. The smallest fish recorded was annafokes at 24.5 centimeters and 680 grams, and at this size, annafokes have reached sexual maturity. In addition, it is unlikely that smaller fishes, of any species, would be caught by fisherfolk using this landing site because mesh sizes are generally not less than 2 inches (6 centimeters). On the whole, the majority of

the fishes measured at this landing site had achieved sexual maturity including high-value species like gillbacker, snook, bangamary, and rare species like cannapa. However, juvenile fishes were also caught. For example, although jewfish was the largest fish caught, it was juvenile for its species with an average length of 77 centimeters and weight of 13,380 grams compared to sexually mature jewfish, which are generally 273 centimeters in length and 383,000 grams in weight. Similarly, snapper, one of the highest-value fishes at this landing site achieves mature weights of up to 15,000 grams and the average weight of fishes measured were significantly lower.

The annual average lengths of fishes measured for the four most abundant species caught indicate that these fishes had reached sexual maturity. However, comparisons of monthly average lengths and weights of these species for the months in which they were measured (Figure F-8) displayed the following trends. Juvenile bangamary, cuirass, and trout were representative of these species in hauls in May 2019, but biometrics measurements were not taken for snook in this month. Monthly average lengths of bangamary from June 2019 onward indicated that these fish had reached sexual maturity. The largest cuirass and trout were caught in August and September 2019. Snook caught in July and August 2019 were also sexually mature. The July to September period is widely believed to be the spawning periods for these fishes and females caught are frequently carrying eggs, which contributes to larger fishes being caught at this time of the year.

When the spawning period ended, smaller fishes caught were cuirass, snook, and trout. A particularly sharp decline in the size of trout and snook was observed in October 2019 when the measured fishes were juveniles. From November 2019, fishes were once again larger and sexually mature. This cycle of larger fishes being caught in spawning season, smaller fishes being caught after the spawning season, and then a subsequent uptick of sizes is likely to be seen in most of the other commercially viable fish species that exhibit similar reproductive behaviors.

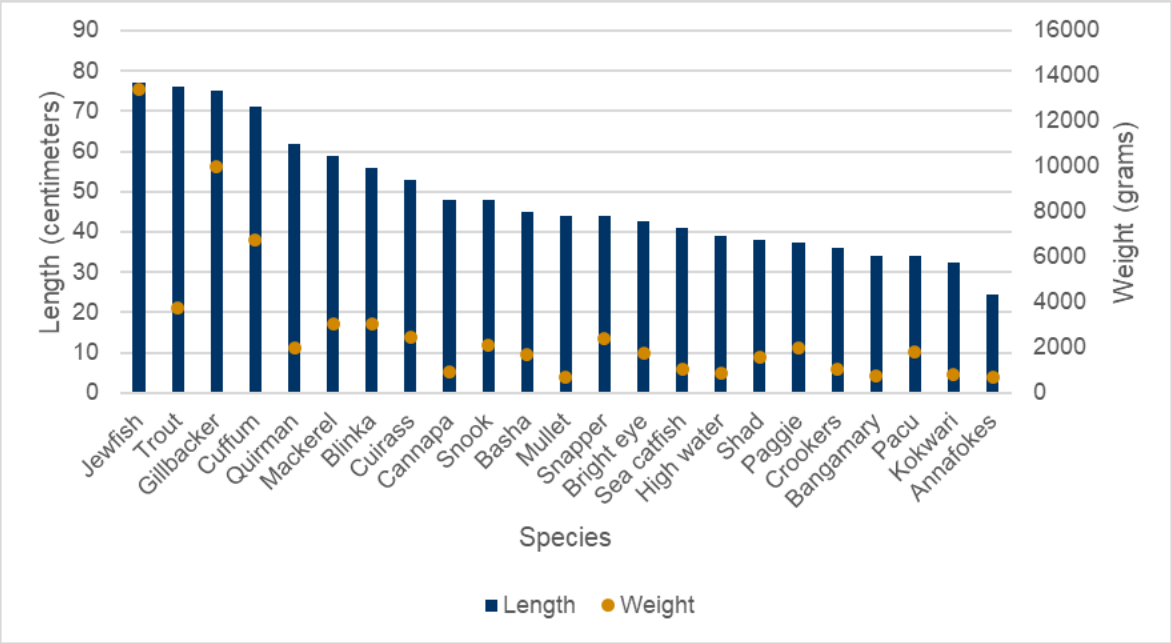


Figure F-7: Annual Average Lengths and Weights for Fishes Measured at Smith's Creek and Morahwanna

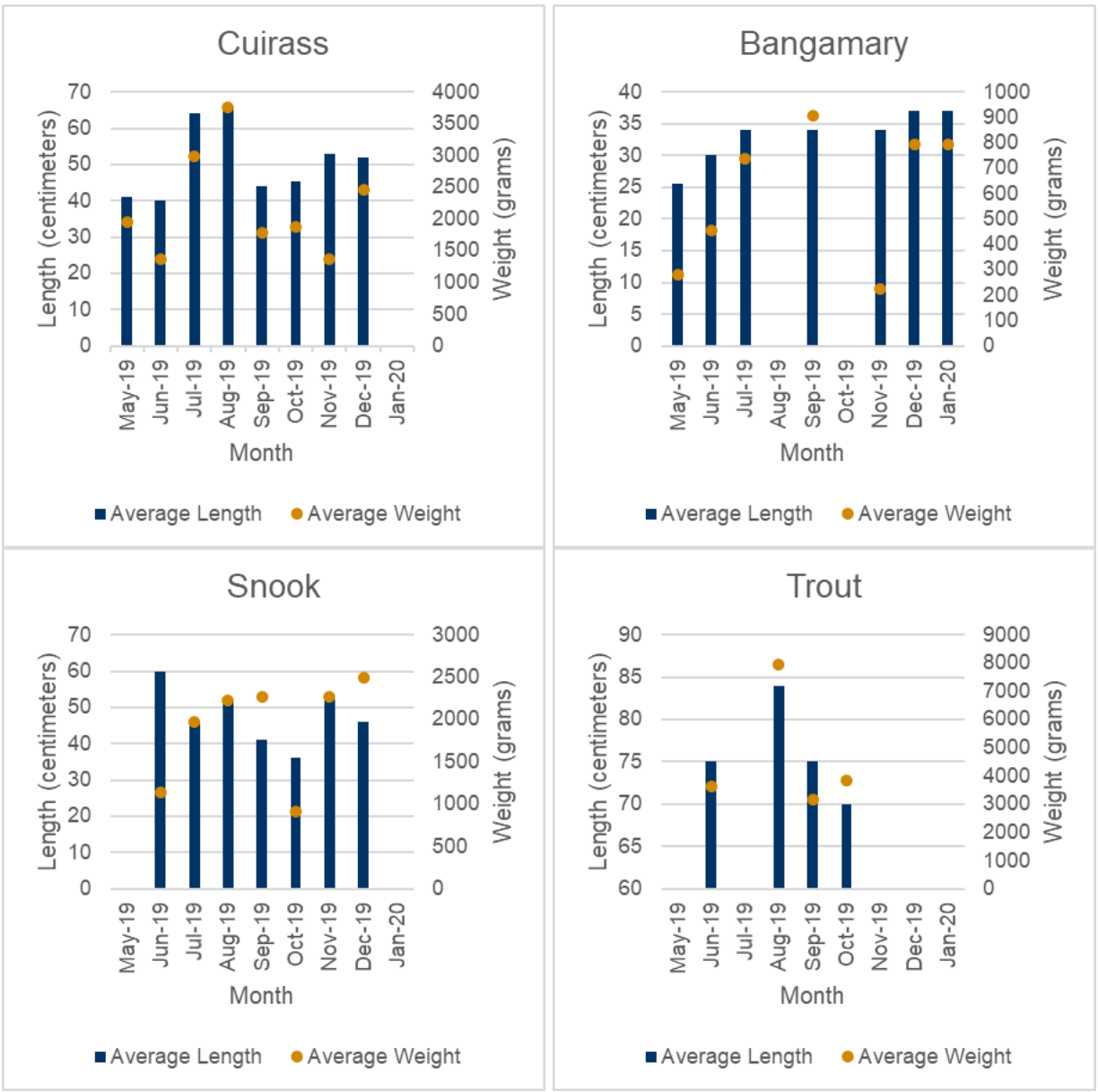


Figure F-8: Monthly Average Lengths and Weights of Most Abundant Species Caught

3 ONBOARD SUPERVISOR RESULTS

Three onboard supervisors were selected at various stages of the study to participate and the Toshao was engaged to assist in selecting the supervisors. Due to the fuel shortage experienced in the region, the onboard supervisor initially selected by the Toshao in April 2019 had ceased all fishing activities by May 2019 and had not resumed fishing by October 2019 and so no data collection from an onboard supervisor occurred during this period. Following further engagements with the Toshao, this supervisor was replaced by two new onboard supervisors (to compensate for the previous period when there was no data collection) who continued commercial fishing activities despite the fuel shortage and collected data commencing November 2019.

Both new onboard supervisors used drift seines with mesh sizes of 2.5, 5, 7.5, 10, and 12.7 centimeters (1, 2, 3, 4, and 5 inches) on an alternating basis while fishing. However, there are some key differences between the two vessels:

- Vessel A is the larger of the two vessels and the target species is sea bats. The vessel has a haul capacity of 3,000 kilograms (6,600 pounds) and is powered by a 40 hp engine. Each fishing trip requires a five-member crew and trips typically last for 6 days. This vessel usually travels approximately 10 kilometers offshore to fish at depths of 18 meters. The main expense per fishing trip is for fuel that is required to facilitate long trips. All sea bats caught are sold to vendors for export to Venezuela, while other fishes were sold to local vendors in Region 1.

- Vessel B has a haul capacity of 1,000 kilograms (2,200 pounds) and is powered by a 15 hp engine. This vessel has no specific target species. Each fishing trip requires a three-member crew and trips typically last for 4 days. This vessel usually travels approximately 5 kilometers offshore to fish at depths of 11 meters. The main expense per fishing trip is for fuel since ration for crew and ice for preservation of haul are not required on these shorter fishing trips. Hauls from this vessel are typically sold in local markets.

Apart from the high price of fuel, neither of the onboard supervisors encountered any other significant challenges during the study period that affected their fishing activities.

3.1 Fishing Area

All the data collected was from the hard season and therefore, unlike the analysis for other landing sites, fishing grounds cannot be analyzed for differences in fishing practices in the good versus the hard seasons. The main fishing area of both onboard supervisors, where most of the fishing points are clustered, is within a zone of 1,741 square kilometers (see Figure F-9). The fishing points were observed in three principal clusters:

- The first cluster of fishing points covered an area of 46 square kilometers and was located at the mouth of the Waini River and along the Region 1 coastline. These fishing grounds were used by both onboard supervisors and were located closest to the Smith's Creek village.

- The second cluster was located approximately 5 kilometers southeast of the first cluster. This cluster covered an area of 36 kilometers and these fishing grounds were also used by both onboard supervisors.

- The final cluster was located approximately 12 kilometers away from the second cluster and was comprised of only two fishing points. These fishing points covered a range of 151 square meters. This final cluster was only traversed by Vessel A, which was larger both in haul capacity and engine size and therefore could travel greater distances for trips.

Both vessels fished relatively close to the shoreline. The farthest distance traveled offshore was 11 kilometers, and this was done by Vessel B. The farthest Vessel A fished from the shoreline was 7.3 kilometers. In addition, Vessel B also fished closest to the shore with a fishing point of 0.22 kilometer.

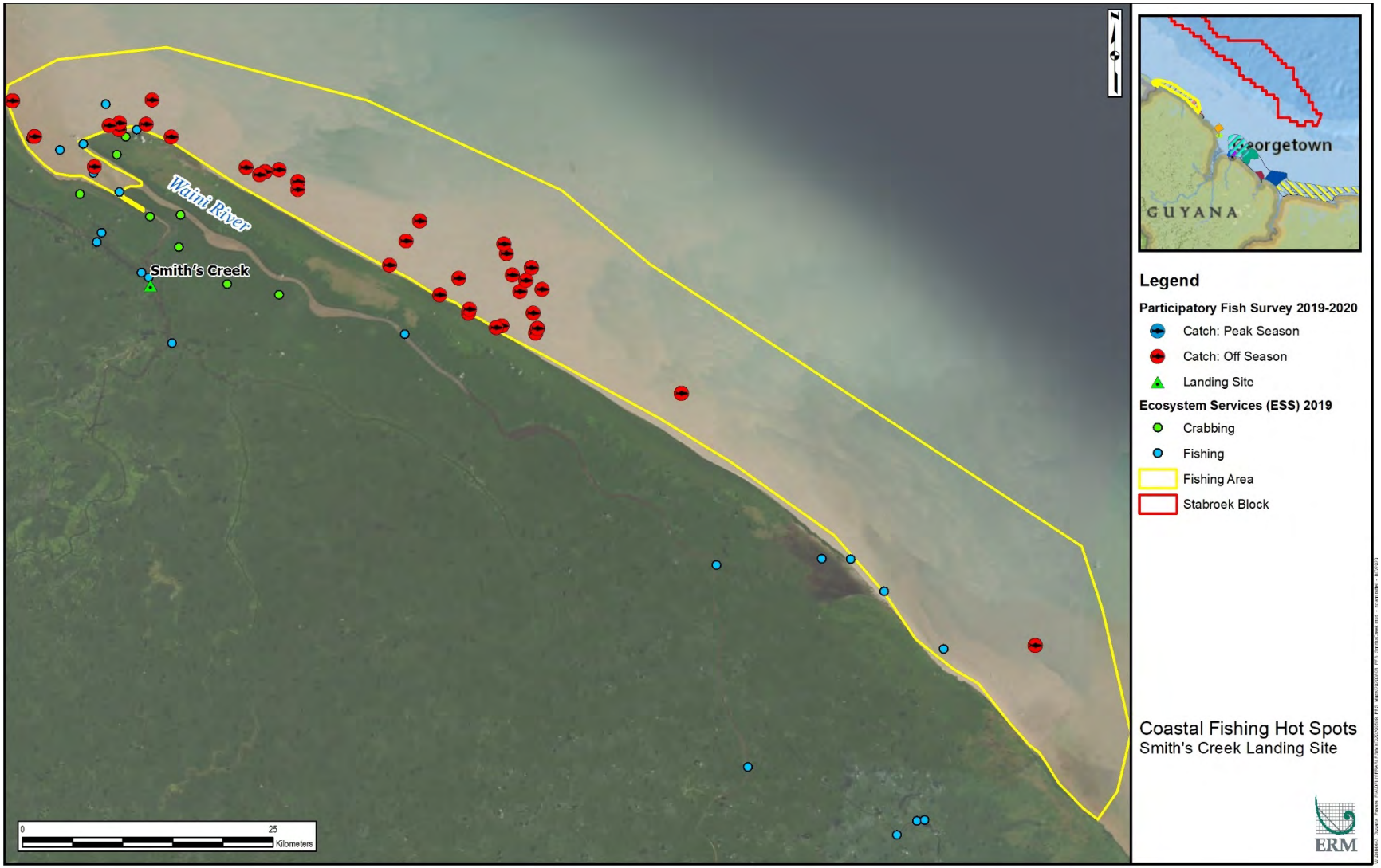


Figure F-9: Fishing Area and Fishing Points Used by the Smith's Creek Onboard Supervisors

3.2 Effort and Haul

As shown on Figure F-10, the total weight of combined hauls from Vessel A over the November 2019 to January 2020 period was 19,813 kilograms (43,680 pounds). The most abundant species caught was the sea bat accounting for 36 percent of the total haul with 7,148 kilograms (15,758 pounds). The supervisor indicated that this species is targeted because of lucrative export markets to Venezuela. Hauls are sold to trawl vessels that dock in the Barima River and transport the produce to Venezuela for sale where sea bats are reportedly considered a high-value species. The second to fourth most abundant species caught was paggie, annafokes, and basha. Among the supervisor's hauls were cuirass, snook, and trout, which are among the most abundant species caught reported by the regional supervisor, and snapper, which was the second most high-value species. Shark was also caught by this onboard supervisor, but the species were not reported, so it cannot be determined whether they are considered an endangered, threatened, protected, or vulnerable species. Overall, 12 species were caught by the onboard supervisor. No bycatch was reported by the onboard supervisor.

The total weights of combined hauls from Vessel B over the November to December 2019 period was 3,511 kilograms (7,740 pounds). The two most abundant species caught were snapper and cuirass accounting for 7.6 percent and 6.6 percent of the total haul, respectively. This is consistent with the data collected by the regional supervisor who also recorded snapper and cuirass as some of the most abundant species caught. Moreover, like the regional supervisor, the catch composition does not demonstrate that there was any target species and this suggests that seines with a variety of mesh sizes were used. The haul included gillbacker, which is the highest-value fish at this landing site and bangamary, which is also highly valued in local markets. Overall, 14 species were caught by the onboard supervisor. No bycatch was reported.

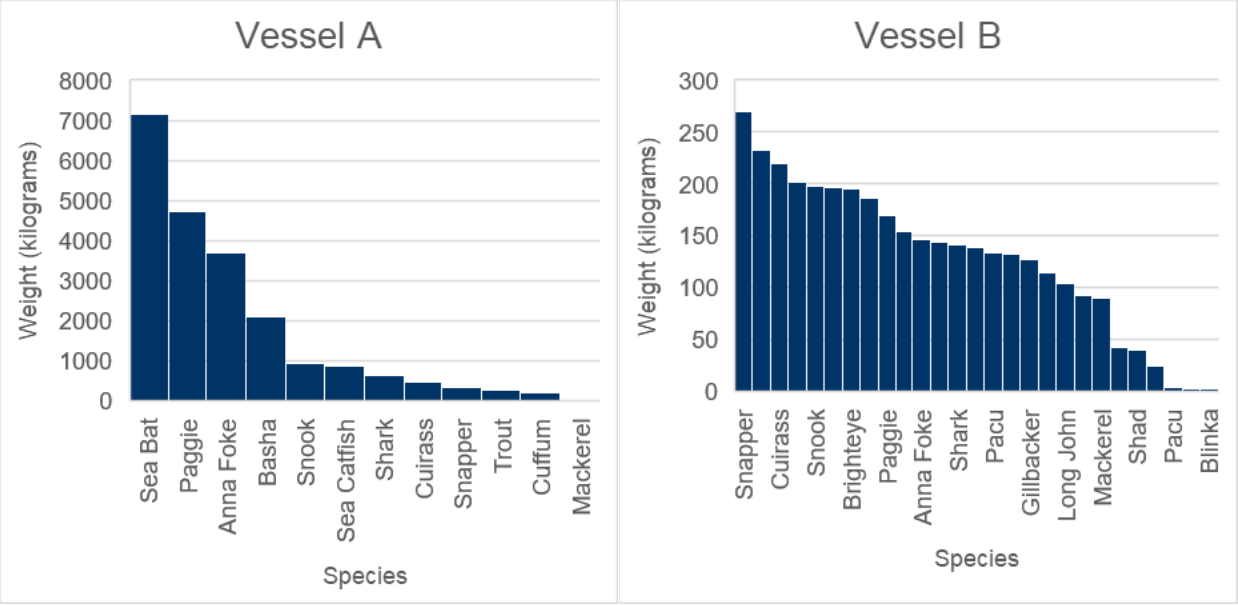


Figure F-10: Total Weight of Species Recorded by Vessel A at the Smith's Creek Landing site

Based on the data available, Vessel B consistently expended greater effort on fishing activities (Figure F-11). In November 2019, Vessel B spent 444 hours fishing compared to 120 hours for Vessel A and similarly, in December 2019 Vessel B spent 480 hours fishing compared to 432 hours for Vessel A. However, as seen on Figure F-12, total hauls from Vessel A were significantly higher than Vessel B from

November to December 2019. Moreover, for Vessel A, average weight of hauls per soaking consistently increased over the November to January 2020 period, whereas for Vessel B there was a decline in December:

- In November 2019, Vessel A had a total haul of 1,948 kilograms (4,294 pounds) with an average weight of hauls per soaking of 244 kilograms (538 pounds). By contrast, the productivity of Vessel B was lower with a total haul of 1,787 kilograms (3,939) pounds with an average weight of hauls per soaking of 48 kilograms (106 pounds).
- In December 2019, Vessel A had a total haul of 17,865 kilograms (39,385 pounds) with an average weight of hauls per soaking of 687 kilograms (1,514 pounds). By contrast, the productivity of Vessel B was significantly lower with a total haul of 1,724 kilograms (3,800 pounds) with an average weight of hauls per soaking of 43 kilograms (95 pounds).

These vessels share the fishing grounds in the Waini and Barima rivers and the differences in productivity are attributed principally to the fishing practices, gear used, and haul capacities of the vessels. By virtue of its larger engine, Vessel A travels more quickly to preferred fishing grounds and can also access fishing grounds farther offshore. This may have been particularly beneficial to Vessel A during the study period because November and December are typically considered part of the hard season and fisherfolk modify their fishing practices by traveling farther offshore to fish. In addition, quicker transits to fishing grounds may have contributed to lower effort being expended by Vessel A, particularly in December 2019 when Vessel A had spent 432 hours fishing and Vessel B 480 hours. However, it should also be noted that total hauls from November to January 2019 were relatively high based on the data collected by the regional supervisor, but this may be attributed to fewer routinely conducted fishing trips due to the fuel shortage.

Moreover, Vessel A also has greater haul capacity that allows each fishing trip to be more productive by both having longer fishing trips and transporting greater haul volumes to market. For example, the average weight of hauls per soaking for Vessel A was 857.5 kilograms (1,890 pounds) and based on its haul capacity this vessel could transport 3,000 kilograms and at least three such hauls. However, Vessel B had a haul capacity of 1000 kilograms and therefore could transport only one haul of such magnitude per soaking.

Finally, although both vessels use the same type of seines on an alternating basis, Vessel A likely used seines with smaller mesh sizes more frequently than Vessel B. This is likely due to sea bats being the target species of Vessel A. In instances where fishing grounds and effort are similar, as seen in December 2019, increased productivity of Vessel A was likely due to using seines with smaller mesh sizes, which captured more of the species passing through it compared to Vessel B.

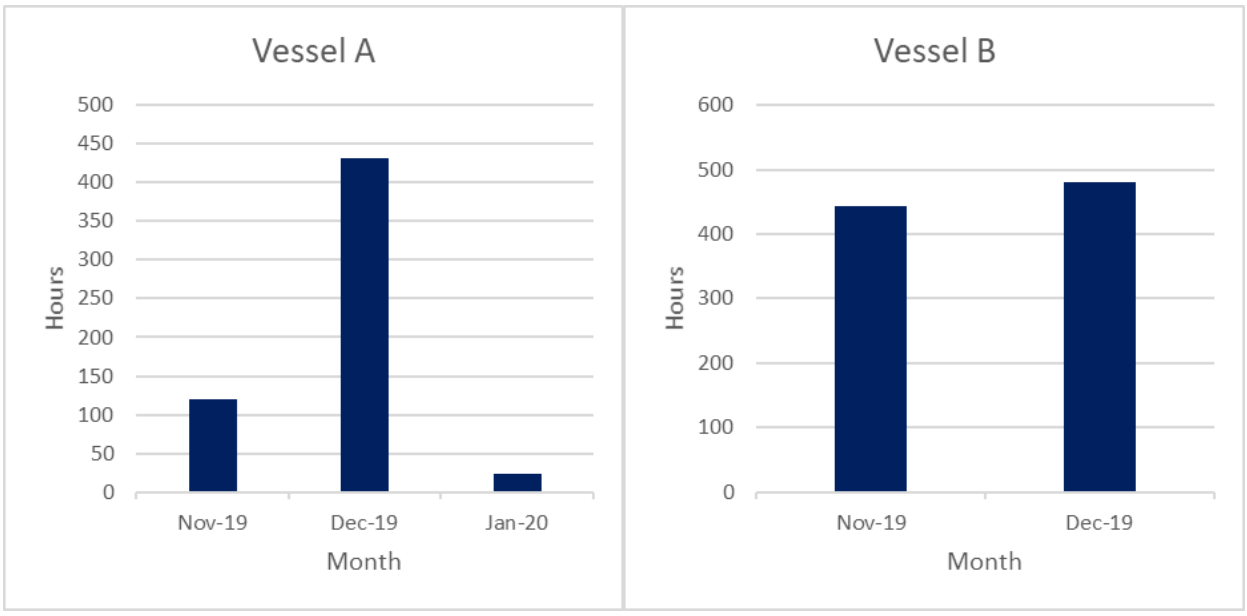


Figure F-11: Total Effort Recorded by the Smith's Creek Onboard Supervisors

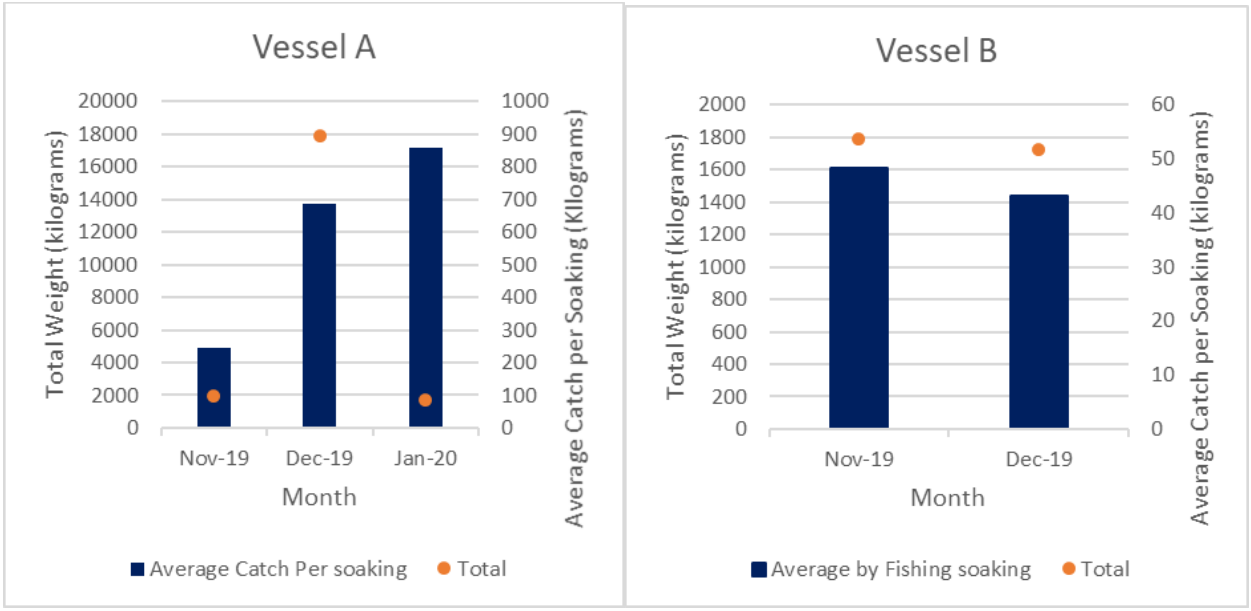


Figure F-12: Total Monthly Weight and Average Weight per Soaking of Hauls Recorded by the Smith's Creek Onboard Supervisor

3.3 Seasonal Productivity

Due to the relatively small data sets for these onboard supervisors, seasonal trends cannot be ascertained. Moreover, the November and December 2019 data sets for Vessel A are incomplete because the onboard supervisor is currently clarifying data collected during February and November.

3.4 Biometrics

Based on the lengths and weights of fishes measured by the onboard supervisors (Figure F-13), all species caught by the onboard supervisor of Vessel B had achieved sexual maturity. However, the average lengths and weights of the sea bats, the most caught species by weight, and annafokes from Vessel A were juveniles. In particular, sea bats reach maturity at lengths of 64 centimeters, but those caught by Vessel A had average lengths of 12.7 centimeters. In instances where the same species were caught by both supervisors, the fishes caught by Vessel B were larger. For example, snapper caught by Vessel A had average lengths of 46 centimeters compared to 52 centimeters for Vessel B. Similarly, sea catfish caught by Vessel A had average lengths of 30 centimeters compared to 41 centimeters for Vessel B. Trout caught by Vessel B were also larger. This is directly attributable to the use of seines with smaller mesh sizes by Vessel A, which would only typically capture smaller fishes. Additional information is required to completely assess the differences in sizes of the species caught by the supervisors.

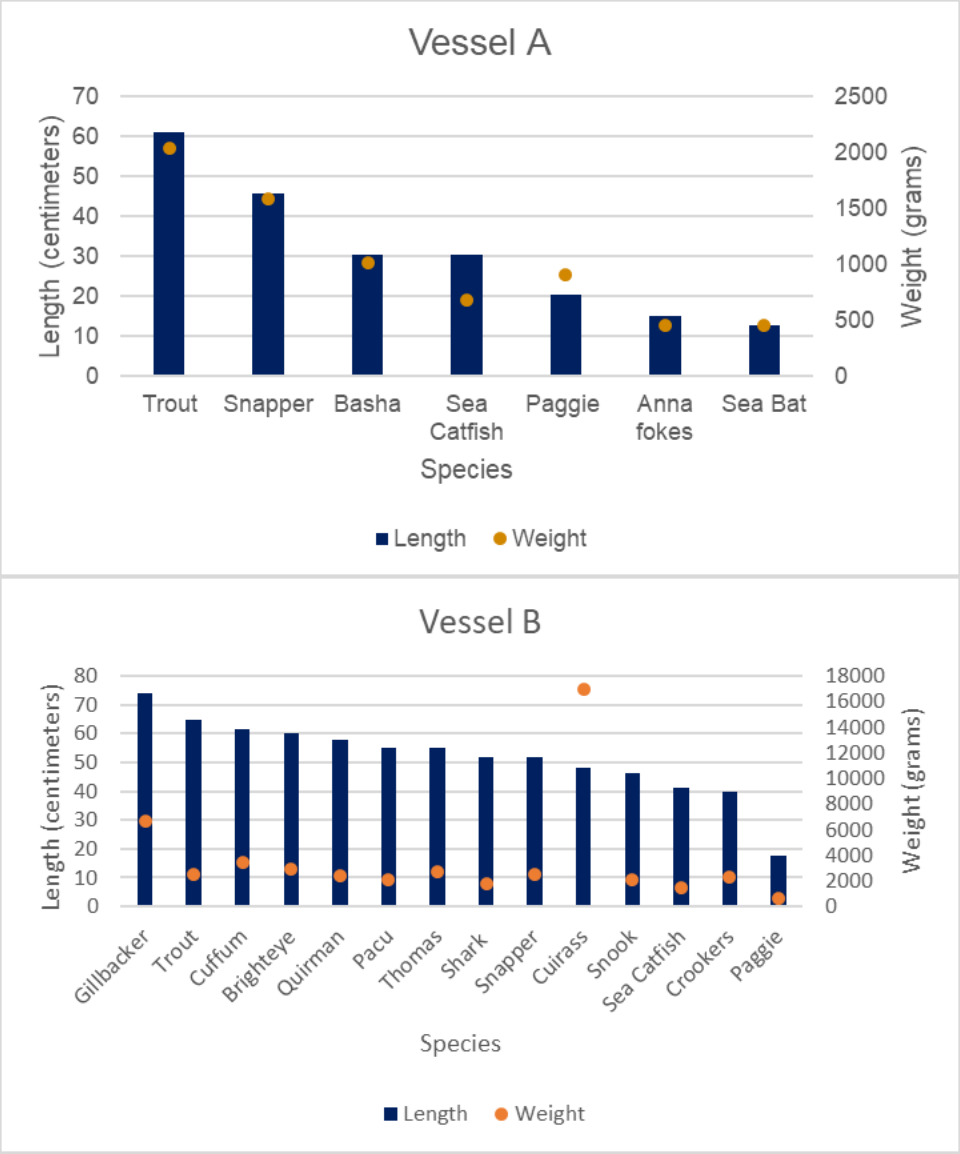


Figure F-13: Average Length and Weight of Fishes Caught by the Smith's Creek Onboard Supervisors

4 QA/QC DATA

4.1 Regional Supervisor

During the first QA/QC exercise, only one vessel (Vessel 1) landed at the Smith's Creek landing site. The vessel used drift seines with mesh sizes of 7.62, 10.16, 15.24, and 20.32 centimeters (3, 4, 6, and 8 inches). The fishing trip lasted for 4 days during which time the seine was soaked twice in an area called Crab Dog. The vessel used a 15 hp Yamaha outboard engine. The fisherfolk indicated that the high price of fuel was the most significant challenge experienced as it was challenging to make economically feasible fishing trips. These fishing practices and experiences were consistent with the fishing practices of fisherfolk from Smith's Creek reported by the regional supervisor. However, data were not collected by the regional supervisor from any vessels that fished in the Crab Dog area. Vessel 1 caught three species totaling 29.4 kilograms (65 pounds), consisting of bangamary at 9 kilograms (20 pounds), trout at 13.6 kilograms (30 pounds), and butterfish at 6.8 kilograms (15 pounds).

During the second QA/QC exercise, two landed vessels were assessed (Vessel 2 and Vessel 3) as seen on Figure F-14. Vessel 2 had a fishing trip lasting for 6 days at sea and made 12 soakings of a drift seine with mesh sizes of 5 centimeters (2 inches). This vessel used a 15 hp engine and traveled to Venezuelan waters to fish. Vessel 2 caught three species totaling 231 kilograms (509 pounds) comprising quirman with 135.9 kilograms (300 pounds), cuirass with 68 kilograms (150 pounds) and gillbacker with 27 kilograms (60 pounds). Vessel 3 had a fishing trip lasting 3 days and used drift seines with mesh sizes of 8 centimeters (3 inches) as well as Cadell lines. The fishing gear was soaked once and the Vessel traveled to the Waini River mouth to conduct fishing activities. Vessel 3 also caught three species, totaling 81 kilograms (179 pounds) which was comprised of high water at 45.3 kilograms (100 pounds), snook at 22.7 kilograms (50 pounds), and bangamary at 13.6 kilograms (30 pounds).

From the data collected by the regional supervisor, there is some variation from the overall catch. However, this may be attributed to the sizes of the vessels assessed, as all had engine sizes of 15 hp or lower, which indicates smaller vessel sizes. The supervisor recorded hauls from several vessels using engine sizes of 40 and 48 hp, which would be larger boats and would catch larger, more species-diverse hauls. A relatively low diversity is related to seine type.

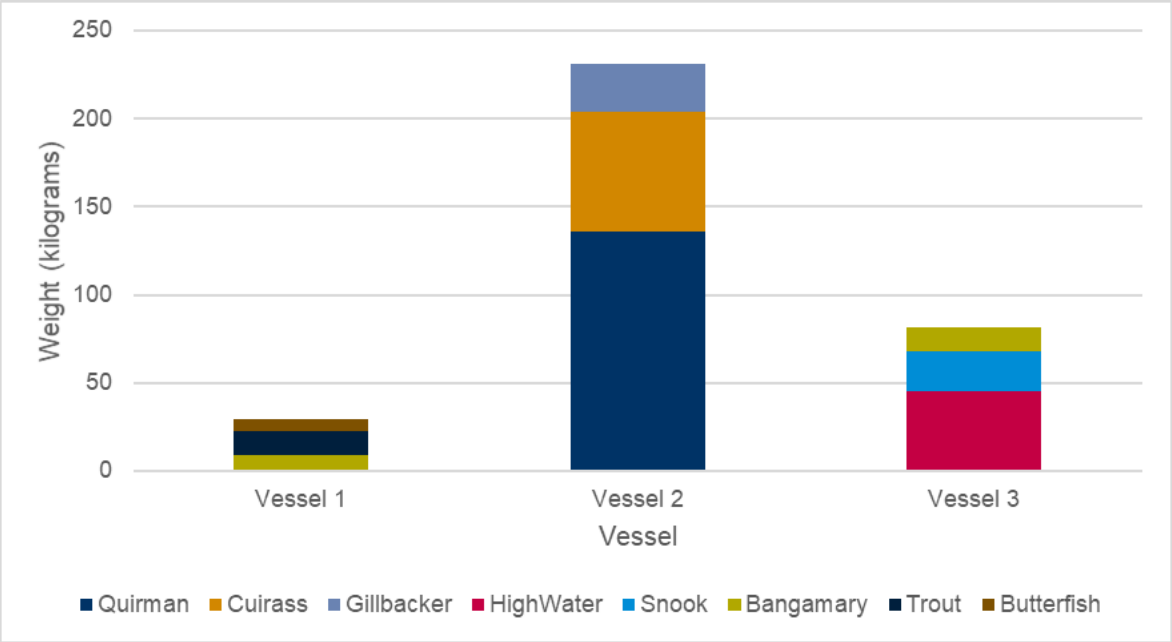


Figure F-14: Total Weight of Hauls Assessed during the QA/QC Exercises

Vessel 1 sold its haul at the following prices: $661 GYD ($3.2 USD) per kilogram of bangamary; $661 GYD ($3.2 USD) per kilogram of trout; and $750 GYD ($3.6 USD) per kilogram of butterfish (Figure F-15). The species caught by the fishing trip assessed were among the most abundant species caught in the collective hauls in the July to September period based on the data collected by the regional supervisor.

However, the prices recorded during the second QA/QC exercise varied from the prices recorded by the onboard supervisor. For example, Vessel 3 sold snook for $661 GYD ($3.1 USD) per kilogram, but maximum prices recorded by the regional supervisor were $529 GYD ($2.5 USD) per kilogram. Two factors would have caused this variance. First, the QA/QC exercise was conducted at a local market where fisherfolk sell their hauls and this may have resulted in the price. Second, the vendors sell by pounds and conversion to price per kilograms would double the variance. If the price per pound were used, the cost variance would have been $46 GYD ($0.2 USD), compared to a variance of $132 GYD ($0.6 USD) based on the price per kilogram. This trend was seen for other species.

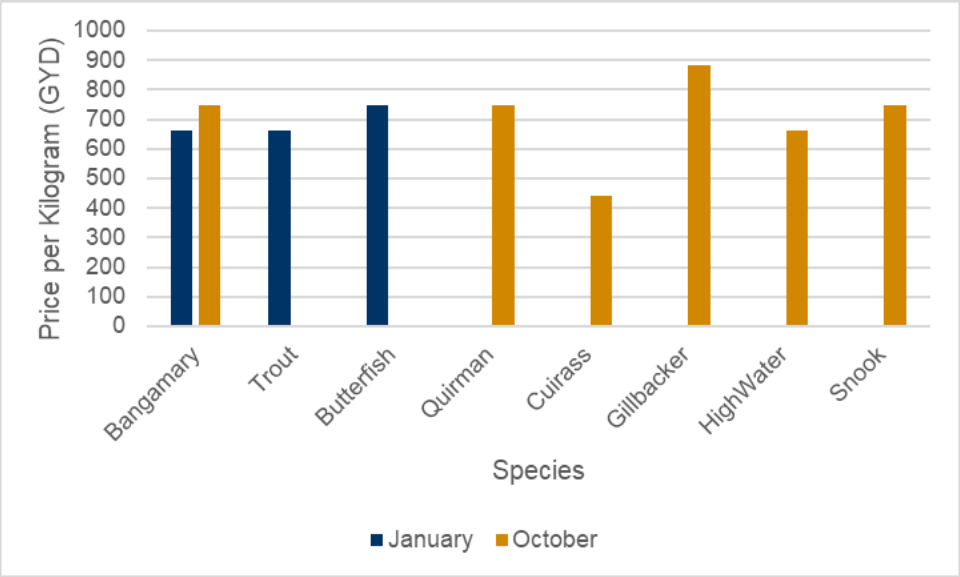


Figure F-15: Prices of Fishes Assessed during the QA/QC Exercises

Figure F-16 presents the lengths and weights of representative fished measured by the study coordinator during the QA/QC exercises. Although these fishes were smaller than the average lengths and weights of fishes measured by the regional supervisor, their sizes were consistent with the smaller fishes measured by the regional supervisor. Overall, the study coordinator was satisfied that the regional supervisor was thorough in collecting data from landed vessels and took accurate biometric measurements throughout the study program.

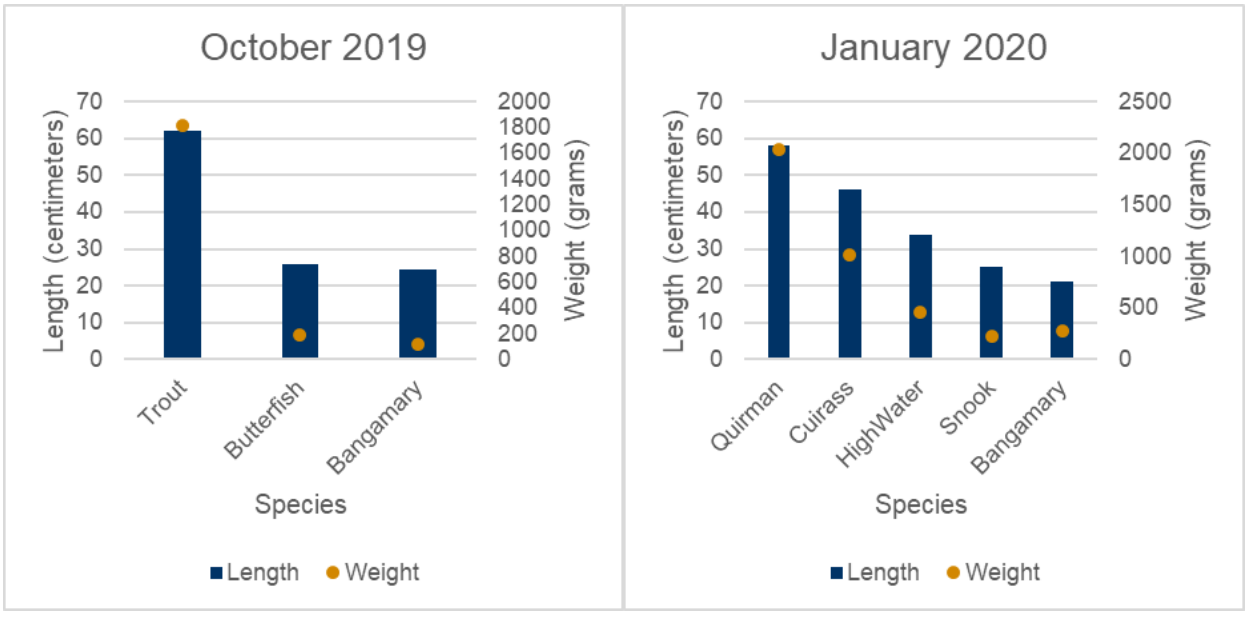


Figure F-16: Lengths and Weights of Fishes Measured during the QA/QC Exercises

4.2 Onboard Supervisors

The team did not get to conduct QA/QC exercise with the onboard supervisors. For Vessel A, the onboard supervisor's vessel did not return to the landing site as scheduled and therefore, the haul could not be assessed. Due to challenges scheduling meetings in Smith's Creek, the team collected data sheets for Vessel A from the onboard supervisor during his monthly visits to Georgetown. In addition, hauls from Vessel B were sold out when the study team arrived at the landing site and therefore could not be assessed.

APPENDIX G WARAMURI/HAIMOKABRA (REGION 1)

1 LANDING SITE OVERVIEW

Waramuri is an Amerindian community on the west bank of the Moruca River within the Moruca sub-district of Region 1. Haimokabra is considered a satellite village of Waramuri. Fishing is one of the most important livelihood activities in Waramuri/Haimokabra. Approximately 20 vessels normally operate from the landing site, all equipped with outboard engines ranging from 5 to 48 hp. Cadell (demersal long line) and drift seines with mesh sizes of 5 to 12 centimeters (2 to 4.7 inches) are the principal fishing gear used at this site.

Fisherfolk at this site use fishing grounds in several locations throughout Region 1 and 2 including Kamwatta, Moruca mouth, Pomeroon mouth, Iron Punt, Charo Beach, and Danfore. Engine size and fishing gear do not determine fishing practices, as both small and large vessels use either longline or drift seines and fish once per month, spending up to 14 days at sea per trip. However, one of the small vessels makes daily trips twice per week to the Moruca mouth for fishing.

Vessels typically fish between 3 to 16 kilometers from the coastline at depths of approximately 8 meters. Fishing trips range from 1 to 10 days. According to fisherfolk, the main species caught at this landing site are catfish, cuirass, snapper, trout, and gillbacker. Yield is typically 70 kilograms (154 pounds) of fish sold for approximately $600 to 800 GYD ($2.9 to 3.8 USD) per kilogram depending on species and season. Produce is sold at the Kumaka Market in Santa Rosa to vendors in the community, or transported by vendors to the Stabroek Market in Georgetown.

Ice is not readily available in this village, so fisherfolk have alternative preservation methods, like salting, smoking, or drying fish, during long fishing trips. To preserve the hauls, fisherfolk normally set up a camp on beaches along the Region 1 shoreline near their fishing zones and return to them daily with their catch to gut and salt the catch as a preservative method. Salted fishes are left to dry on the beach for the duration of the fishing trip. Although this is an essential part of the salting process, it also serves the practical function of maximizing the vessel's daily haul capacity and may also reduce fuel consumption because of lower vessel weight on a daily basis. At this particular landing site, it was observed that women play a leading role in drying and smoking fishes for sale, more so than in other landing sites.

Fisherfolk reported that the main challenges they encounter are conflicts with other fisherfolk using drift seines because the Cadell lines become entangled in the seines. They also reported encounters with sharks as one of the main challenges they face. Drift seine fisherfolk indicated that sargassum (a specific type of seaweed) is the main challenge affecting them. The main expenses per trip are fuel and fishing bait for the Cadell lines. Each fishing trip costs approximately $11,000 GYD ($53 USD).

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor at this site who participated in the study uses Cadell lines (demersal longlines) to fish. His trips last for up to 10 days and he typically fishes approximately 9 kilometers from the shoreline offshore of the mouth of the Moruca River. On each fishing trip, approximately 5,000 Cadell hooks are soaked for approximately 1 hour. Lines are soaked 5 to 10 times per fishing trip depending on the number of days spent at sea. The vessel is fitted with an outboard cruiser with an engine size of 15 hp and a haul capacity of 500 kilograms (1,100 pounds). Each fishing trip has four crew members, inclusive of the onboard supervisor. The highest cost per fishing trip is fuel because of the relatively long 10-day trips.

During the reporting period, the onboard supervisor did not report any challenges that significantly affected his fishing practices. However, he indicated that the fuel shortage that seriously impacted fishing at Smith's Creek also had minor negative impacts on his fishing practice.

Due to challenges in scheduling meeting times with the onboard supervisor, the study team was only able to obtain data collected by the onboard supervisor for the May to November 2019 period.

2.1 Target Species and Diversity

During the study, the total weight of combined hauls from the onboard supervisor's vessel was 2,753 kilograms (6,069 pounds) from 1,128 hours of effort from May to October 2019. As seen on Figure G-1, sea catfish was the most abundant species caught by a significant margin accounting for 75 percent of the total haul with 2,083 kilograms (4,592 pounds). This is similar to the haul from the onboard supervisor from La Grange (Region 3) where fishing by Cadell lines had a haul in which sea catfish comprised 85 percent. Hauls from fishing activities using Cadell lines significantly targets species that are benthic feeders because the hooks attached to the lines lie on the seafloor and benthic fishes are more easily hooked. Cuirass and gillbacker were the second and third most abundant species caught with 551 kilograms (1,215 pounds) and 111 kilograms (245 pounds), respectively. Overall, only five species were caught by the onboard supervisor. No bycatch was recorded by the onboard supervisor using this fishing method.

This is lower than the species diversity reported by the onboard supervisor from La Grange (Region 3) and although sea catfish was the most abundant caught species by both supervisors, the species composition of the hauls also showed marked differences. For example, gillbacker was not caught by the onboard supervisor from La Grange while bangamary and smaller species like annafokes were not caught by the onboard supervisor from Waramuri. This may be attributed to a variety of factors including the smaller data pool for Waramuri and the supervisors' preferred fishing grounds. In addition, bycatch was not reported by the La Grange onboard supervisor.

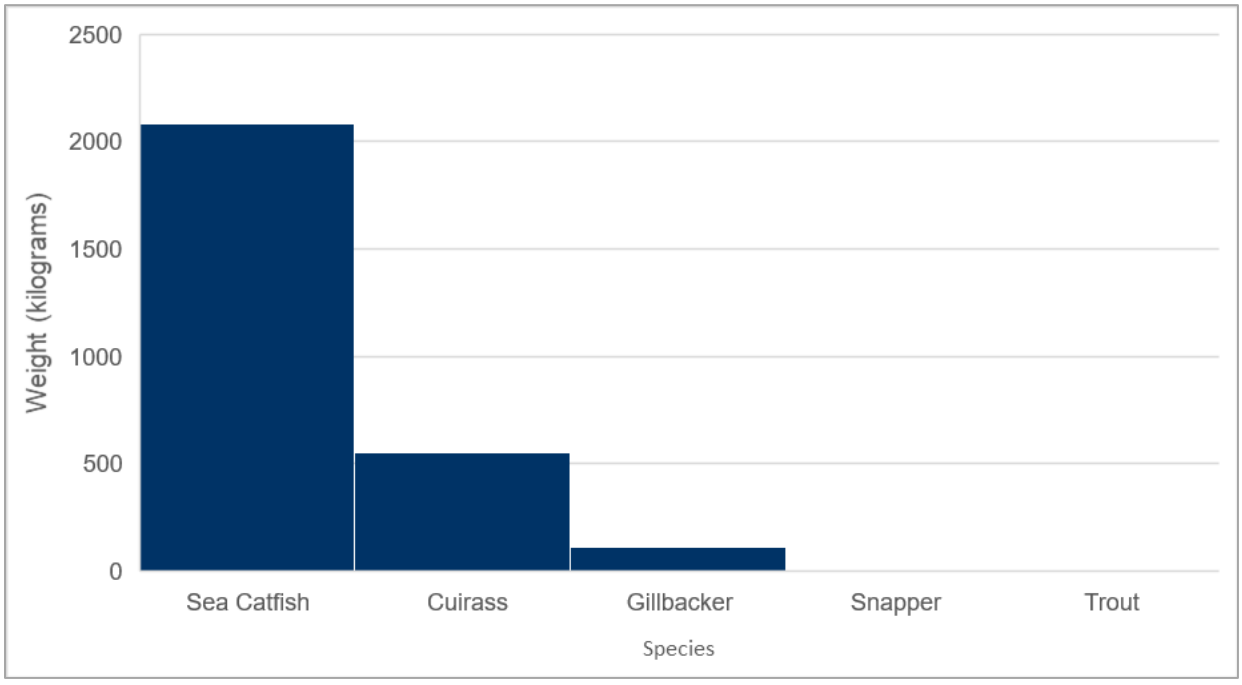


Figure G-1: Total Weight of Species Recorded by the Onboard Supervisor at the Waramuri/ Haimokabra Landing Site

2.2 Fishing Areas

As shown on Figure G-2, the main fishing area, where most of the fishing points are clustered, is within a zone of 65 square kilometers. The supervisor traveled 50 kilometers from the Waramuri landing site to access these fishing grounds. However, after leaving the landing site in Waramuri, the onboard supervisor landed at a beach area along the coast where the crew camped and where daily trips were launched. In total, the onboard supervisor has a traveling range of 458 square kilometers located along the coast of Region 1. Despite the distance traveled to access fishing grounds, the onboard supervisor stays relatively close to the shore compared to fishing activities of onboard supervisors from Regions 2 to 6. The farthest distance from shore at which a fishing point was located was 12.5 kilometers. This may be due to the lack of competition from nearshore fishing activities because fishing with Chinese seines and pin seines is not prevalent in Region 1.

Generally, several factors determine where the onboard supervisor decided to soak the fishing lines. These factors include the amount of fishes caught in these locations before, time and distance traveling to and from fishing grounds, and the presence of other fisherfolk or fishing activities in the area. All fish caught by the supervisor were mature.

Figure G-2: Fishing Area and Fishing Points Used by the Waramuri Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip. Most of the data collected at Waramuri/Haimokabra was for the good season and therefore, unlike the analysis for other landing site fishing grounds cannot be analyzed for differences in fishing practices in the good versus the hard seasons.

The effort expended per fishing trip monthly, as seen on Figure G-3. Figure G-4 and G-5 show the total weight of hauls monthly and the average haul weight per soaking of the seine. In the May to September 2019 good season the total weight of hauls was 2,528 kilograms (5,573 pounds) with 984 hours spent at sea. On average, soaking of the seine in this period yielded 64 kilograms (141 pounds). During this period, the supervisor expended the greatest effort (384 hours spent fishing) and recorded the highest total haul with 774 kilograms (1,706 pounds). However, the average weight of hauls per soaking was 48 kilograms (106 pounds), which was the lowest during the good season. The greatest average hauls were observed in May and September 2019 with hauls of 79 kilograms (174 pounds) and 78.5 kilograms (173), respectively. In May, the total haul was 474 kilograms (1,045 pounds) from 144 hours of effort while in September, the total haul was 707 kilograms (1,558 pounds) from 216 hours of effort.

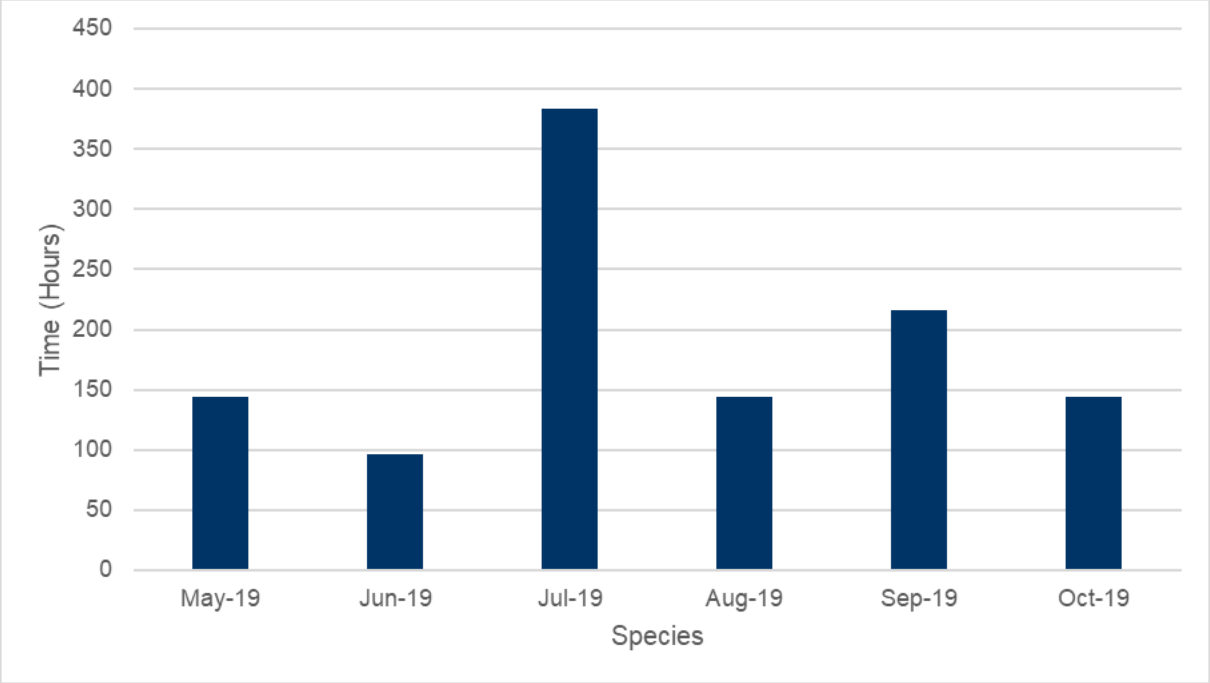


Figure G-3: Total Monthly Fishing Effort Recorded by the Waramuri/Haimokabra Onboard Supervisor

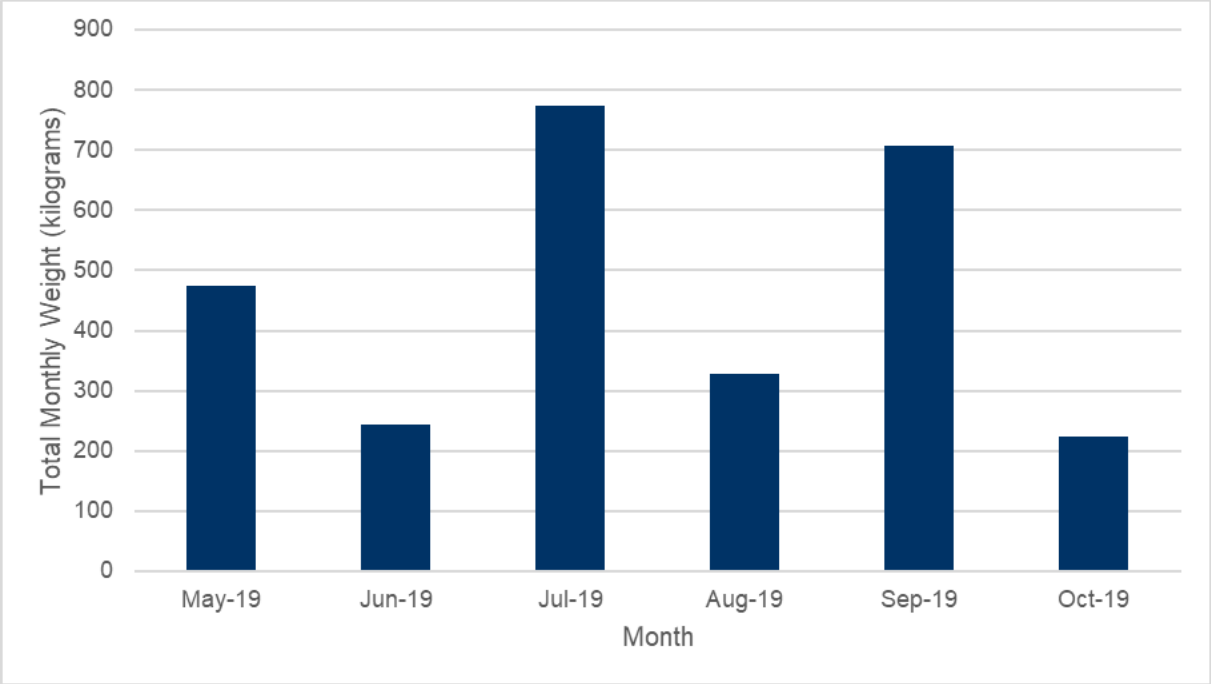


Figure G-4: Total Weight of Species Recorded by the Waramuri/Haimokabra Onboard Supervisor

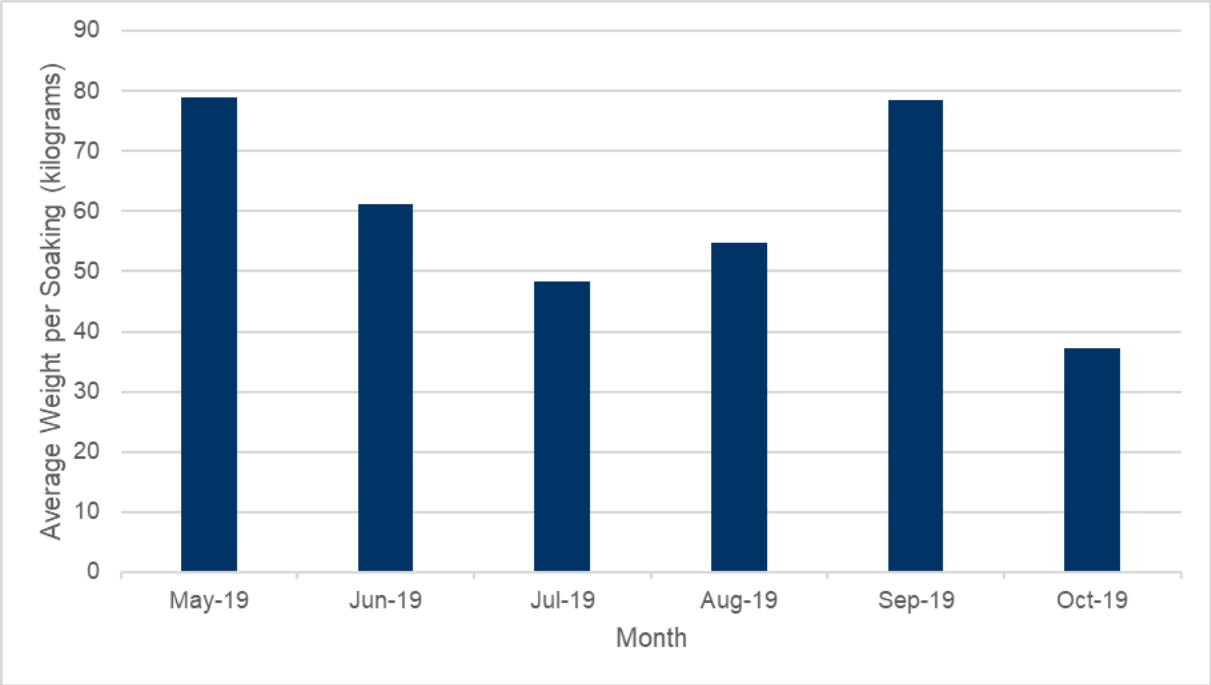


Figure G-5: Average Weight per Soaking Recorded by the Waramuri/ Haimokabra Onboard Supervisor

Based on the available data, productivity of the onboard supervisor's fishing activities could not be assessed for the entirety of the hard season from October 2019 to March 2020. However, October 2019 was one of the least productive months with a total haul of 224 kilograms (494 pounds). Although the total

haul in June 2019 was similar, there were significant differences in the total effort expended and average weight of hauls per soaking in these two months. In June 2019, the average weight of hauls per soaking was 61 kilograms (134 pounds) from a total effort of 96 hours, whereas in October 2019, the average weight of hauls per soaking was 37 kilograms (82 pounds) from a total effort of 144 hours. Similarly, the onboard supervisor expended comparable levels of effort, but total hauls were lower in October 2019 compared with 328 kilograms (723 pounds) in August 2019. This is directly a result of a higher average weight of total hauls per soaking of 55 kilograms (121 pounds) in August 2019, which is higher than the average weight of total hauls per soaking recorded in October 2019.

Seasonal trends in the primary wet and dry season were as follows:

- In August to October 2019, the primary dry season, total weight of hauls was 1,259 kilograms (2,776 pounds) with 504 hours spent at sea. On average, soaking of the seine in this period yielded 171 kilograms (377 pounds).
- In May to July 2019, the primary wet season, total weight of hauls was 1,439 kilograms (3,172 pounds) with 624 hours spent at sea. On average, soaking of the seine in this period yielded 63 kilograms (138 pounds).

There is not sufficient enough data to determine whether productivity of fishing supports fisherfolk views of the peak and off-peak fishing seasons. However, productivity was lowest in October 2019, which is typically when the hard season is believed to begin. Moreover, there was no definitive trend in productivity based on climatic seasonality because the difference in combined average productivity for the primary wet and dry seasons was not significant. Specifically, based on the data available, productivity was higher in the primary wet season than in the primary dry season. However, there was increased effort over the May to July primary wet season. The hauls from the onboard supervisor demonstrate that during the good season, increased effort is a reasonable predictor of increased productivity. In May and September 2019 there were comparable average weight of hauls per soaking but total hauls were greater in September when more effort was expended.

However, increased effort is not an indicator of increased productivity during the hard season. This is seen in June and October 2019, which had comparable total hauls, but greater effort was expended in October 2019 where the average weight of hauls per soaking is lower. Increased hauls per soaking in the good season may be attributed to several factors. In the wet season, greater nutrient loads are likely at the mouths of rivers, including the Moruca River, which may attract marine life. In the dry season, waters are warmer and calmer creating ideal conditions for fishes, which also act as an attractant. In addition, spawning season occurs during the July to September period, and fishes come closer to the shore to spawn.

2.4 Biometrics

The onboard supervisor measured the lengths and weights of representative fishes per each haul and the annual average lengths and weights of these fishes are shown on Figure G-6. Based on the measurements taken by the onboard supervisor, all of the fishes caught were sexually mature. By comparison, the onboard supervisor from the La Grange landing site captured adult and juvenile fish, but captures of juvenile bony fishes were largely confined to the hard season. He captured juvenile sharks throughout the year.

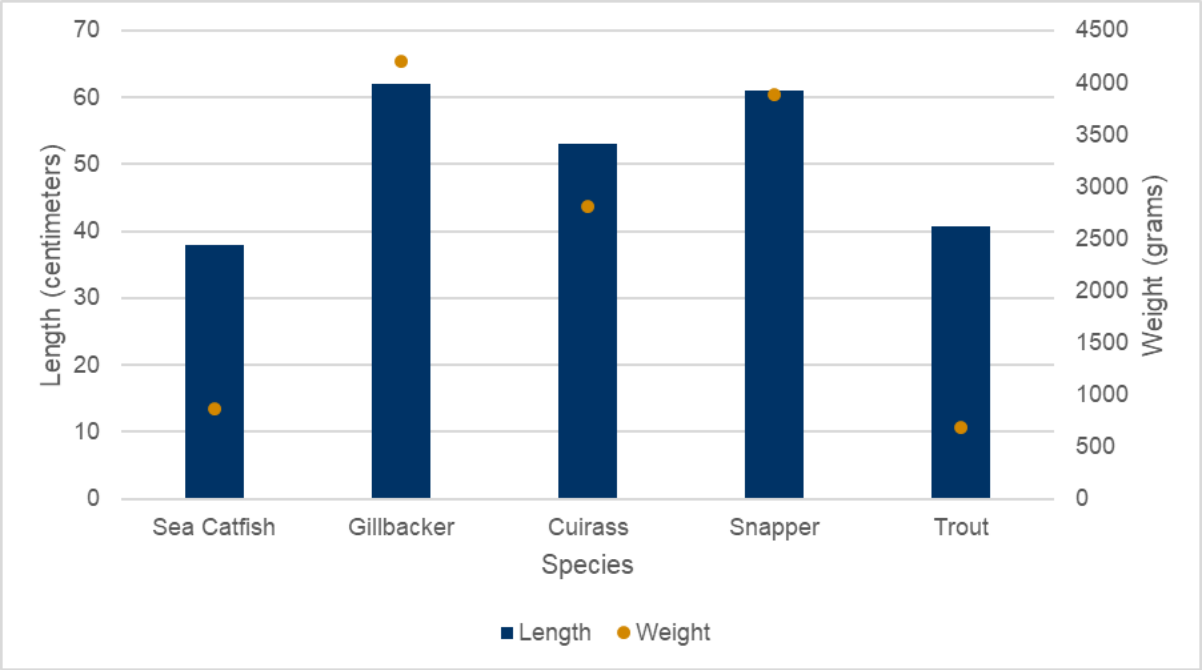


Figure G-6: Average Length and Weight of Fishes Caught by the Waramuri / Haimokabra Onboard Supervisor

The monthly average lengths and weights of the four most abundant species caught are presented on Figure G-7. All of the fishes measured had reached maturity. The largest, sea catfish, cuirass, and gillbacker, were caught in June and July 2019, after which sizes declined. This may have been due to more mature females with eggs coming closer to the shoreline to spawn in lagoons, estuaries, and mangroves. This trend is also seen in the data recorded at several other landing sites, like Smith's Creek, Charity, etc., where smaller fishes are caught after the spawning season ends.

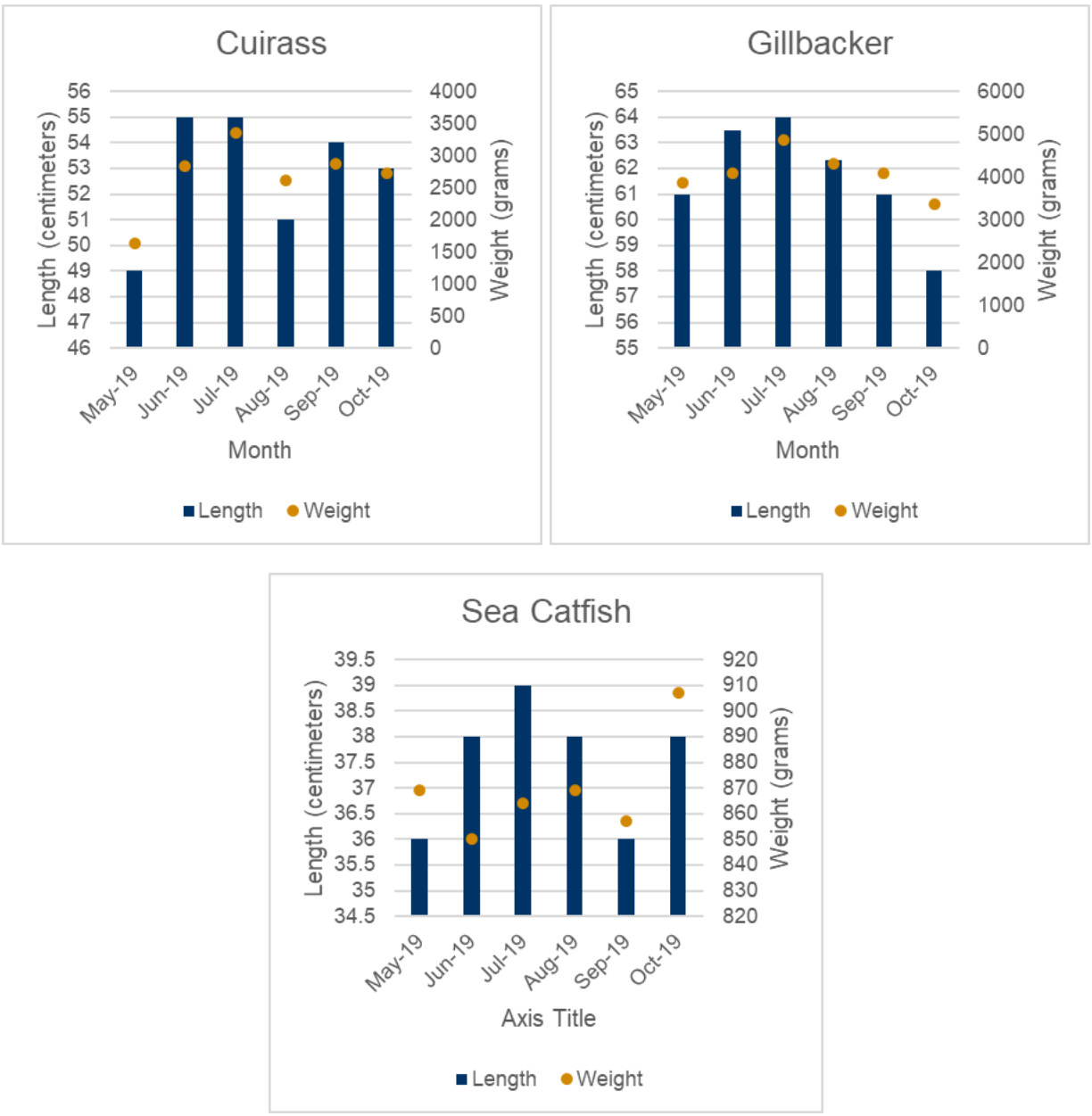


Figure G-7: Monthly Average Length and Weight of Most Caught Species by the Waramuri/Haimokabra Onboard Supervisor

3 QA/QC DATA

The study team initially intended to meet with the onboard supervisor's vessel when it landed to assess the haul, take biometric measurements, and compare these results to the data collected by the onboard supervisor. However, this could not be accomplished due to unexpected schedule changes in the supervisor's expected return date to shore. As an alternative, the team visited the Kumaka Market in Santa Rosa in an effort to meet another fisherfolk who used the Cadell method of fishing and who preferred the same fishing ground as the onboard supervisor. However, none of the fisherfolk at the market at the time used the Cadell fishing method. All of the fisherfolk used drift seines with variable mesh sizes. As a result of these challenges, the team could not conduct QA/QC exercises of the onboard

supervisor's haul and also was unable to assess hauls from a similar fishing type. Due to COVID-19 restrictions, a subsequent visit to conduct the QA/QC exercise did not occur.

APPENDIX H CHARITY (REGION 2)

1 LANDING SITE OVERVIEW

Charity is one of the main ports in Region 2 with commercial passenger vessels, produce vessels, and artisanal fishing vessels all using it as an embarkation/disembarkation site. It is the largest landing site by volume of landed fish in Region 2. Fishing by vessels at this landing site occurs along the Essequibo Coast (Region 2), and northwest from Charity to the Waini River (Region 1). Both inboard and outboard cruisers (designation for where the engines are placed on the vessel) operate from this port. Inboard cruisers, the type of boat most frequently landed at the site, have engines of 100 hp or more (Figure H-1), and are the largest artisanal fishing vessels in Guyana. Unlike many other vessels in Guyana, inboard cruisers would have engines that are built inside the boat. Outboards have an engine on the outside of the vessel that is easily removed.

The landing site is located in the waterfront area of the privately-owned Big Bird and Sons Fish Port Complex that includes an ice factory from which fisherfolk purchase ice to be used for fish preservation during fishing trips. Fisherfolk from as far as Mabaruma in Region 1 visit the Complex to purchase ice when there are shortages in their area. The Complex also provides a ready marketplace for landed vessels at Charity as vendors visit the site to purchase hauls from fisherfolk. In addition, large quantities of fishes are also purchased by the proprietors of the Complex for export. Fisherfolk indicate that an artisanal fleet of up to 70 vessels use the site.

Figure H-1: Inboard Cruiser at the Charity Landing Site

Vessels use drift seines with mesh sizes of 10 to 20 centimeters (4 to 8 inches) to target snapper. These vessels have extended fishing trips averaging 15 days at sea. Hauls also include jewfish (endangered, rare, and protected species) and shark species, some of which may be considered endangered, rare, protected, or vulnerable species. Due to the extended number of days spent at sea, fishes are usually de-gutted before vessels land at Charity. (Note: This practice hindered biometric measurements at this landing site.) Fisherfolk spend $40,000 to 540,000 GYD ($191 to 2,583 USD) to conduct a fishing trip and have haul sizes of 200 to 1,700 kilograms (440 to 3,740 pounds) of fishes. Their main expenses are ice (some indicated ice shortages) and fuel.

Fisherfolk from this landing site reported conflicts with other fisherfolk associated with sharing preferred fishing grounds, conflicts with trawlers that are believed to cut the lines of the drift seines, and conflicts with Venezuelan vessels fishing in Guyana's waters. Fisherfolk also shared fears of theft and threats to personal safety that would arise from acts of piracy, but incidences of piracy were reported during the study period. Some fisherfolk also reported that seaweed in the mouth of the Pomeroon River that flows up to the Waini River also affects their fishing activities (during the January to March 2019 season). Some fisherfolk are also challenged by significant variability in prices for fishes at the landing site at different times of the year.

2 REGIONAL SUPERVISOR RESULTS

One regional supervisor participated in the study. Most vessels at this site are inboard cruisers that use drift seines with mesh sizes from 10 to 20 centimeters (4 to 8 inches) to target snapper. Although there is a small population of "bangamary boats" that target bangamary and use drift seines with mesh sizes of 7 centimeters (2.75 inches), the study team advised the regional supervisor to focus data collection efforts on inboard cruisers because they were unique to this landing site. These vessels were mainly the inboard cruisers. As such, only two data sets from the vessels that target bangamary were collected, and as a result, the data reported herein on bangamary should not be considered as representative of hauls from all vessels.

2.1 Effort and Haul

Based on the data collected, 14 commercial species were caught with a combined weight of 105,470 kilograms (232,521 pounds). This overall catch volume is significantly higher than the data recorded for other landing sites and is principally attributed to the use of inboard cruisers that have significant haul capacities and typically conduct extended fishing trips. As a preservative measure during prolonged fishing trips, fishes are gutted at sea, whereas at other landing sites with regional supervisors, the recorded landed weights are of fishes that are whole/un-gutted. Total haul volumes per trip for vessels at the Charity landing site are higher compared to data collected by the other regional supervisors due to the prolonged time the vessels spend at sea when compared to the other types of vessels.

Inboard cruisers typically fish along the Essequibo Coast (Region 2), but are known to frequently travel to fishing grounds ranging from the mouth of the Pomeroon River to the mouth of the Waini River (Region 1). These vessels fish from 3 to 48 kilometers from the coastline and in depths of approximately 70 meters. Compared to other vessels in Guyana's artisanal fleet, inboard cruisers typically spend upward of 2 weeks at sea per fishing trip because of larger capacities that accommodate crew, maintain a stock of supplies, and store hauls on ice. Moreover, gutting fishes at sea is not only a preservation method but also reduces the total weight of fishes stored onboard. This facilitates increased soakings of the seine per fishing trip and creates the opportunity for maximizing the vessel's haul capacity on each fishing trip.

Over the April 2019 to February 2020 period, a fishing trip lasted for 15 days on average. However, the average duration of fishing trips varied on a monthly basis (Figure H-2) and no clearly discernable trend for consecutive months was observed. For example:

- The shortest average monthly trips lasted for approximately 14 days and were observed in May, July, and September of 2019 and also in January 2020. The shortest trip recorded in these months was 10 days and the longest was 18 days.
- The longest average monthly trips lasted for approximately 16 days and were observed in April, June, August, and November of 2019, and again in February 2020. The shortest trip recorded in these months was 8 days and the longest was 19 days.

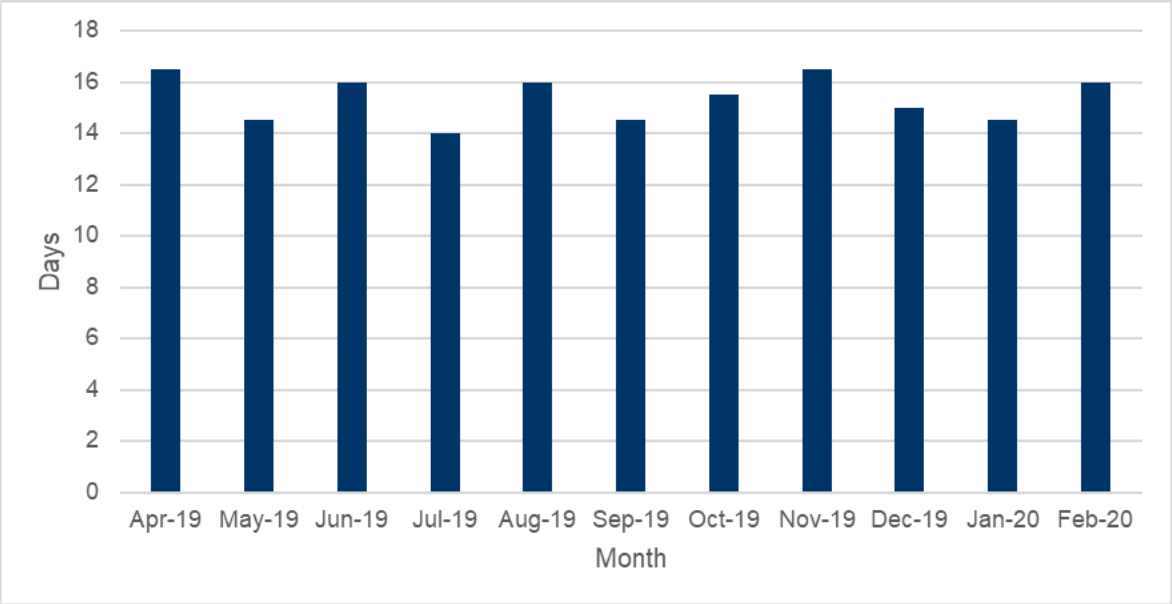


Figure H-2: Average Monthly Fishing Effort at the Charity Landing Site

2.2 Target Species and Diversity

Snapper is the fish most caught by weight at this landing site (see Figure H-3) with a total weight of 63,537 kilograms (140,075 pounds); snapper accounted for 60 percent of total haul weight. This was expected as most of the data were collected from vessels that target snapper. Trout was the second most abundant species caught with a total weight of 14,733 kilograms (32,480 pounds); cuirass was the third with 11,005 kilograms (24,261 pounds), and cuffum fourth with 5,592 kilograms (12,328 pounds). These four species as well as the 10 other species that were caught all tend to be comparatively large-bodied fish. Catch comprising large fishes is typical of snapper seines, which have the largest mesh sizes used by artisanal fisherfolk, which limits capture of smaller species and smaller fishes. This was also observed at other landing sites where seines with larger mesh sizes are used including Hampton Court (Region 2), Bushlot and Rosignol (Region 5), and Complex 66 (Region 6).

In addition, endangered, rare, and protected species were also reported in hauls from this landing site. Jewfish was also reported at the Charity landing site from fishing trips to the Waini River in June 2019 and February 2020. It is likely that these vessels shared common fishing grounds with the fisherfolk from Smith's Creek and Morahwanna who caught jewfish in the Waini River in May, September, October, and December 2019, and January 2020. Shark were caught in greater quantities than jewfish, but were not reported by species so it was impossible to determine whether they included endangered, rare, or protected species.

Of 14 different species of fishes caught by fisherfolk at this landing site, no more than 9 were caught in any given month (see Figure H-4). Seasonal trends were not evident in species diversity and most of the fishes caught are not migratory. Species diversity is significantly lower than that observed at Smith's Creek and is principally due to the use of seines with large mesh sizes that allow most of the smaller fisher and smaller species of fish to escape.

Most of the fishes measured at this landing site had achieved sexual maturity.

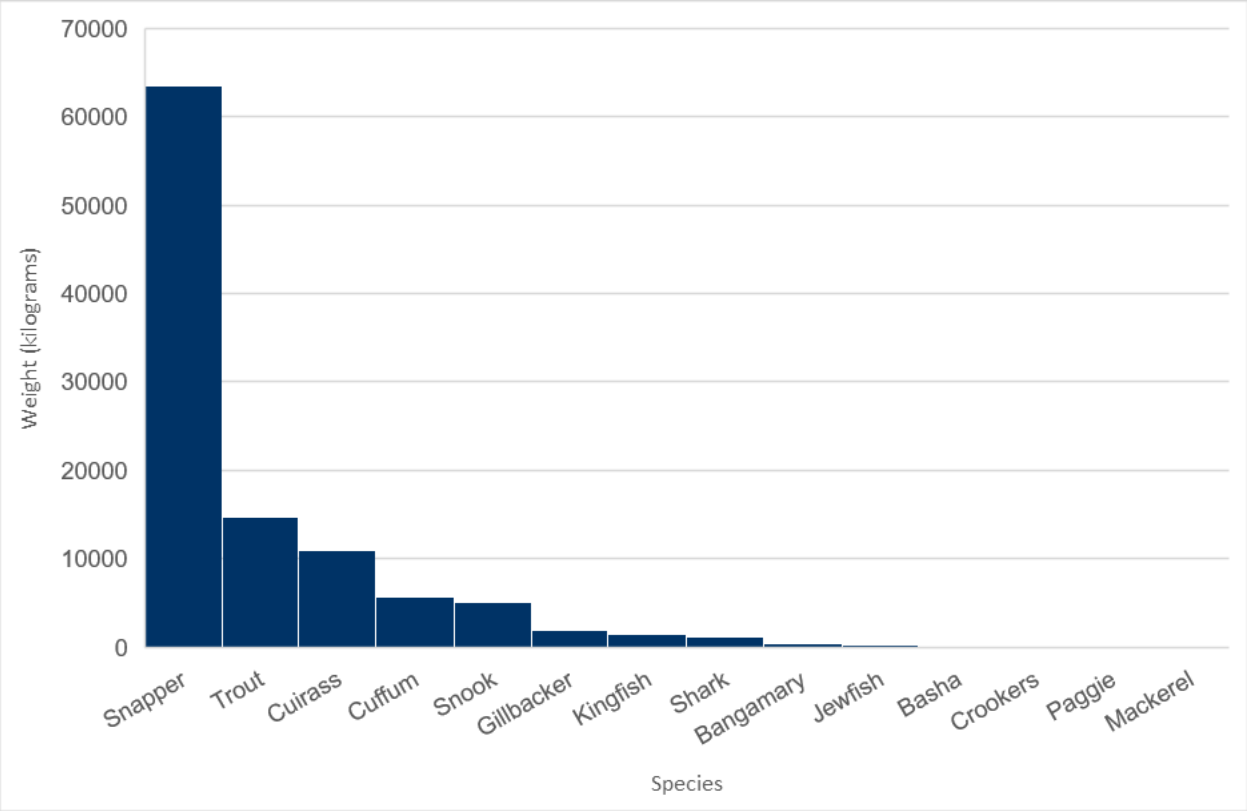


Figure H-3: Total Weight of Species Caught at the Charity Landing Site

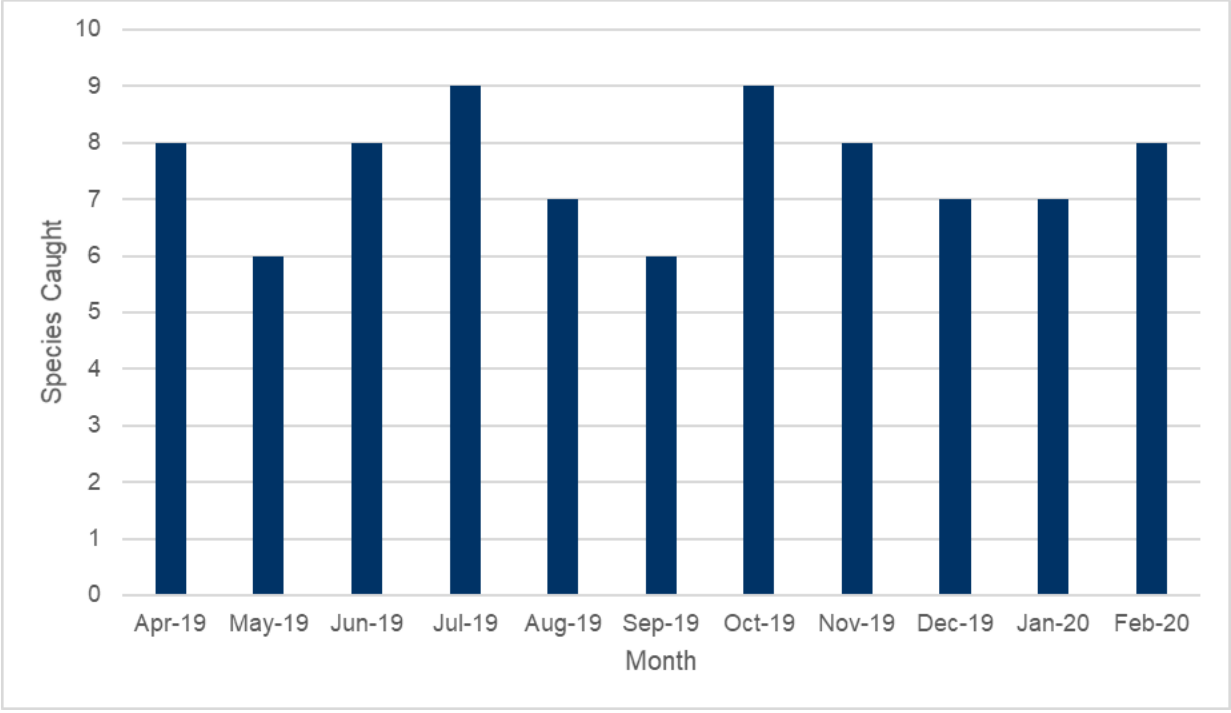


Figure H-4: Species Diversity at the Charity Landing Site

2.3 Seasonal Productivity

Artisanal fisherfolk in Guyana subscribe to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip. Figure H-5 presents the average monthly productivity of hauls, which was measured as total monthly productivity (in kilograms) divided by the number of fishing trips. As expected, the average monthly productivity varied with the following key observations:

- The highest average monthly productivity with hauls greater than 1,000 kilograms (2,205 pounds) were observed in May, July, and September 2019. May was the most productive month with an average productivity of 1,091 kilograms (2,405 pounds). These were the same 3 months in 2019 when the least effort was expended per fishing trip. However, it is not evident whether less effort was expended by design, or whether a greater abundance of fishes allowed fisherfolk to achieve optimum haul capacities more quickly. The months of June and August 2019 recorded the second greatest average monthly productivity with hauls greater than 900 kilograms (1,984 pounds). However, greater effort was expended per fishing trip during these months.

- By contrast, average monthly capacity was 800 kilograms (1,764 pounds) or lower in April 2019, and over the October 2019 to February 2020 period. February 2020 was the least productive month with an average productivity of 624 kilograms (1,375 pounds) and was also one of the months during which most effort was expended. This may be attributed to a spring tide cycle that made the seas extremely rough, challenging the mobility of fisherfolk and increasing the difficulty of fishing activities.

By comparison, combined capacities for wet and dry seasons were as follows:

- From May to July 2019, the primary wet season, the average combined haul was 356 kilograms (785 pounds).

- From August to October 2019, the primary dry season, the average combined haul was 368 kilograms (811 pounds).

- From November 2019 to January 2020, the secondary wet season, the average combined haul was 368 kilograms (811 pounds).

- From February 2020 to April 2020, the secondary dry season, the average combined haul was 390 kilograms (860 pounds). Data were not able to be collected for March 2020 to complete the trend for this season.

The trends observed in average monthly productivity support fisherfolk views of the peak and off-peak fishing seasons. Guyana’s wet and dry seasons do not appear to influence productivity as combined average productivity for the primary wet and primary dry seasons was not significant. In fact, the peak season comprises consecutive months of the primary wet and dry seasons. These are also different from the seasonal trends observed at Smith’s Creek where average monthly productivity was lower in the May to July wet season as compared to the August to October dry season. However, as previously noted, fuel prices peaked in Smith’s Creek during the May to July period, which curtailed fishing activities at that landing site.

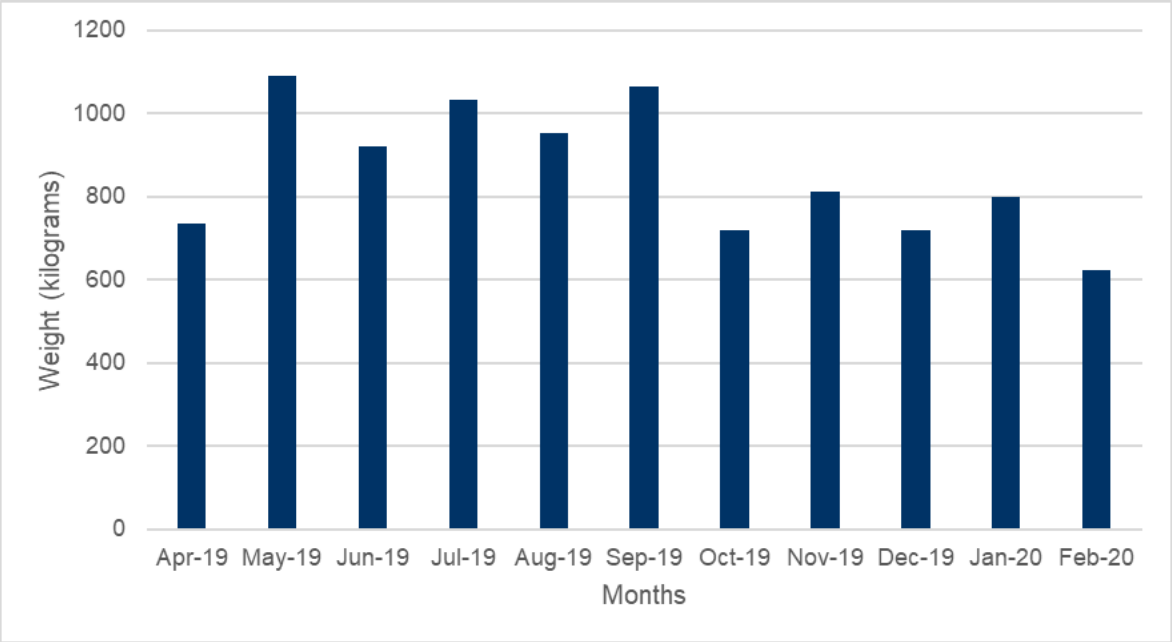


Figure H-5: Average Monthly Productivity of Fishing Trips at the Charity Landing Site

2.4 Prices and Markets

In total, sales of fishes at this landing site were the highest earnings at any landing site at which regional supervisors collected data. Snapper is the most expensive fish by kilogram (Figure H-6) with an annual average price of $719 GYD ($3.5 USD) per kilogram. Gillbacker was the second most high-value species with an annual average price of $610 GYD ($2.9 USD). Previously, the gillbacker was sold for the highest prices at this landing site and other areas of the country due to high demand on the export markets. However, prices dipped following the cessation of exports to the United States in 2018. Trout and bangamary were the third and fourth most high-value species, with average prices of $339 GYD ($1.6 USD) and $231 GYD ($1.1 USD), respectively. Jewfish and shark were not high-value with comparable annual average prices of $132 GYD ($0.6 USD) and $129 GYD ($0.6 USD), respectively. Based on the data collected by the regional supervisor, earnings from sales at this landing site totaled $54,725,111 GYD ($263,101 USD).

Earnings per fishing trip are also increased by sale of the glue (swim bladders) of snapper and to a lesser extent, of trout. Prices at which glue was sold throughout the year were not collected by the regional supervisor as part of the study. However, interviews with the regional supervisor and fisherfolk at the landing site indicated that the price per kilogram of glue from snapper and trout is consistently greater than the price per kilogram of the flesh of these fishes. Moreover, eggs harvested from sexually mature fishes are also sold separately from the flesh and reportedly the highest demand for eggs is from gillbacker. Generally, fisherfolk using inboard cruisers heavily depend on the sale of these products, particularly glue, to make fishing trips economically feasible as a single fishing trip using these vessels costs approximately $540,000 GYD ($2,583 USD). The maximum approximate income per trip was recorded during August 2019, which was $648,740 GYD ($3,119 USD), and the minimum approximate income per trip was recorded in October 2019, which was $304,489 GYD ($1,464 USD).

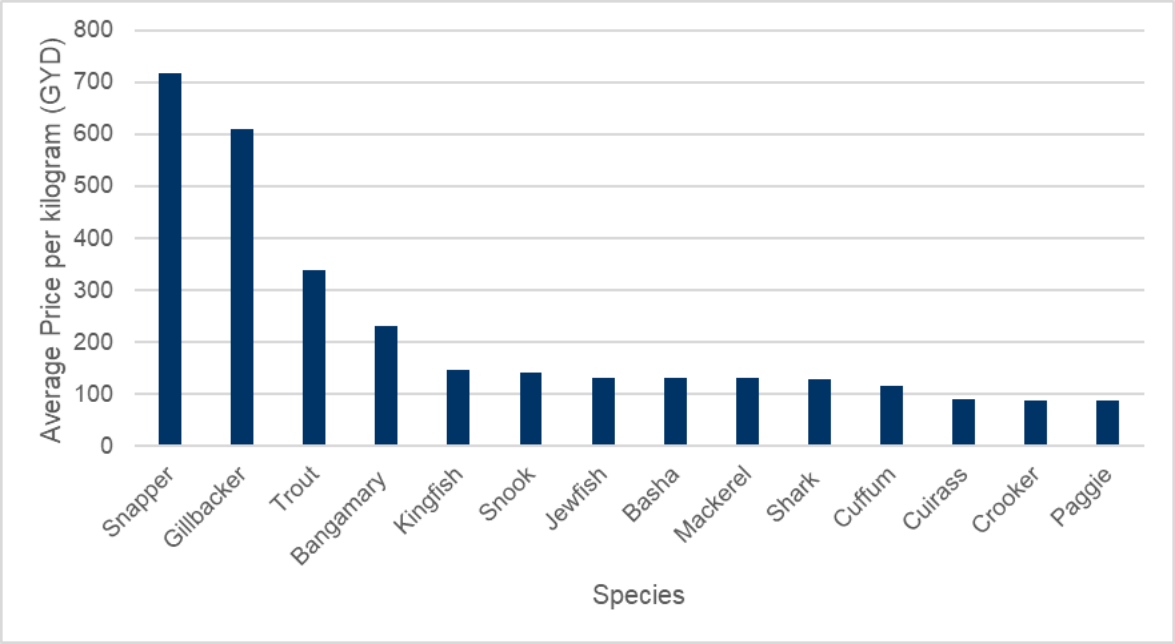


Figure H-6: Annual Average Price per Kilogram of Fishes at the Charity Landing Site

In general, the prices at which fishes are sold varies by species and season and Figure H-7 shows the minimum, maximum, and average prices for the four most abundant species caught. Prices of the target species, snapper and trout, and other high-value species like gillbacker are relatively consistent. The differences between minimum and maximum prices for these species are also negligible during most periods of the year. Nonetheless, prices are likely to swing in response to market forces. For example, the prices of snapper significantly increased in July and August 2019 and the regional supervisor indicated that during this period, demand for export of snapper to China increased. Prices subsequently declined in September and October 2019 due to lower demand for exports to China, which was reportedly related to the protests in Hong Kong and the resultant surplus of fish in the local marketplace. The regional supervisor also indicated that the demand for snapper glue also sharply declined around this time.

Fisherfolk indicated that the price decline challenged the economic viability of their fishing activities and some opted to store the glue harvested from the fishes for sale until market prices again increased. By November 2019, prices had returned to those observed in the April to June 2019 period, but started to climb once more from December 2019 to February 2020, presumably due to lower supply as the hard season progressed. Trout, from which glue is also harvested for sale and export, also experienced price declines for the flesh of the fish that were similarly related to the loss of glue markets. Unlike snapper, the prices were lowest during the hard season.

The annual average prices of trout, cuirass, and cuffum were significantly lower than for snapper. Cuirass was one of the lowest-priced species and prices were stable throughout the year except for spikes in June, August, and September 2019. Prices also remained stable throughout the hard season. The reason for these price spikes is unknown. The prices of cuffum varied significantly throughout the year and major differences in minimum and maximum prices were also observed. Like trout, the lowest prices were observed in the hard season. This trend suggests that prices of middle-value and lower-value fishes may not be as responsive to market forces and scarcity as are high-value species like snapper.

Figure H-7: Monthly Price Variations of the Four Most Abundant Species Caught

2.5 Biometrics

The regional supervisor measured the lengths and weights of fishes that were representative of hauls for which data were collected. The annual average length and weight of these fishes are presented on Figure H-8.[2] However, it should be noted that the practice of gutting fishes at sea has reduced the total weight of landed fish at this site compared to other landing sites in the study. Jewfish was the largest species caught with a length of 152 centimeters and gutted weight of 149,685 grams (330 pounds). Only two jewfish catches were recorded during the reporting period. The fishes caught at the Charity landing site would be considered sexually mature, unlike those captured at the Smith's Creek/Morahwanna landing site. Based on the reported lengths, it is unlikely that any of the sharks landed had reached sexual

[2] Jewfish is not included on Figure H-8 because, with an annual average weight of 149,685 grams (330 pounds) and an average length of 152 centimeters, it significantly skews size representations for the other species.

maturity. Overall, the annual average lengths and weights of the other species caught indicate that they have reached sexual maturity. The trend of larger fishes of the species caught with seines that have large mesh sizes is expected and has been observed at other landing sites.

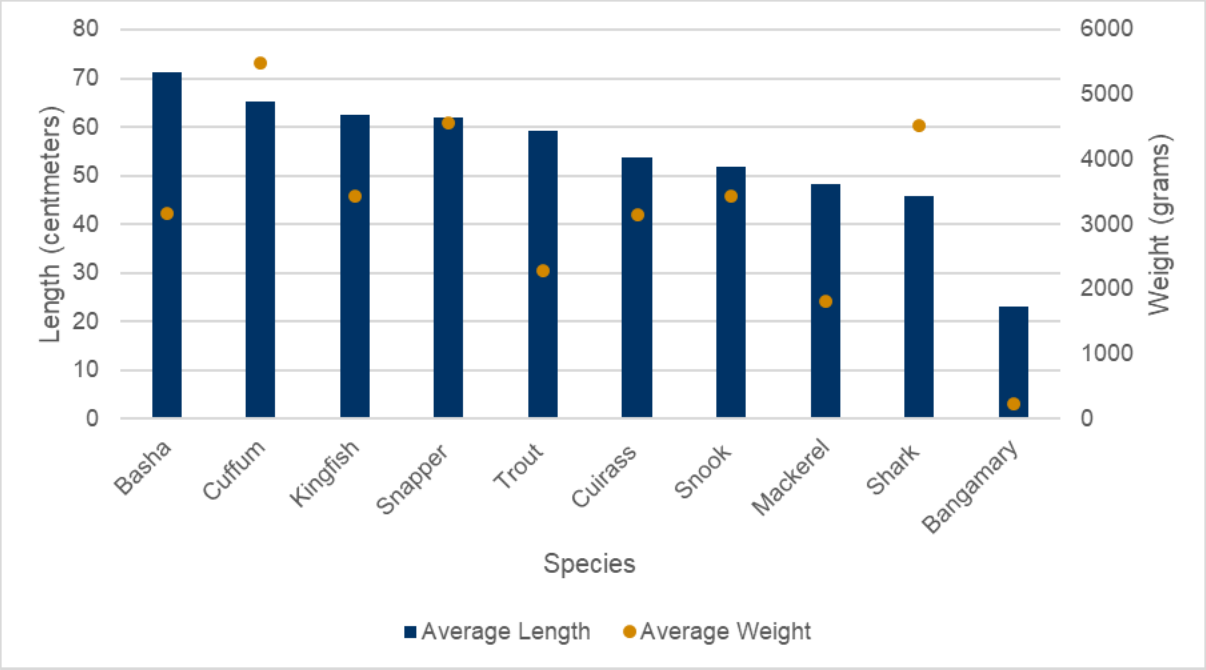


Figure H-8: Annual Average Lengths and Weights for Fishes Measured at the Charity Landing Site

The monthly average lengths and weights of the four most abundant species caught (Figure H-9) show some variability, but most of the species were considered sexually mature. The smallest—snapper, trout, and cuirass—were recorded in February 2020, which was also the month with the lowest annual average productivity and one of the months of greatest effort. The largest fishes of these four species were caught in the April to September peak season and smaller fishes were caught in October and November 2019. Larger snapper, cuirass, and cuffum were once again caught during the December 2019 to February 2020 period for.

This is similar to the trend that was observed at Smith's Creek and Morahwanna. As previously discussed, size variation may be attributed to two reasons. Lowe-McConnell (1962) suggested that fishes come closer to shore during the rainy seasons due to increased nutrient flows and calmer trade winds. Fishes subsequently return close to the shore in August to September for spawning.

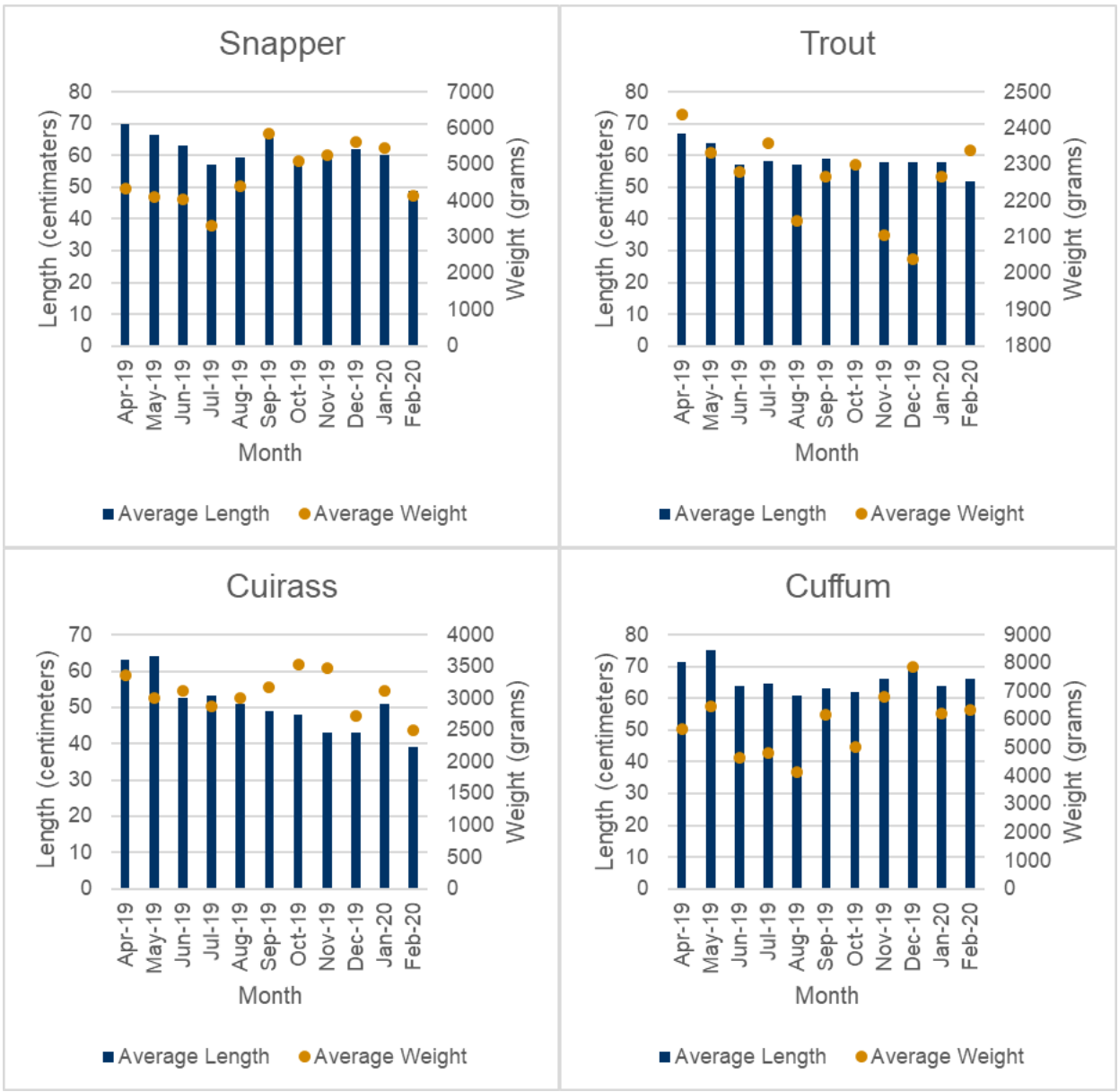


Figure H-9: Monthly Average Lengths and Weights of Most Abundant Species Caught

3 QA/QC DATA

During the initial visit, the regional supervisor at the Charity landing site collected data from inboard cruisers that target snapper and use drift seines with mesh sizes of 18 centimeters (7 inches). Over the 3-day period for which the QA/QC exercise was conducted in Region 2, no inboard cruisers landed at the site. The regional supervisor indicated that this is common as inboard cruisers do not frequently land. Due to these circumstances, the QA/QC assessment of data collected by the regional supervisor could not be conducted.

During the second QA/QC exercise, an inboard cruiser landed at this site, but this vessel did not have a successful fishing trip, deemed locally as a “bust trip.” The vessel was forced to return to the landing due

to mechanical difficulties after having only spent 5 days fishing. The total haul of the vessel was 376 kilograms (829 pounds). As seen on Figure H-10, snapper was the most abundant species caught, and with a total weight of 220 kilograms (485 pounds), it accounted for 59 percent of the total haul. Trout was the second most abundant species caught at 99 kilograms (218 pounds). These are normally the two most commonly landed species at the landing site based on the data collected by the regional supervisor. Prices of snapper from this trip were $748 GYD ($3.6 USD) per kilogram, trout $308 GYD ($1.4 USD) per kilogram, mackerel $143 GYD ($0.7 USD) per kilogram, and snook $132 GYD ($0.6 USD) per kilogram. These were all consistent with the level of pricing recorded by the regional supervisor throughout this period.

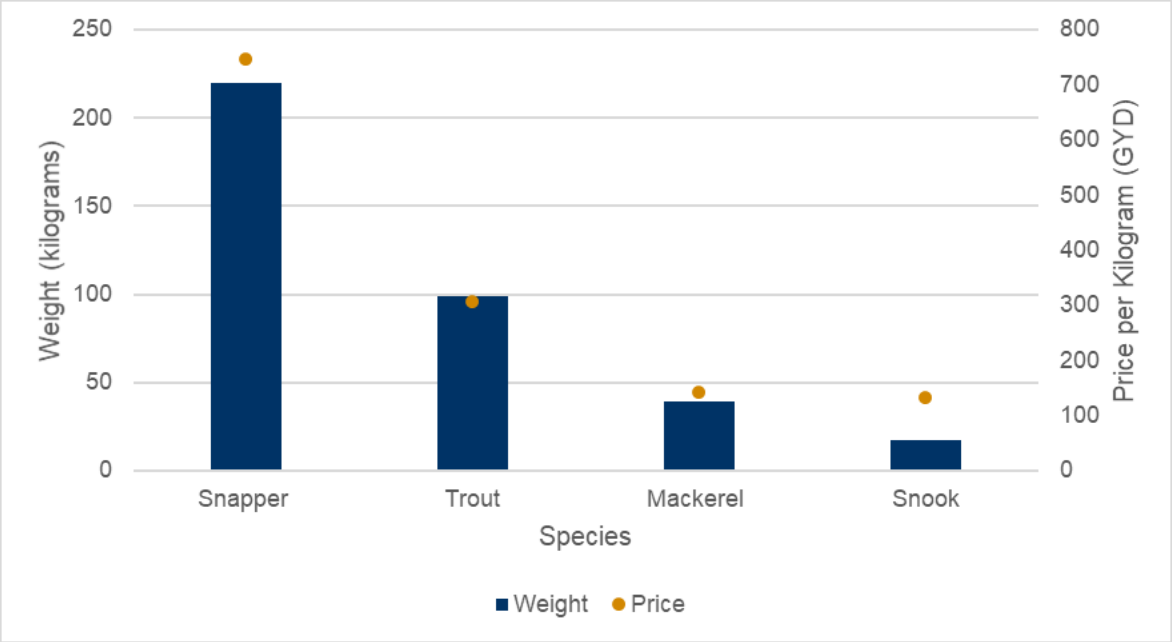


Figure H-10: Total Weight and Prices of Fishes from Vessel Assessed during the Second QA/QC Exercise

Biometric data collected from the catch was similar to those recorded by the supervisor. However, there was significant variance in the sizes of the snapper with the measurement during the QA/QC exercise being approximately 20 centimeters greater than the annual average lengths of fishes measured by the regional supervisor (Figure H-11). Random selection of fishes and the larger data pool on which the average lengths were calculated for the regional supervisor's measurement may account for the change. Overall, the study team was satisfied with the data collected; however, due to the relatively small sample size from the vessel from which the data were collected, more analysis would be needed to completely satisfy QA/QC requirement. However, the general trends seen in the data would represent accurate trends that were seen from the data collected by the regional supervisor hence the data can be deemed credible.

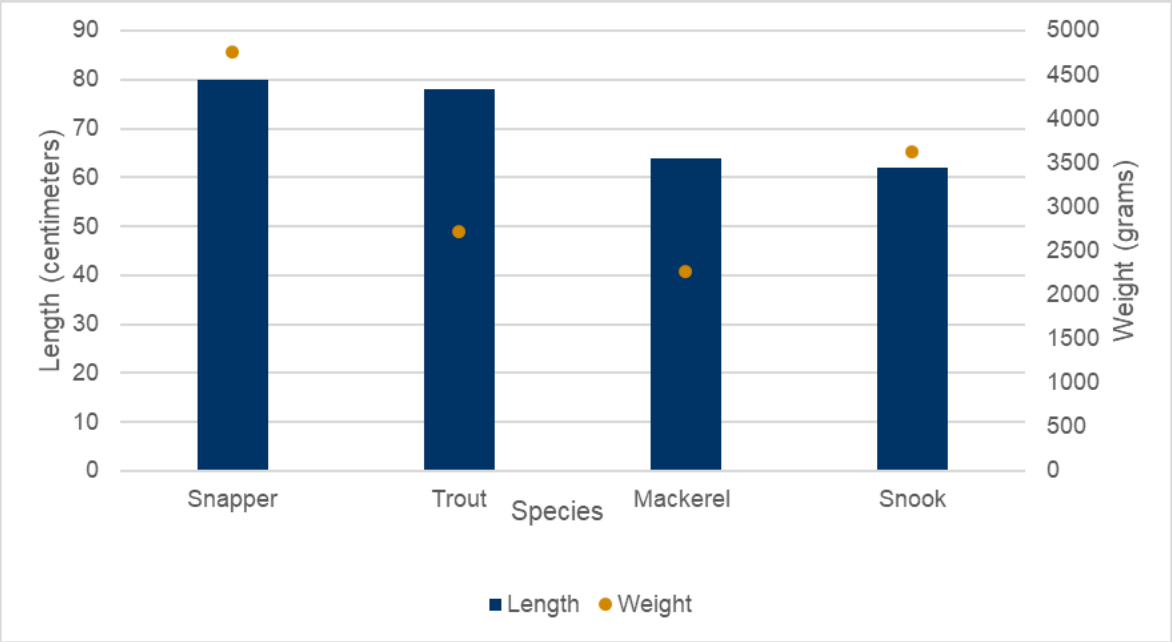


Figure H-11: Lengths and Weights of Fishes Measured during the Second QA/QC Exercise

APPENDIX I HAMPTON COURT (REGION 2)

1 LANDING SITE OVERVIEW

The Hampton Court landing site is one of the largest landing sites on the Essequibo Coast (Region 2) and is used by vessels that target both fishes and shrimp. Approximately 22 vessels use the Hampton Court landing site, all of which are outboard cruisers with engine sizes ranging from 5 to 60 hp. Larger vessels, with engines of 40 hp or greater, travel farther from the coastline and spend 2 to 6 days and typically use drift seines with mesh sizes of 13 to 20 centimeters (5 to 8 inches) to target larger fishes like snapper, gillbacker, and trout. Smaller vessels, with engine sizes of less than 40 hp, make fishing trips lasting for 1 day or less and use Chinese seines with mesh sizes of 2.5 to 10 centimeters (1 to 4 inches) to target shrimp and smaller species of fish. Seines are typically soaked for 4 to 6 hours. In general, fisherfolk at this site usually fish 3 to 16 kilometers from the coastline and fish up to 15 meters deep.

The main commercial species caught by fisherfolk are cuirass, snapper, bangamary, shrimp, gillbacker, and trout. During the peak season, hauls from vessels using drift seines range from 455 to 682 kilograms (1,000 to 1,500 pounds) of fishes while hauls from vessels using Chinese seines were approximately 38 kilograms (85 pounds) of shrimp. Most of the fishes caught are sold to vendors who export fishes and visit the landing site with refrigerated trucks. However, some fisherfolk sell produce in nearby villages or to vendors for sale in local markets. Prices per kilogram of fishes vary by species. For example, the price per kilogram of shrimp was $220 GYD ($1.05 USD) while high-value fishes such as snapper and gillbacker were sold for more than $600 GYD ($2.90 USD) per kilogram. Costs per fishing trips for the vessels using Chinese seines were approximately $1,000 GYD ($4.80 USD) while $100,000 GYD ($478 USD) is required for the larger vessels.

The principal challenges encountered are trawlers, sargassum, piracy, jellyfishes, ice shortages, and theft. There are frequent conflicts between the fisherfolk at the Hampton Court landing site who use drift seines and Chinese seines. Conflicts were also reported with fisherfolk who use Cadell lines and fisherfolk who practice anchor seine fishing along the Region 2 coastline. According to the Department of Fisheries, vessels using anchor seines are only allowed to fish in Region 3.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor who participated in the study at this landing site uses a drift seine with mesh sizes of 20 centimeters (8 inches) to target larger species of fishes, specifically the high-value species gillbacker and snapper. The vessel used has a haul capacity of 907 kilograms (2,000 pounds) and is powered by two 48 hp engines. Most of the hauls from the onboard supervisors are sold to fishing trucks that visit this landing site to purchase fishes for export. The onboard supervisor's fishing trips typically last 2 to 8 days. Each fishing trip requires a three-member crew. The main expenses per fishing trip are for crew rations, fuel, and ice for the preservation of the haul. Due to the prolonged periods spent at sea, the supervisor also guts fishes before icing them during the fishing trip. When gutting fish, the supervisor harvests the swim bladders (glue) from the snapper and trout. These are iced and sold separately from the flesh of the fishes upon return to the landing site.

During the April 2019 to February 2020 study period, the onboard supervisor encountered several problems that reduced fishing activity. These included:

- Reports that the seines were damaged by anchor seines. (According to the Department of Fisheries of the Ministry of Agriculture, anchor seine fishing is illegal in Region 2.)
- Frequent shortages of ice due to broken ice machines in June, September, and November 2019. Three main ice distributors are in Region 2, one of which is located at the Big Bird and Sons Fish

Port Complex. Shortages of ice significantly impact activities of fisherfolk who undertake fishing trips of more than 12 hours where it is required to preserve the haul while at sea.

- There was significant accretion of mud in the channel used to travel to and from the landing site over the period late May to June 2019. This prevented the supervisor from going to sea as the water levels were too shallow. Thereafter, the landing site was inaccessible for approximately 1 week in July 2019 as the channel was being excavated.
- The onboard supervisor became severely ill and was unable to take any fishing trips for 2 weeks in July 2019.
- The sluice malfunctioned and could not be opened in January 2020 and several vessels that had moved into the canal for servicing and repairs were grounded and could not venture out to sea. The onboard supervisor's vessel was one of those remaining on the inland side of the sluice when it malfunctioned.

2.1 Target Species and Diversity

The total weights of combined hauls from the onboard supervisor's vessel over the period April 2019 to February 2020 was 7,048 kilograms (15,538 pounds). Gillbacker and snapper were the two most abundant species caught with total weights of 3,895 kilograms (8,587 pounds) and 2,796 kilograms (6,164 pounds), respectively (Figure I-1). These two species accounted for 96 percent of the total catch with gillbacker accounting for 56 percent and snapper 40 percent, respectively. The remaining 4 percent of the haul was comprised of trout, cuirass, snook, and sea patwa. The onboard supervisor reported that bycatch from his fishing activities was low because the mesh size of the drift seines used are designed to target gillbacker and snapper. As a result, only larger species and larger fishes are captured in seines. Overall, species diversity was low with only six species being recorded by the onboard supervisor, all of which were mature.

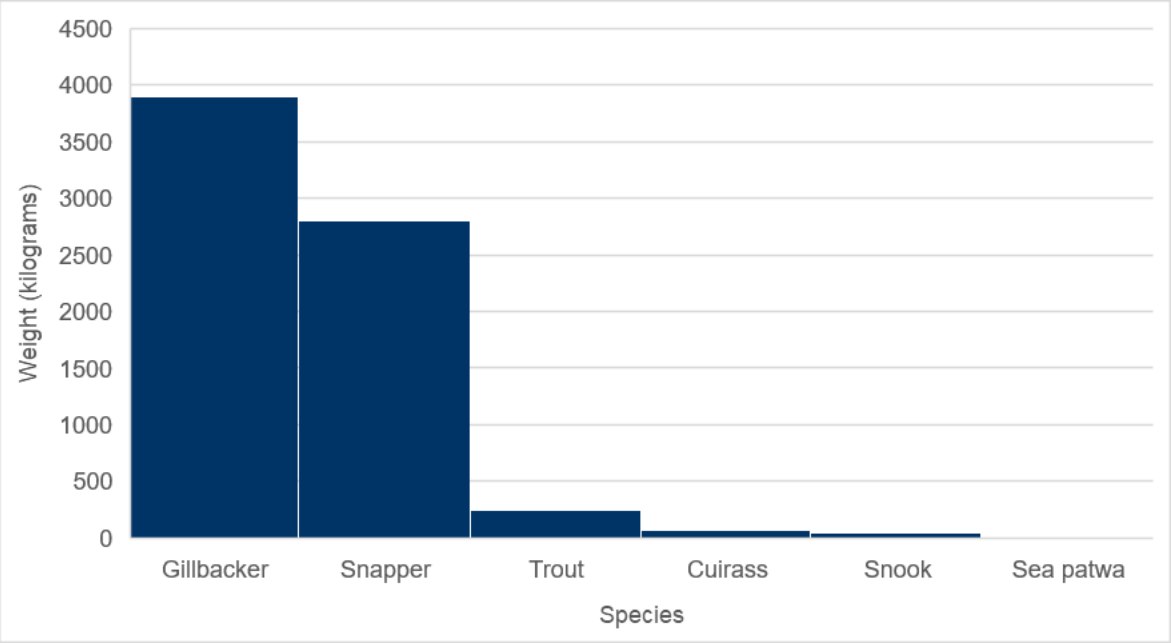


Figure I-1: Total Weight of Species Recorded by the Hampton Court Onboard Supervisor

2.2 Fishing Areas

The onboard supervisor travels in an area of 272 square kilometers. Based on the clusters of fishing points as seen on Figure I-2, the main fishing grounds cover an area of 93 square kilometers and are to the north of the landing site. The fishing points are generally fixed and the locations of fishing grounds do not change seasonally. Since the onboard supervisor is proficient in the use of GPS, he is able to use GPS to fish in the same areas that have already been marked. The onboard supervisor typically travels 11 kilometers from the landing site to fish during both seasons. However, the supervisor traveled a maximum of 15 kilometers offshore during the off-peak season and a minimum of 4 kilometers during the peak season. This aligns with fisherfolk beliefs that fishing is best conducted farther offshore in the hard season whereas fishing can be conducted closer to shore during the good season. The supervisor also recorded for the study team the waypoint of a prominent wreckage.

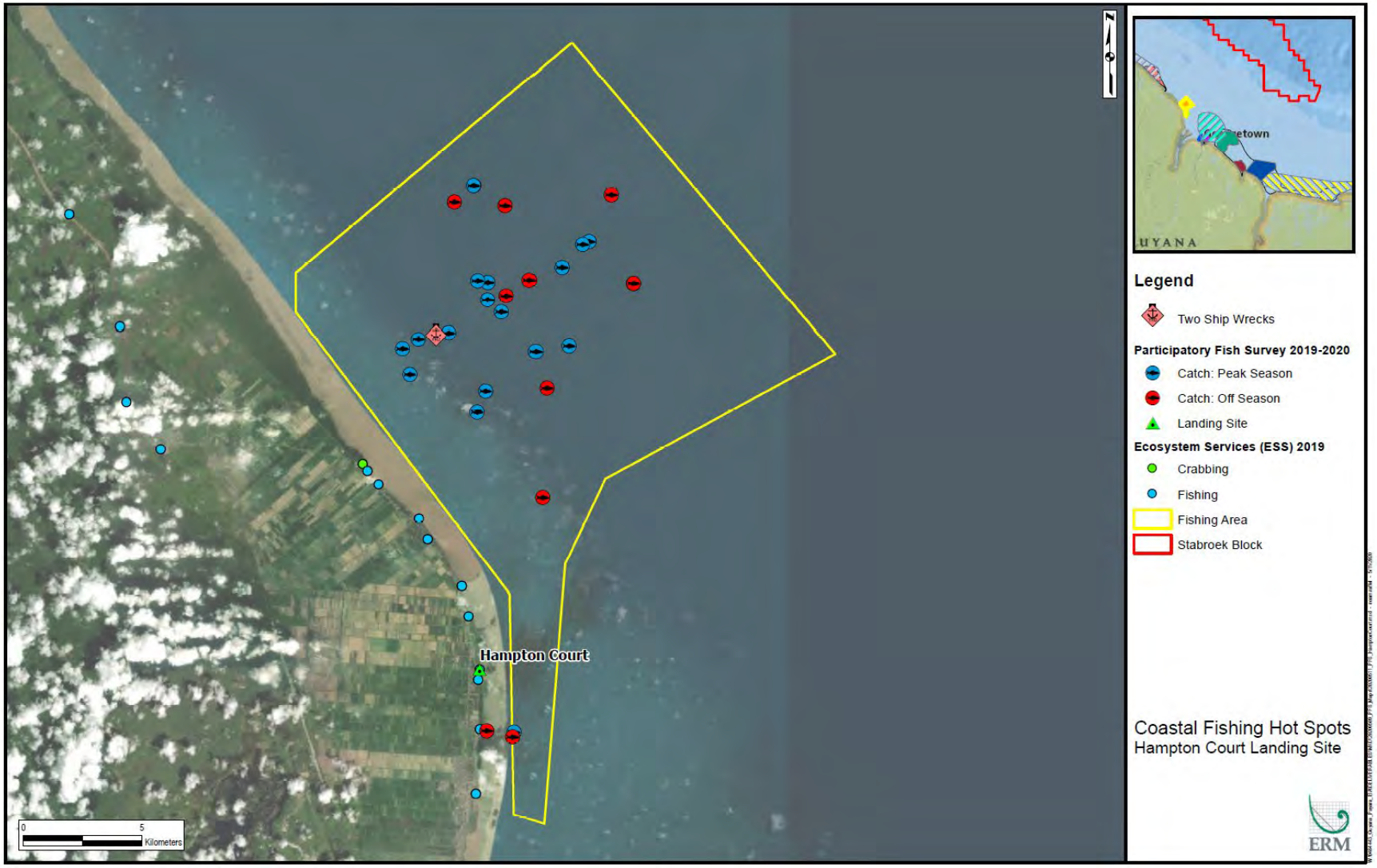


Figure I-2: Fishing Area and Fishing Points Used by the Hampton Court Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip. The supervisor’s hauls at Hampton Court were the highest during the good season. Within the disaggregated timeframes of the good and hard seasons, hauls were higher in the rainy seasons.

The onboard supervisor spent an average of 212 hours per month fishing. There were variations in the effort expended per fishing trip on a monthly basis as seen on Figure I-3. The highest effort was expended in August 2019 with 552 hours spent fishing and June 2019 was the second highest month with 384 hours spent fishing. By contrast, the lowest effort was expended in April, May, and December 2019 with less than 100 hours spent fishing per month. Variations in effort expended seasonally were as follows:

- In the good season, lasting from May to September 2019, the average monthly effort expended was 244 hours. By contrast, the monthly effort for April 2019 and October 2019 to February 2020 was 156 hours.
- In the primary and secondary wet seasons, May to July 2019 and November 2019 to January 2020, the average monthly effort expended was 192 hours and 104 hours, respectively.
- In the primary dry season, August to October 2019, the average effort expended was 342 hours. (Data were unavailable for March 2020, so the average effort expended in the secondary dry season could not be calculated. However, it should be noted that average monthly effort expended in April 2019 and February 2020 was 144 hours.)

Seasonal trends in fishing effort during the good and hard seasons indicate that the onboard supervisor maximized effort during the peak seasons when the waters were warmer and calmer. During the hard season, it is likely that lower effort was expended because the seas were rougher, which made fishing trips shorter. Moreover, the greatest effort was recorded during the primary dry season and the second most productive season was the primary wet season. These seasons last for consecutive months of May to October and as such, there is significant overlap with the good season. Similarly, the hard season significantly overlaps with the secondary wet and dry seasons when lower effort was recorded. Greater effort during the primary dry season may be due to more favorable conditions for fishing with waters being warmer and calmer.

Overall, it may be concluded that the onboard supervisor expended the greatest effort during the good season and within that period, the greatest effort was recorded in the primary dry season. However, these trends should be approached with caution given the significant disruptions in the fishing activities by the onboard supervisor.

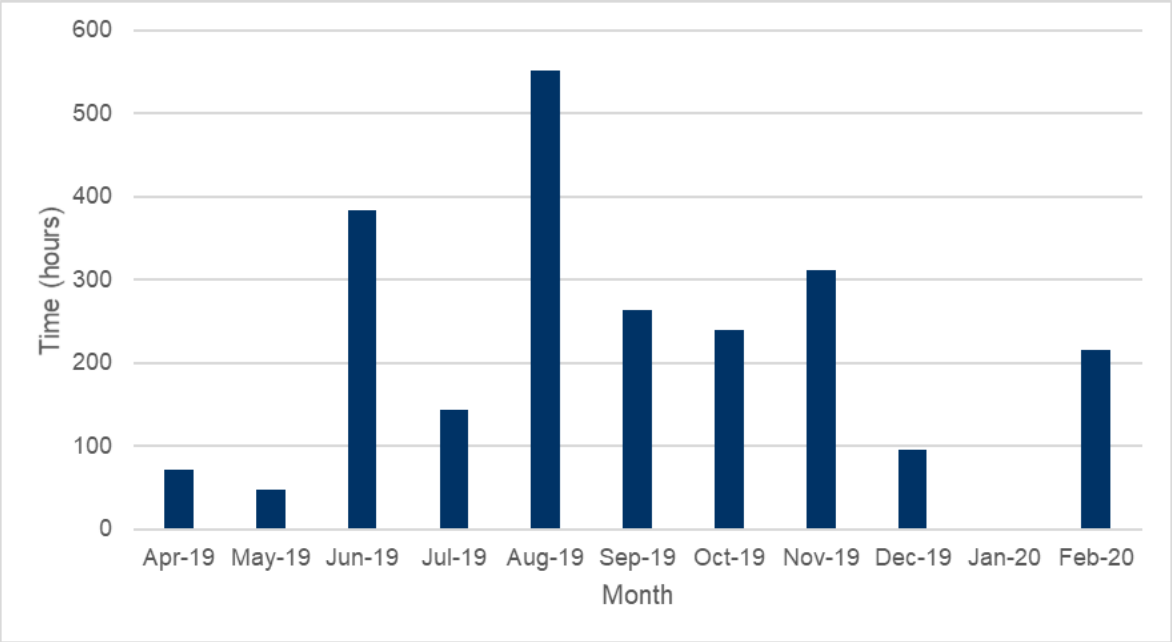


Figure I-3: Total Monthly Fishing Effort Recorded by the Hampton Court Onboard Supervisor

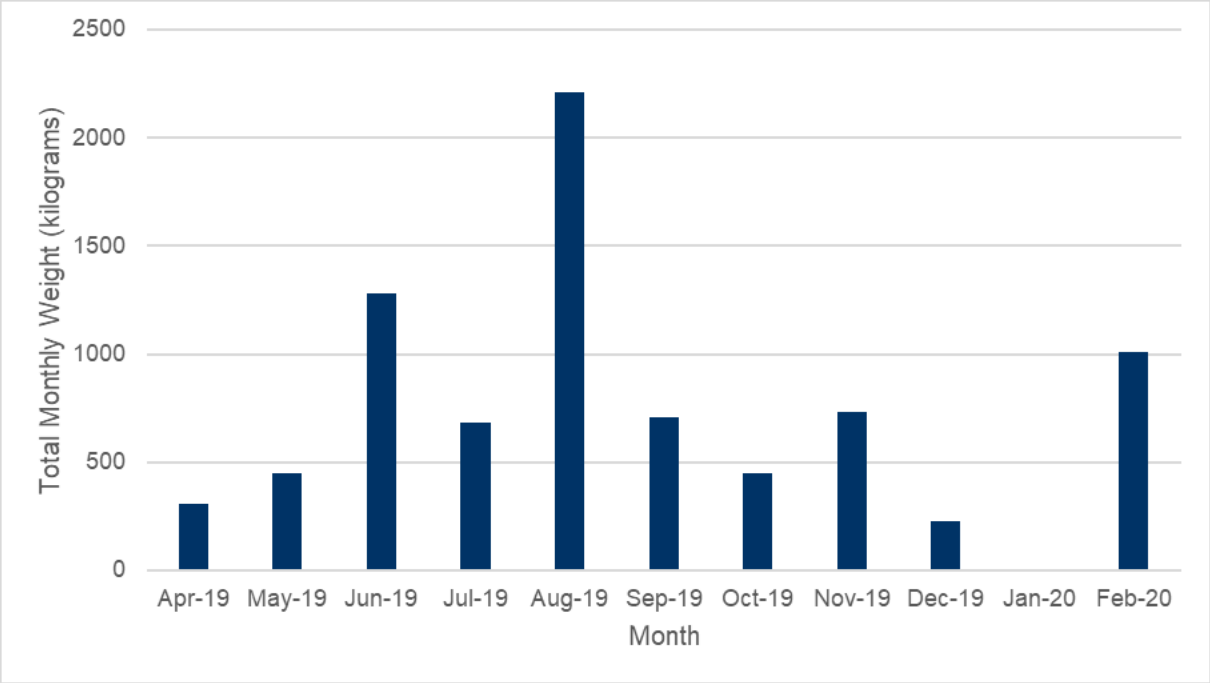


Figure I-4: Total Monthly Weight Recorded by the Hampton Court Onboard Supervisor

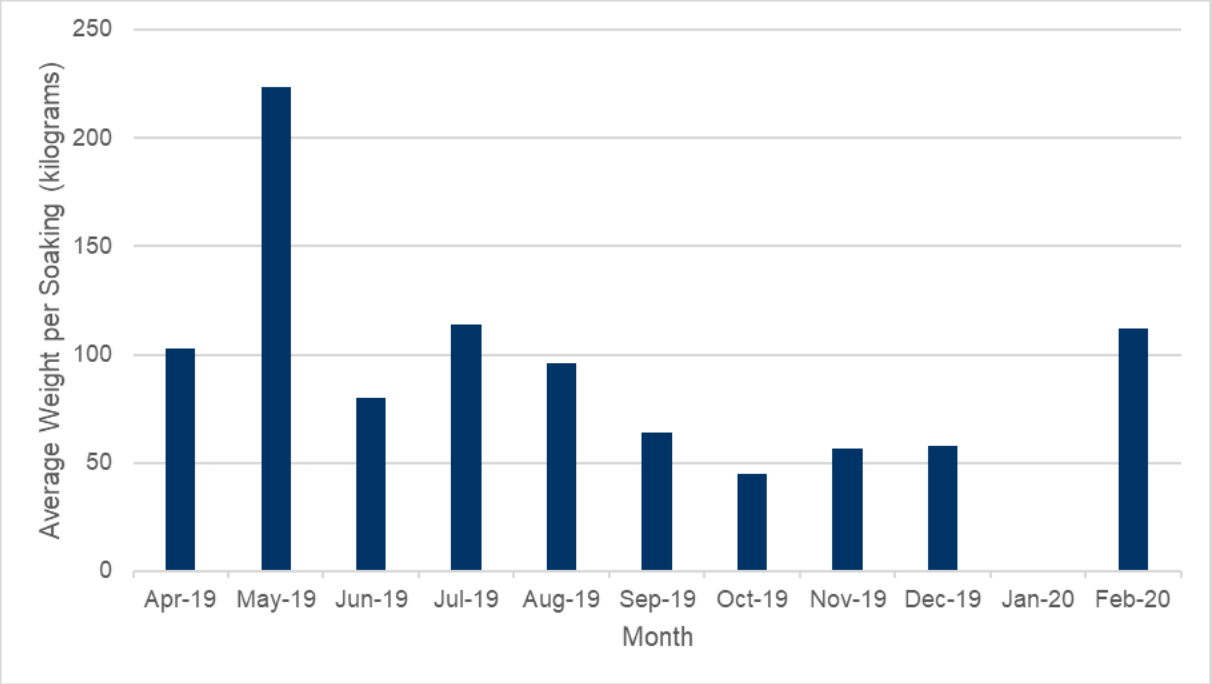


Figure I-5: Average Weight per Soaking Recorded by the Hampton Court Onboard Supervisor

Figure I-4 shows the total weight of hauls on a monthly basis and Figure I-5 shows the average haul weight per soaking of the seine. As anticipated, there were monthly variations in productivity with the following key observations:

- In the good season, lasting from May to September 2019, the combined total haul was 5,326 kilograms (11,742 pounds) with average haul per soaking of 115 kilograms (254 pounds). The highest total catch was recorded in August 2019 with 2,209 kilograms (4,870 pounds), but the average weight of hauls per soaking was lower than 100 kilograms (220 pounds). The second highest total catch was in June 2019 with 1,280 kilograms (2,822 pounds), but the average weight of hauls per soaking was 80 kilograms (176 pounds). June and August 2019 were the months in which the greatest effort were expended with 384 and 552 hours spent fishing, respectively. This indicated that the supervisor spent more days at sea and therefore, soaked the seine more frequently. It should be noted for comparison purposes that June and August were the second most productive months for the fisherfolk at the Charity landing site (Region 2) as well, and some of those fisherfolk share fishing grounds with the onboard supervisor from Hampton Court.

- In the hard season, which included April 2019 and October 2019 to February 2020, the combined total haul was 2,729 kilograms (6,016 pounds) with average haul per soaking of 74 kilograms (163 pounds). The lowest total catch was observed in April 2019 with 308 kilograms (679 pounds), but the average weight of hauls per soaking was 103 kilograms (227 pounds). This is higher than the average weight of hauls per soaking in August 2019. Similarly, in May 2019, the total weight of hauls was also low with 447 kilograms (985 pounds), but hauls per soaking were the highest of all reported months with 114 kilograms (251 pounds). In these two months, the supervisor expended significantly less effort with less than 100 hours at sea. It is likely that if the supervisor had expended greater effort in these two months, the total monthly hauls would have been higher. It should be noted that total hauls in the hard season would increase if fishing trips could have been conducted in January 2020.

By comparison, combined total weights per soaking for wet and dry seasons were as follows:

- In the May to July 2019 period, which is the primary wet season, the total haul weight was 2,411 kilograms (5,315 pounds) and the average haul per soaking was 139 kilograms (306 pounds).
- In the August to October 2019 period, which is the primary dry season, the total haul weight was 3,362 kilograms (7,412 pounds) and the average haul per soaking was 68 kilograms (150 pounds).
- In the November to January 2020 period, which is the secondary wet season, the total haul weight was 964 kilograms (2,125 pounds) and the average haul per soaking was 57 kilograms (126 pounds). (No fishing trips were conducted in January 2020 because of the sluice malfunction).
- In February 2020 and April 2019, which is the secondary dry season, the total haul weight was 1,318 kilograms (2,906 pounds) and the average haul per soaking was 107 kilograms (235 pounds). (Data were not available for March 2020 to complete the trend for this season.)

Based on the data collected, seasonal variations in average weight of soakings support fisherfolk views on the good and hard seasons for fishing activities with significant differences in total haul between these seasons. The trends in productivity during the wet and dry seasons demonstrated interesting trends. In particular, total hauls were higher in the primary and secondary dry seasons compared with the wet seasons. However, the most productive hauls were recorded in the primary wet season and the secondary dry season. These seasonal trends should be considered with caution. The challenges encountered by the onboard supervisor significantly curtailed normal fishing practices in several months for which data were collected. Further data collection is required to determine whether the trends observed thus far can be representative of fishing practices of the onboard supervisor at Hampton Court.

2.4 Biometrics

Based on the lengths and weights of fishes measured by the onboard supervisor (see Figure I-6), all species caught by the onboard supervisor had achieved sexual maturity. Many of the fishes caught are not only mature, but are also close to their maximum length. This is attributed directly to the mesh sizes of 20 centimeters (8 inches) used by the onboard supervisor.

Specifically, for the two most abundant species caught:

- The average length of snapper caught is 94 centimeters and, as seen on Figure I-7, the smallest snapper was caught in June 2019 with an average length of 83.5 centimeters. By contrast, mature lengths for snapper are 40 centimeters and total maximum length is 110 centimeters. In addition, the average lengths of the snapper caught by the onboard supervisor is significantly greater than the average length of 62 centimeters caught by the fisherfolk at the Charity landing site where snapper is the primary target species.
- The average length of gillbacker caught is 107 centimeters and, as seen on Figure I-7, the smallest average length of gillbacker caught in February 2020 had an average length of 85 centimeters. Mature gillbacker have average lengths of 46 to 59 centimeters and total maximum length is 190 centimeters.

In addition, average weights of gillbacker and snapper both peaked in August 2019, which is a month considered part of the spawning season. The onboard supervisor confirmed that eggs were also harvested from the fishes caught in August indicating that the largest fishes caught were spawning females. There was also an uptick in the sizes of snapper caught in February 2020, but this may have been an anomaly.

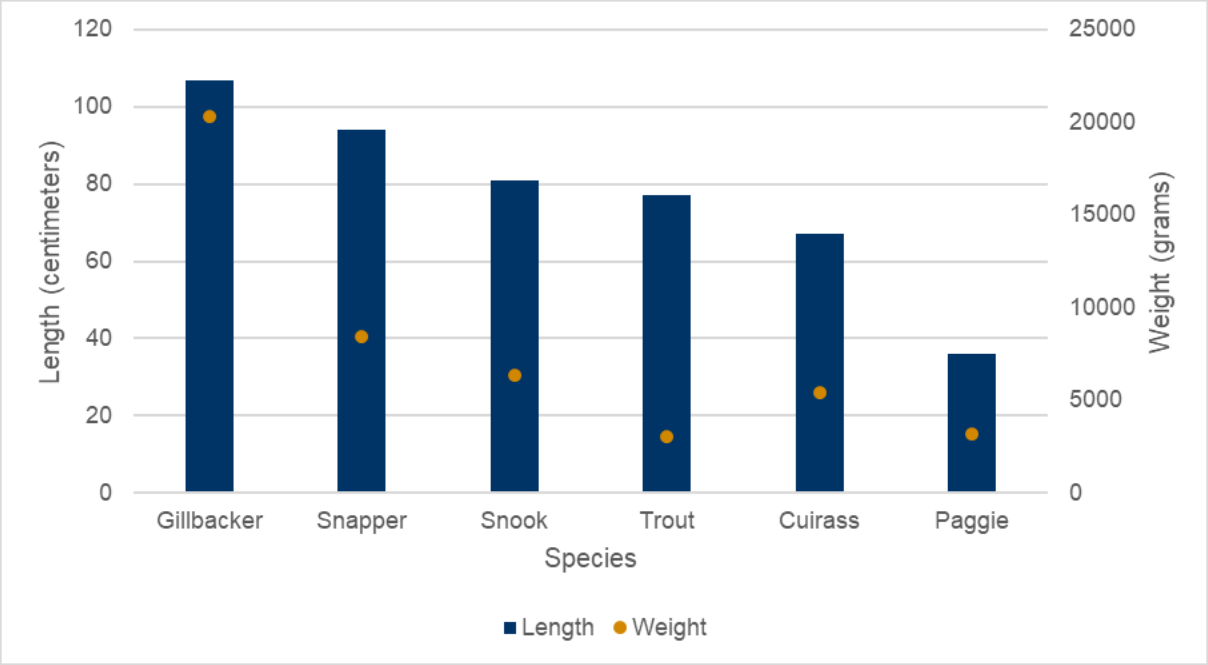


Figure I-6: Average Length and Weight of Fishes Caught by the Hampton Court Onboard Supervisor

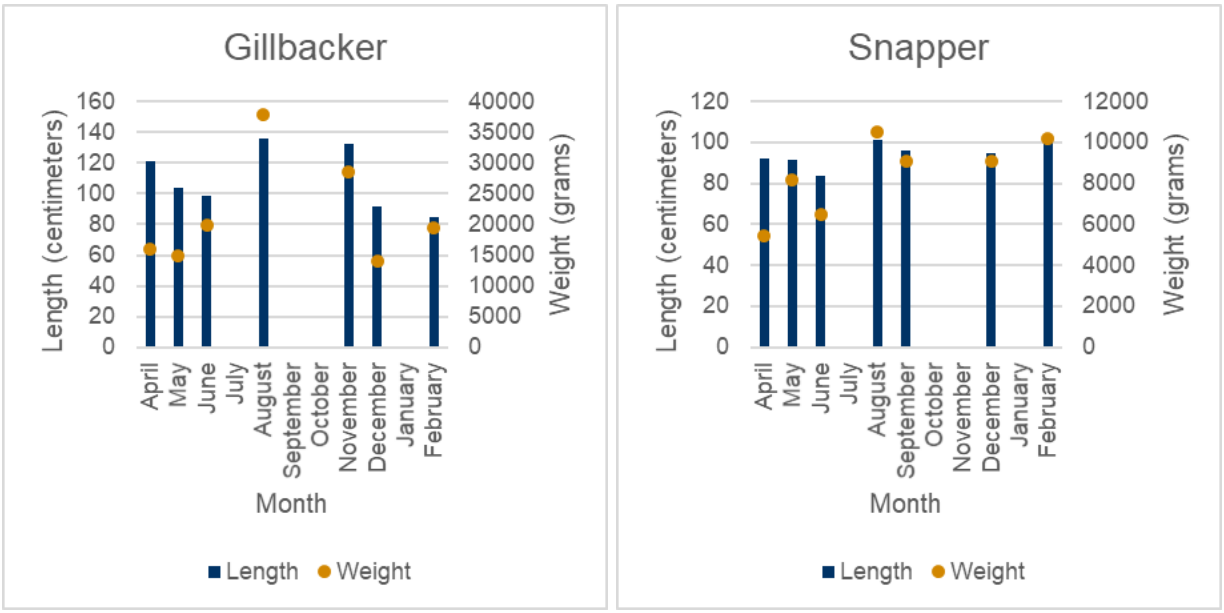


Figure I-7: Average Lengths and Weights of the Most Abundant Species Caught

3 QA/QC DATA

During the first QA/QC exercise, the study team met the onboard supervisor's vessel when it landed at the Hampton Court landing site. The supervisor had completed a 3-day fishing trip outside the mouth of the Pomeroon River. The supervisor used a drift seine with mesh sizes of 20 centimeters (8 inches). The fishing vessel used two outboard engines each of which was 48 hp. These practices were consistently reported by the onboard supervisor. The haul contained only gillbacker and snapper (see Figure I-8). The

gillbacker was already degutted, scaled, and packaged by weights. However, the study team was able to take biometric measurements of the snapper, which was also measured by the onboard supervisor. Both sets of measurements showed that the snapper was 96 centimeters in length and 9,071.84 grams in weight.

The onboard supervisor did not record any bycatch species that may have been contained in the total haul. The supervisor indicated that hauls are typically gillbacker and snapper only with occasional catches of other species such as cuirass, snook, and trout. The study team was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

During the second QA/QC exercise, the team was unable to collect data from the onboard supervisor's vessel because a malfunction of the sluice had effectively grounded the vessel.

Figure I-8: The Study Coordinator Weighing a Snapper at the Hampton Court Landing Site

APPENDIX J LIMA (REGION 2)

1 LANDING SITE OVERVIEW

Lima is a smaller landing site in Region 2 that is used by 15 vessels that target fish and shrimp. All vessels are fitted with small outboard cruisers that have engine sizes of 10 to 25 hp. Fisherfolk indicated that several different types of gear are used, foremost of which are Chinese seines for targeting shrimp and drift seines with mesh sizes ranging from 2.54 to 15 centimeters (1 to 6 inches). Some fisherfolk also set pin seines close to the shore. These smaller vessels usually travel to preferred fishing grounds approximately 2 to 3 kilometers from the coastline and fish at depths of 4 meters. Fishing trips from this site usually range from less than 1 day to 8 days at sea with soak times of 2 to 8 hours.

Fishing with Chinese seines typically requires less effort than other types of fishing for two main reasons. Firstly, “pens” are established relatively close to the shore and therefore less time and fuel are required to travel to and from their fishing grounds than for other fishing methods. Travel to and from the pens is largely dependent on the 6-hour tidal cycles resulting in less time spent at sea than other types of fishing. Secondly, vessels that use Chinese seines have relatively low haul capacities and as a result, the duration of a fishing trip is usually shorter as vessels are not able to transport large hauls on a single trip. In general, lower hauls by weight are from pin seine and Chinese seine fishing.

Fisherfolk indicated that the main commercial species caught at the Lima landing site are cuirass, bangamary, shrimp, sea patwa, annafokes, gillbacker, and trout among others. Hauls are typically 5 to 50 kilograms (11 to 110 pounds) depending to the type of fishing gear used and the season. Fishes and shrimp are sold both at the landing site and in surrounding villages and prices range from $220 to $440 GYD ($1.06 to $2.11 USD) per kilogram.

The principal challenges encountered by fisherfolk at this landing site are conflicts with anchor seine vessels, piracy, and theft.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor who participated in the study principally used a Chinese seine with mesh sizes of 2.54 to 10 centimeters (1 to 4 inches) to target shrimps, mainly the white belly shrimp. Fishing trips are dependent on tidal conditions. The supervisor travels to the pens to set the seine during high tide. He has three pens located approximately 5 kilometers from the shore. Each fishing trips lasts, on average, 6 hours. The onboard supervisor generally did not undertake longer trips as there was additional fishing gear he used to complement the Chinese seines on fishing trips. The onboard supervisor’s vessel has an estimated haul capacity of 500 kilograms (1,102 pounds) and he typically returns to the landing site after the seine has been hauled. He is the sole crew of his vessel. When the study started, he used a 15 hp engine but this was replaced by a 25 hp engine after the former was stolen. Fuel is the main expense as the fishing activity does not require large quantities of ice given the relatively short period spent at sea per fishing trip.

Although the Chinese seine is the principal gear used, the onboard supervisor augments fishing practices when hauls of shrimp are low. Specifically, drift seines with mesh sizes of 10 centimeters (4 inches), pin seines with mesh sizes of 10 centimeters (4 inches), and Cadell lines are all used. On some fishing trips, the supervisor uses several of these gear types at the same time. Due to these practices, the onboard supervisor showed the greatest versatility of fishing methods used of any participant in the study. However, for comparison purposes, onboard supervisors at landing sites in Windsor Forest (Region 3) and Ogle (Region 4), whose principal fishing gear was Chinese seines, were also observed to use Cadell lines while the seines were soaking.

From April 2019 to February 2020, the onboard supervisor encountered a few challenges that reduced fishing activity and hauls:

- Sargassum seaweed was abundant in April and May 2019, which significantly reduced the fishing effort expended by the supervisor during these months. Sargassum seaweed subsequently declined but became abundant again in February 2020. The sargassum seaweed was reported to drift into seines and reduce the quantities of shrimp that can be caught in the seine. Cleaning sargassum weeds from the Chinese seines is also a very time consuming process and this has been reported to last for days.

- In October 2019, while the supervisor's vessel was docked at the landing site, the engine was stolen. Due to the cost of the engine, the supervisor sought help from the Ministry of Agriculture, which replaced the engine.

2.1 Target Species and Diversity

The total weight of combined hauls from the period for which data were collected was 2,935 kilograms (6,470 pounds) from 952 hours of effort total. Shrimp was the most abundant species caught with a total weight of 870 kilograms (1,918 pounds) as seen on Figure J-1. It should be noted that the supervisor caught both white belly shrimp and corse shrimp/seabob but recorded both as "shrimps." In addition, hauls of shrimps were not separated for sale. It should be noted that although shrimp was the most abundant species caught, its percentage representation of 71 percent of total haul is typical of Chinese seine fishing. For example, based on data collected by the regional supervisor at the Zeeburg landing site (Region 3) where all vessels use Chinese seines, white belly shrimp accounted for 85 percent of the total haul. Similarly, the onboard supervisor at the Ogle landing site (Region 4) also uses Chinese seines for fishing and had total hauls of which 71 percent were corse shrimp/seabob.

Highwater and cuirass were the second and third most abundant species caught representing 23 percent and 9 percent of the haul, respectively. While the shrimp would have been caught exclusively by the Chinese seines, highwater and cuirass could be caught by any of the four fishing methods employed by the onboard supervisor. The fourth most abundant species caught was lau lau, accounting for 6 percent of the total haul. Lau lau is a freshwater fish and hauls containing this species are typically good indicators of fishing activities occurring relatively close to the shoreline. Moreover, lau lau was only caught during the primary wet season, in May and June 2019, when the salinity of nearshore waters is lowest.

Overall, 29 species were caught by the onboard supervisor including white belly shrimp and corse shrimp and several high-value species such as snapper, gillbacker, lau lau, and trout. Overall, low- to medium-value species were generally caught with greater abundance including shrimps, highwater, and cuirass. This high species diversity is likely directly related to the varied fishing methods employed since the target species of several types of fishing practiced are represented in the haul. For example, shrimps are the target species of Chinese seines; sea catfish are the target species of Cadell lines, and bangamary, butterfish, snapper, gillbacker, and trout are the target species of drift seines with a range of mesh sizes. In addition, higher species diversity is also expected from Chinese seines, which have smaller mesh sizes and typically captured most fishes including smaller species such as the Suriname mullet.

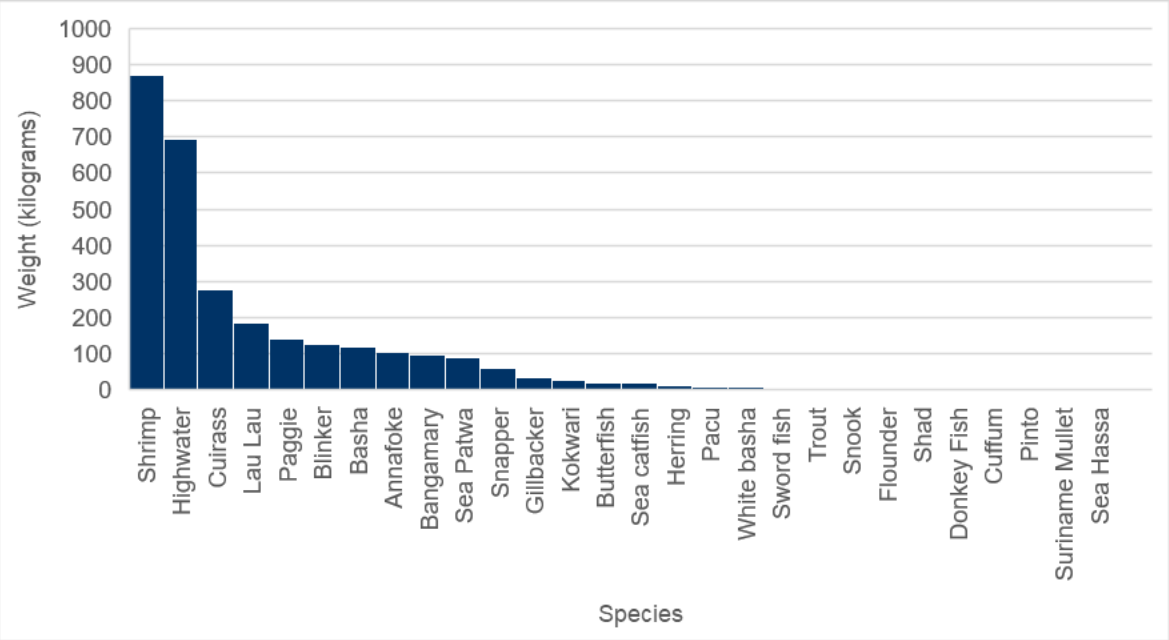


Figure J-1: Total Weight of Species Recorded at by the Lima Onboard Supervisor

2.2 Fishing Areas

The onboard supervisor had a fishing area of 20 square kilometers as depicted on Figure J-2. The supervisor uses three different fishing points based on the different types of fishing gear. The fishing point located closest to the shore was 0.23 kilometers offshore and was used to set the pin seines. This point was only used during the October to February period, which is considered the hard season for artisanal fishing. The other two fishing points are both located approximately 1.37 kilometers offshore and represented the locations of the onboard supervisor's pens used for soaking the Chinese seines. On occasions when the onboard supervisor uses drift seines, they are set in locations proximate to the Chinese seine fishing points.

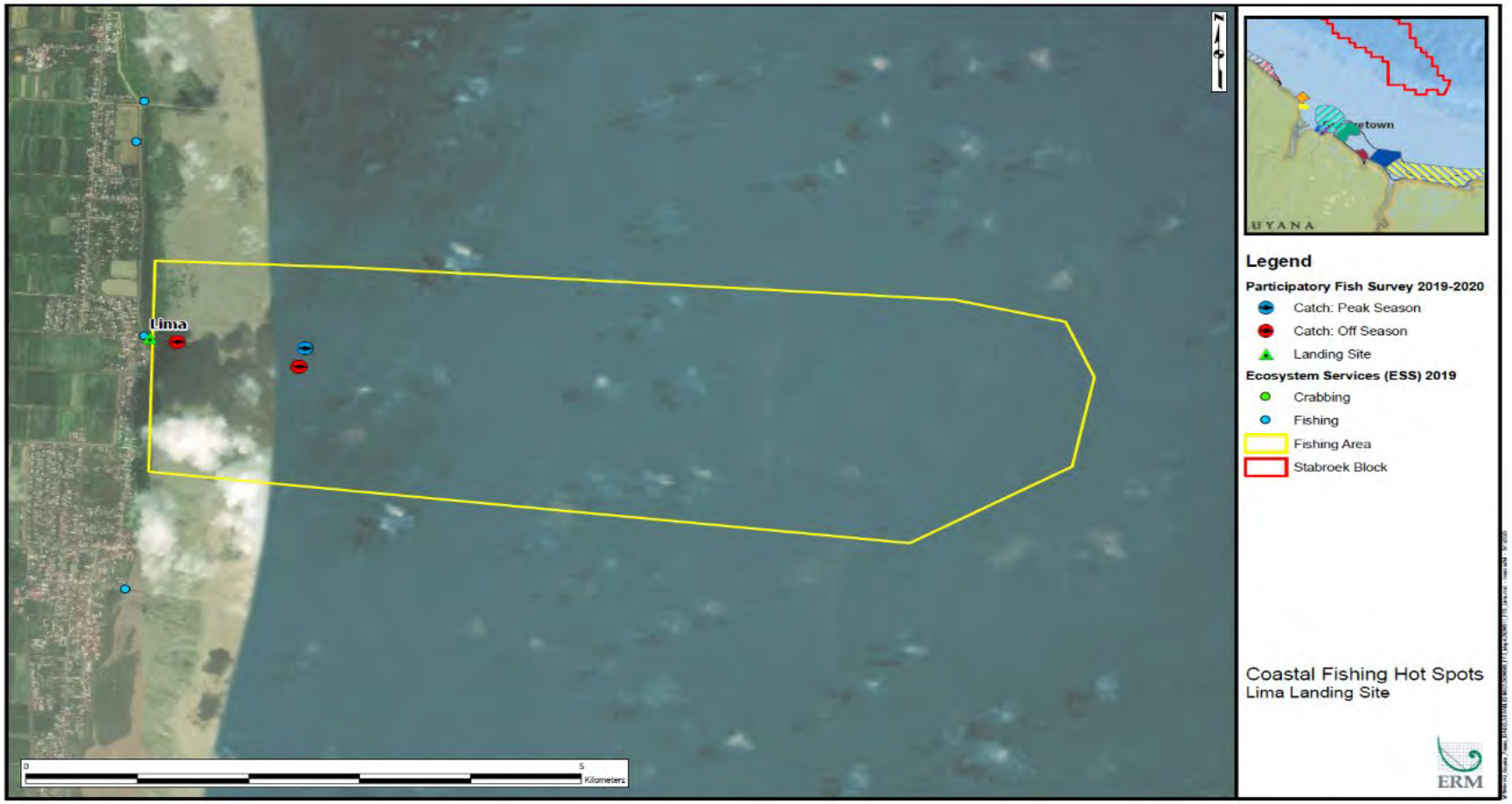


Figure J-2: Fishing Area and Fishing Points Used by the Lima Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. However, fisherfolk have varying beliefs on the most productive months for shrimping. At the Zeeburg landing site (Region 3), some fisherfolk indicated that shrimp catch generally increases during the closed trawl season, which occurs from 16 August to 5 October annually, and may allow more shrimp to come closer to the shore. Other fisherfolk indicate that the average productivity increases during the dry seasons of February to April and August to September because the waters are generally more saline compared to the wet season. Another common belief is that shrimp productivity increases during the spawning seasons of January to April and June to July (Pereira et al. 2017) when shrimp come closer to shore to spawn in the mangroves. By virtue of the varied fishing methods practiced by the onboard supervisor, it is unlikely that there are clear seasonal trends in either effort or hauls.

The onboard supervisor spent an average of 86 hours at sea per month. As seen on Figure J-3, the greatest effort was expended in November 2019 and January 2020 with 155.5 and 128.5 hours, respectively. By contrast, the lowest effort was expended in December 2019 when 40 hours were spent fishing. Although 7.5 hours were expended in April 2019, data collection did not begin until 23 April 2019, and as such, there is no comparable monthly data pool for this month.

As seen on Figure J-4, the highest average catch per soaking was recorded in February 2020 with 28 kilograms (62 pounds) and in June 2019 with 24 kilograms (53 pounds). The lowest average catch per soaking was observed in May and August 2019 with 12 kilograms (26 pounds) and 15 kilograms (33 pounds), respectively. The greatest total hauls were observed in November and July 2019 with 475 kilograms (1047 pounds) and 421 kilograms (928 pounds), respectively. Low total hauls were observed in May, August, and December 2019 with 169 kilograms (372 pounds), 176 kilograms (388 pounds), and 125 kilograms (276 pounds), respectively. The lowest total haul was seen in April 2019 but as previously noted, data collection started in the final week of the month.

Seasonal comparisons of effort expended by the onboard supervisor and the hauls recorded are as follows:

- In the May to September 2019 good season, the total average weight of hauls was 1,412 kilograms (3,113 pounds) with 481 hours spent at sea. On average, soaking of the seine during this period yielded 18 kilograms (40 pounds).
- In the October 2019 to February 2020 hard season, the total weight of hauls was 1,499 kilograms (3,304 pounds) with 463 hours spent at sea. On average, soaking of the seine during this period yielded 21 kilograms (46 pounds).

Additional seasonal trends at this landing site are as follows:

- In August to October 2019, the primary dry season and the closed trawl season, the total weight of hauls was 643 kilograms (1,418 pounds) with 256.5 hours spent at sea. On average, soaking of the seine during this period yielded 17.5 kilograms (39 pounds).
- In February 2020 and April 2019, two months of the secondary dry season, soaking of the seine during this period yielded, on average, 24 kilograms (53 pounds). Total effort and hauls were not presented for this period because the data pool for April 2019 is relatively small, and data were not able to be retrieved for March 2020 to complete this season.

- In April 2019 and January and February 2020, three of the four months of the first shrimp spawning season, soaking of the seine yielded, on average, 22 kilograms (49 pounds). Similarly, total effort and hauls were not presented for this period because the data pool for April 2019 is relatively small and data were not able to be retrieved for March 2020 to complete this season.
- In the June to July 2019 period, the second shrimp spawning season, the total weight of hauls was 802 kilograms (1,768 pounds) with 108 hours spent at sea. On average, soaking of the seine during this period yielded 22 kilograms (49 pounds).
- In May to July 2019, the primary wet season, total weight of hauls was 971 kilograms (2,141 pounds) with 285 hours spent at sea. On average, soaking of the seine in this period yielded 19 kilograms (42 pounds). In addition, the two most productive months, May and July, were part of this season.
- In November 2019 to January 2020, the secondary wet season, the total weight of hauls was 965 kilograms (2,127 pounds) with 324 hours spent at sea. On average, soaking of the seine during this period yielded 19 kilograms (42 pounds).

Based on the data collected, productivity at this landing site did not follow the good and hard seasons that were identified by fisherfolk. In fact, productivity was higher during the hard season but the difference in total hauls was not significant. Greater effort was expended during the May to September period when the total hauls and productivity per soaking were lower, but the differences in effort and productivity between the good and hard seasons were relatively small. The results may indicate the seasonality of shrimping is different than it is for fishing, but the variety of gear types used and the large number of fish species caught by the supervisor makes it difficult to attribute these results to any specific cause.

Moreover, interesting trends were observed in the other seasons for which productivity was considered. The greatest effort was expended during the wet seasons and the second spawning season. Total hauls during these seasons were higher than the total haul during the primary dry season and other seasons for which trends were examined. The greatest effort was expended in the secondary wet season while the lowest effort was expended in the second spawning season. However, the most productive haul per soaking was observed in the secondary dry season. The second highest hauls per soaking were recorded in both shrimp spawning seasons. It is interesting to note that there is a significant overlap of the first spawning season (January to April) and the secondary dry season (February to April). As such, based on the information collected, the most productive periods for the onboard supervisor's fishing practice were both of the shrimp spawning seasons. The first shrimp spawning also overlaps with the secondary dry season and the productivity was also higher during this time. However, this should be considered with caution given that the onboard supervisor did not exclusively use Chinese seines in the fishing practice during the study period and that gaps in some of the data collected may also influence this conclusion.

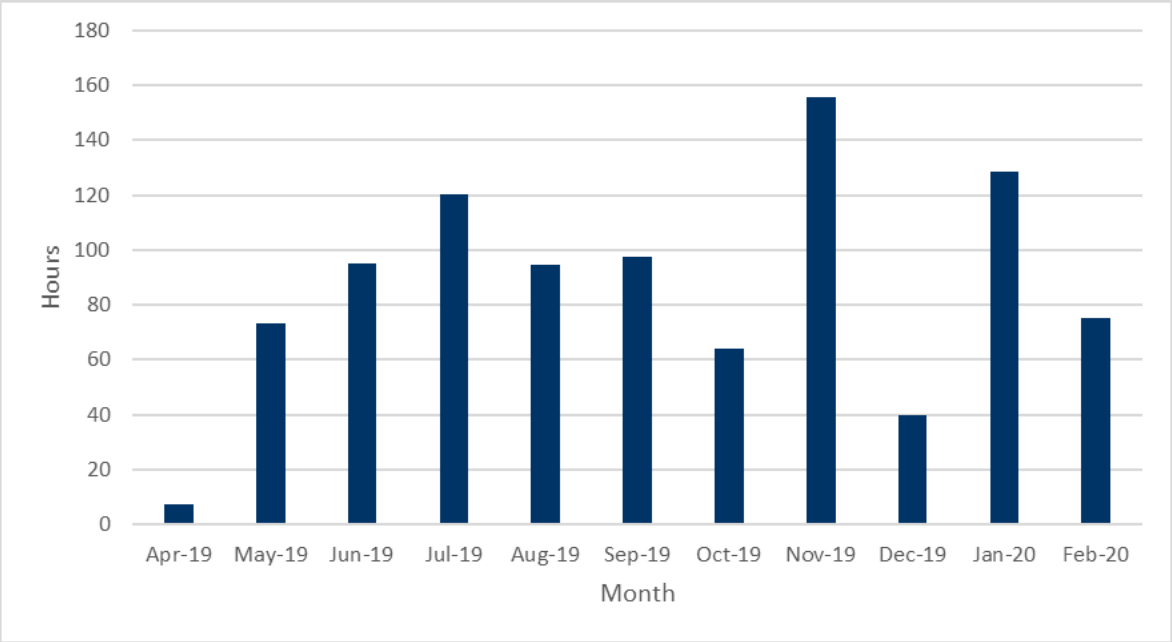


Figure J-3: Total Monthly Fishing Effort Recorded by the Lima Onboard Supervisor

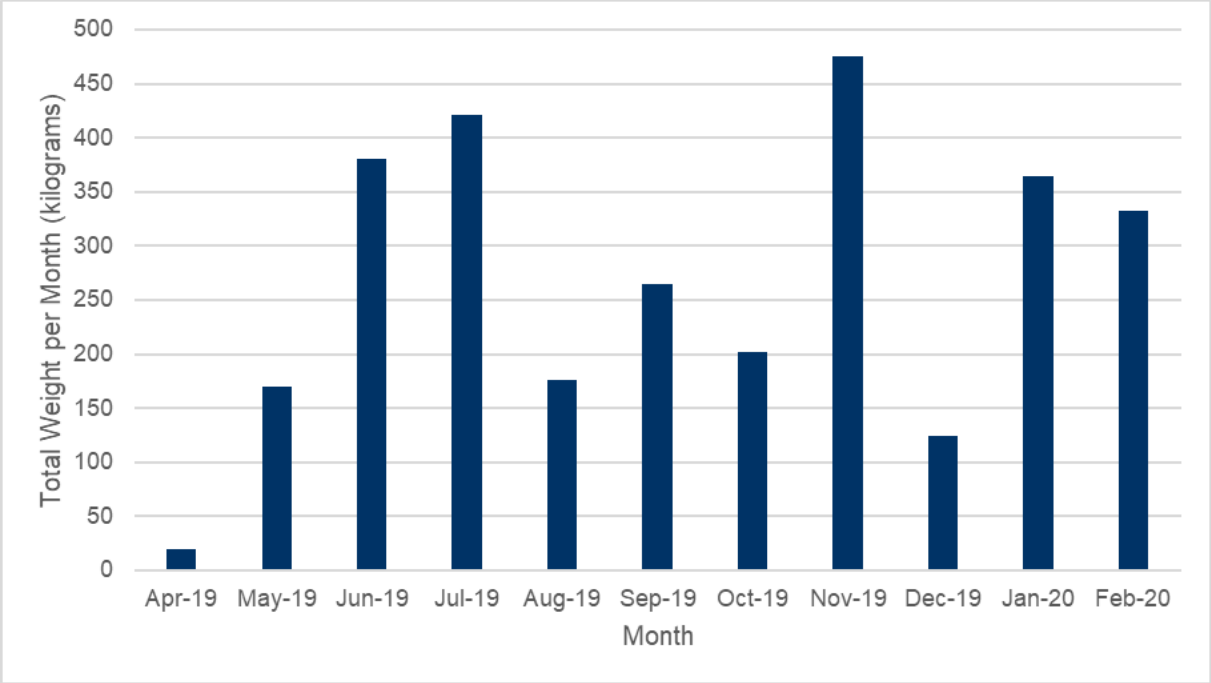


Figure J-4: Total Weight of Species Recorded by the Lima Onboard Supervisor

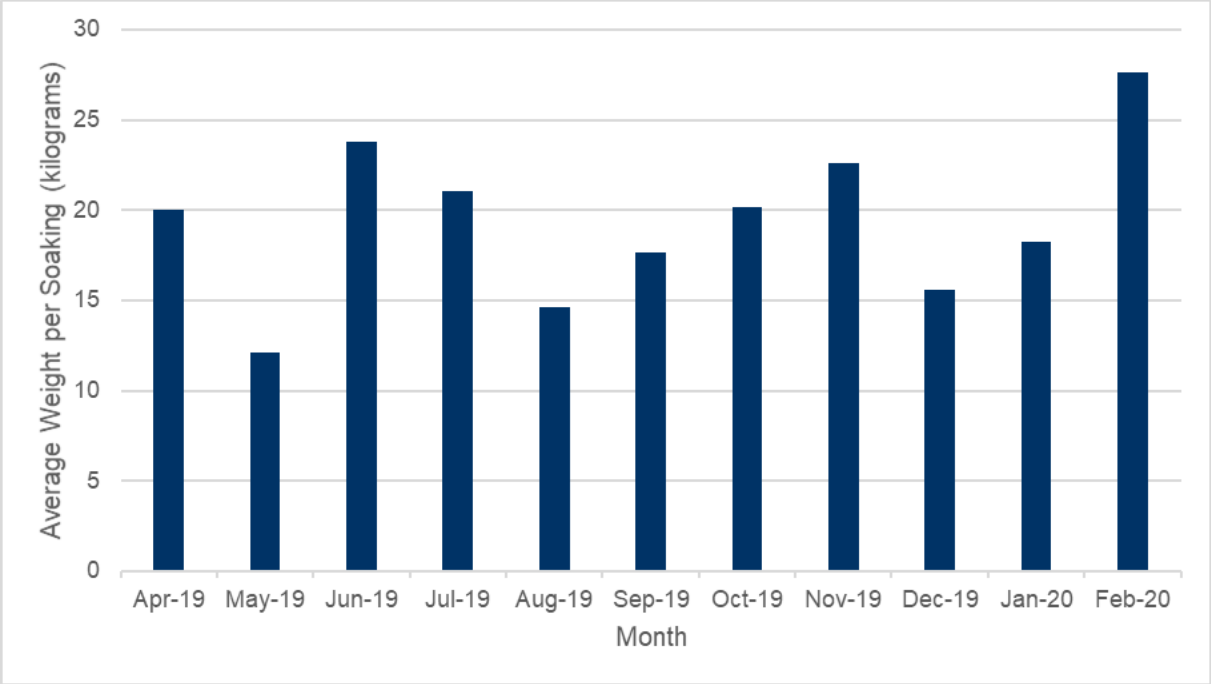


Figure J-5: Average Weight per Soaking Recorded by the Lima Onboard Supervisor

2.4 Biometrics

The onboard supervisor measured the average lengths and weights of representative fishes of the species caught. Both mature and immature fishes were caught. The mature species included gillbacker, lau lau, cuffum, cuirass, blinker, and pacu, which were all considered to be mature at 79, 78, 76, 61, 47, and 34 centimeters, respectively. It is likely that these fishes were caught by the fishing methods other than the Chinese seine because the mesh sizes would generally not allow for capture of the larger fishes. Other mature species included shad, flounder, and annafokes, which could have been captured by all other seine types. None of the other 12 species caught had achieved maturity. Biometric data were not collected for the shrimp, which is the target species of the Chinese seine fishing type. However, lengths of white belly shrimp measured by the study team during site visits ranged from 4 to 6 centimeters and this is considered mature. Since the onboard supervisor used a series of different fishing methods, the comparison of average monthly weights and lengths of the most abundant species caught would reflect no defined trends (see Figure J-6).

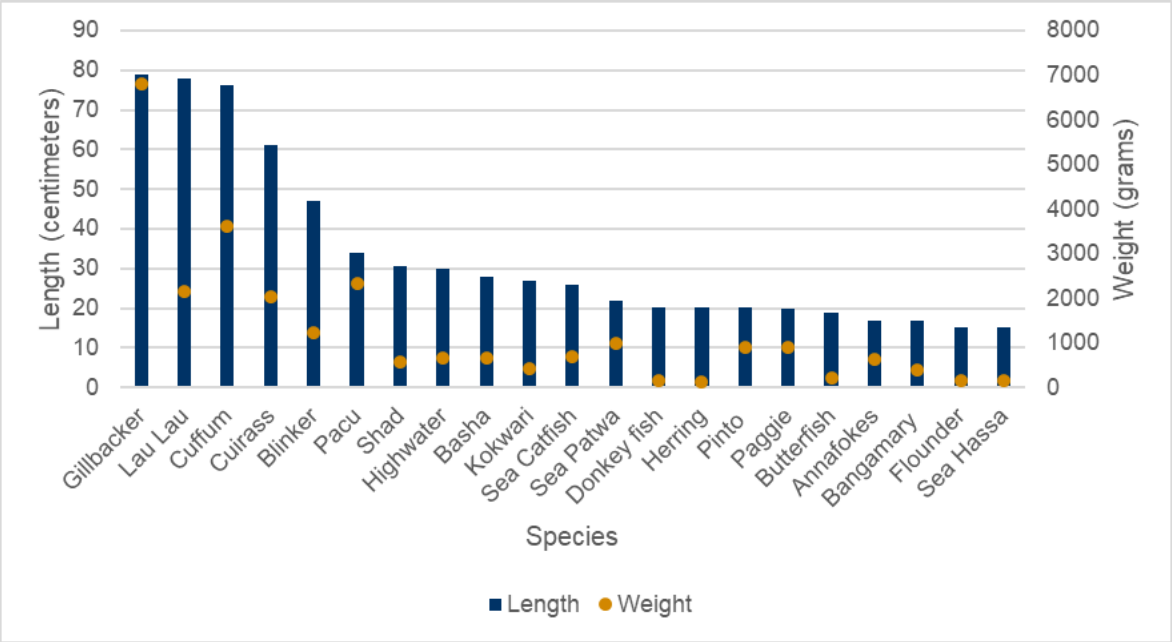


Figure J-6: Average Length and Weight of Fishes Caught by the Lima Onboard Supervisor

3 QA/QC DATA

During the 3-day period for which the QA/QC exercise was conducted in Region 2 in September 2019, neither the onboard supervisor, nor any of the other fisherfolk operating at the Lima landing site, went to sea. This was due to a spring tide causing the seas to be too rough for smaller Chinese seine vessels to conduct fishing activities. As a result of these circumstances, the QA/QC exercise could not be conducted for the Lima onboard supervisor.

During the second QA/QC exercise, the supervisor's haul was recorded. However, the onboard supervisor had a "bust trip" because hauls were significantly lower than what is typically obtained. During the trip assessed, the onboard supervisor used drift seines with mesh sizes of 10 and 13 centimeters (4 and 5 inches). However, only three highwater were caught by the onboard supervisor. Although low, these data were consistent with data collected by the onboard supervisor during other unsuccessful fishing trips. Overall, the study coordinator was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

APPENDIX K ZEEBURG (REGION 3)

1 LANDING SITE OVERVIEW

Zeeburg is one of the largest landing sites in Region 3 and is used almost exclusively by vessels equipped with 30 hp outboard cruisers for Chinese seine fishing. Fisherfolk estimate that over 30 vessels use this site with Chinese seines that have mesh sizes of 1.27 to 10.16 centimeters (0.5 to 4 inches). The target species of the Chinese seines used at this landing site is the white belly shrimp. The landing site is also used to dry the white belly shrimp. The drying process involves cleaning the shrimp (locally referred to as “picking shrimps”) and removing the carapace, tail, swimerettes, and occasionally the shell from the abdomen. The shrimp is then steamed over open fire pits placed on concrete pads at the landing site. The steamed shrimp is then laid out on a concrete surface, normally the seawall, during sunny conditions. There are ready markets for fresh and dried shrimp as trucks visit the landing site on a daily basis to purchase the catch. Some of these trucks source the shrimp directly from women in the village who are involved in the “picking shrimp” process.

In July to September 2019, major infrastructural works were conducted by the government at the landing site to replace the Zeeburg seawall with rip-rap (see Figure K-1 on left). Fisherfolk indicated that their fishing activities were affected during the construction period as construction materials were stockpiled on areas of the seawall used for storing fishing gear and drying shrimp. With the installation of the rip-rap, all concrete surfaces were demolished and the landing site was frequently muddy. After construction, fisherfolk continued to experience challenges as severe overtopping during the spring tides in September 2019 resulted in significant, unprecedented damage to the landing site as the areas intended to be used for drying shrimp were covered with mud (see Figure K-1 on right). This situation was further exacerbated by heavy rainfall. This reduced drying activity at the site and forced a temporary stoppage of work at the landing site in October 2019 as fisherfolk tried to rehabilitate some sections of the landing site and the concrete pads to be used for drying shrimp, as well as installing channels to drain water that had accumulated behind the seawall after the overtopping events. Most fisherfolk contended that the rip-rap were less effective than the original sea walls in preventing overtopping at the site.

Fisherfolk reported further challenges related to the theft of fishing equipment stored at the landing site and pirate attacks when at sea.

Figure K-1: Installation of Rip-Rap and Seawall Demolition (Left) and Aftermath of Overtopping (Right)

2 REGIONAL SUPERVISOR RESULTS

One regional supervisor participated in the study and he provided the results in this section over the course of the study period.

2.1 Effort and Haul

Based on the data collected, white belly shrimp was the most abundant species caught by weight with 111,535 kilograms (245,892 pounds) accounting for 85 percent of the total haul at the landing site (see Figure K-2). Bangamary, cuirass, and mullet were the second, third, and fourth most abundant species caught with 8,115 kilograms (17,890 pounds), 6,681 kilograms (14,729 pounds), and 2,365 kilograms (5,213 pounds), respectively. In total, recorded hauls at this landing site had a total weight of 130,656 kilograms (288,047 pounds).

Fisherfolk travel distances ranging from 5 to 30 kilometers from the landing site to “pens” along the shorelines of Region 2 and 3, and around Leguan Island at the mouth of the Essequibo River. Chinese seines are set in the pens at depths of approximately 5 to 30 meters and are soaked one to two times for approximately 4 to 6 hours per fishing trip. Typically, these vessels are staffed by two to three crew members. Over the study period, a trip lasted for 7 hours on average. Figure K-3 shows the average number of hours for which seines were soaked on a monthly basis and represents the average monthly effort for fisherfolk at this landing site. The following trends were observed in the effort expended on a monthly basis:

- The shortest average trips lasted for less than 7 hours and were observed in May to July 2019, September 2019, and again from November 2019 to January 2020. Of these, the shortest trips were observed in consecutive months from May to July 2019. The periods May to July and November to January are Guyana’s primary and secondary wet seasons. Lower effort in September 2019 was directly related to damage at the landing site resulting from spring tides, which curtailed and consequently, temporarily stopped activities at the landing site in October.

- The longest average trips lasted for more than 7 hours and were observed in April and August 2019, and again in February 2020. In addition, trips with average lengths of more than 8 hours were observed in April 2019 and February 2020. It is likely that these longer trips were as a result of the seines being soaked more than once per fishing trip. Additional data are needed to better understand the factors that influence multiple soakings per trip including haul per soaking and fisherfolk perception of seasonal influence.

No data on fishing effort in the dry seasons were collected at this landing site because activities at the landing site were curtailed in the primary dry season (August to October 2019). In addition, data were not available from the regional supervisor for March 2020 to show any trends in fishing activities for the February to April secondary dry season.

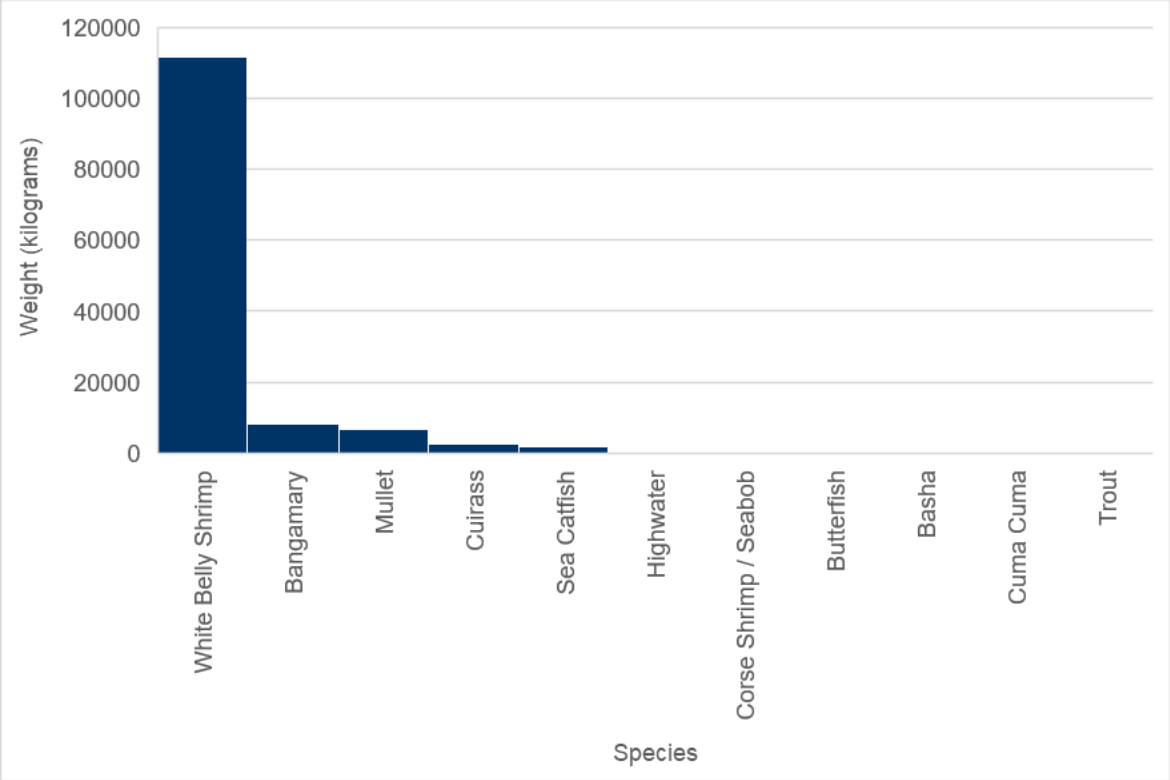


Figure K-2: Total Weight of Species Caught at the Zeeburg Landing Site

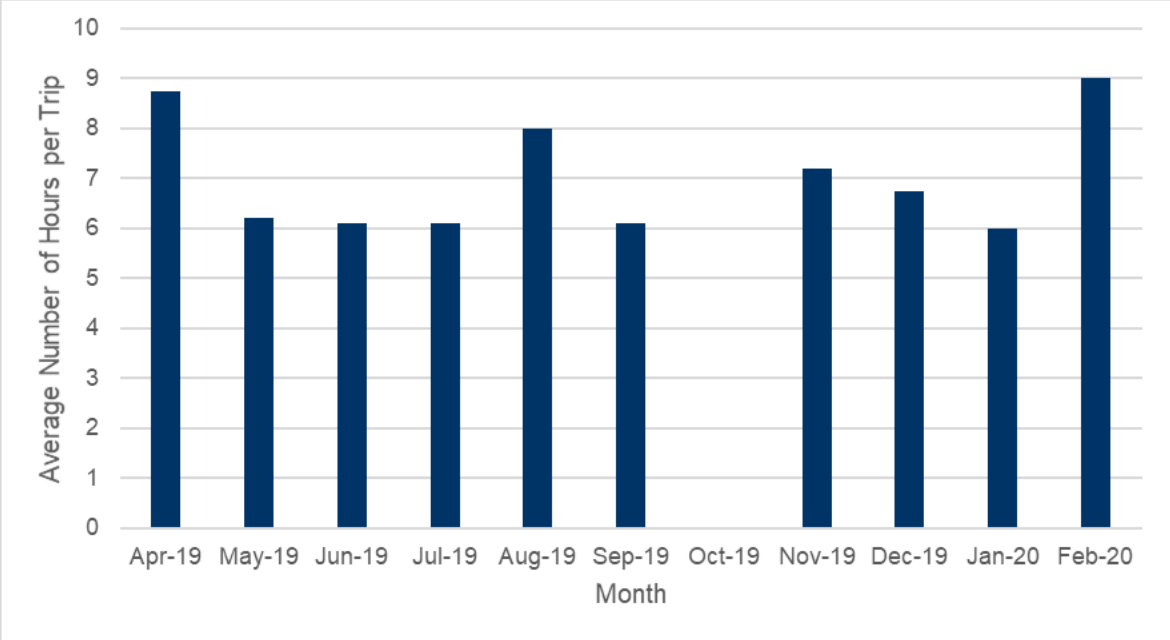


Figure K-3: Average Monthly Fishing Effort at the Zeeburg Landing Site

2.2 Target Species and Diversity

Eleven species were caught by the regional supervisor (see Figure K-4). This number is unusual as Chinese seine fishing typically has greater species diversity in reported hauls (see data in Appendices J,

M, and O, respectively, for species composition of hauls from onboard supervisors at landing sites in Lima (Region 2), Windsor Forest (Region 3), and Ogle (Region 4) who all use Chinese seines. In addition, during visits to the landing site, the study team observed significant quantities of bycatch in hauls including fish species such as banjaman and rockhead, and non-fish species such as jellyfish. The regional supervisor indicated that data are only collected for species and fishes that are considered commercial at this landing site and therefore no bycatch was recorded by the regional supervisor. As such, it is likely that species diversity of the haul is higher than reported and also that bycatch includes juveniles of commercial species, like bangamary.

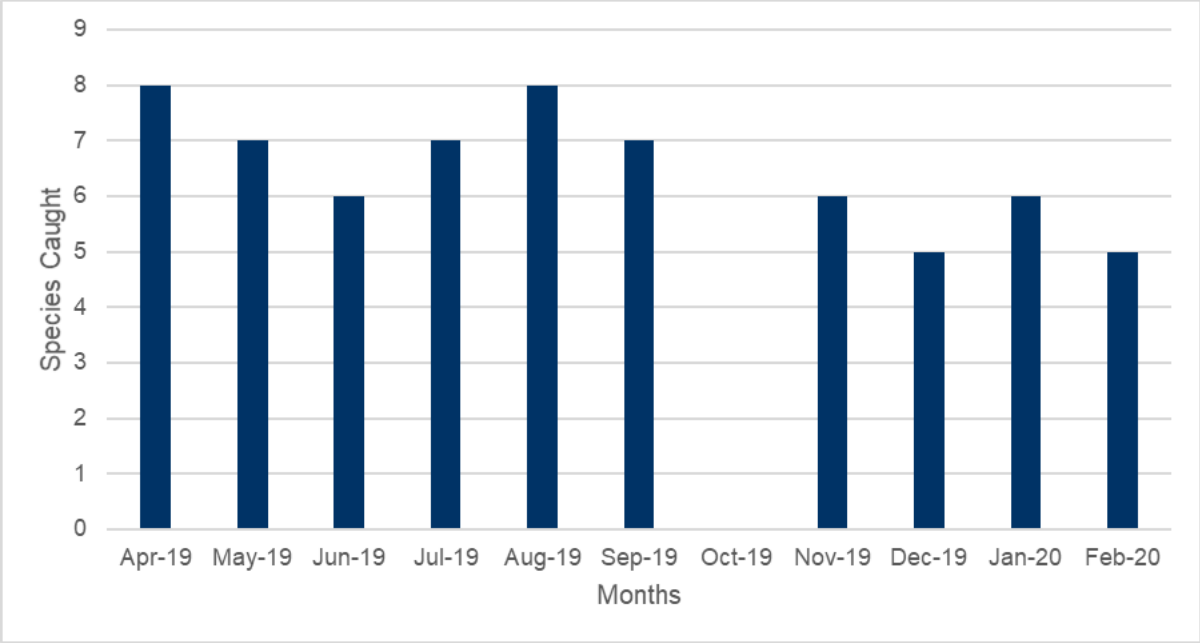


Figure K-4: Species Diversity at the Zeeburg Landing Site

2.3 Seasonal Productivity

Artisanal fisherfolk believe that the peak and off-peak seasons for fishing occur from May to September and October to April, respectively. However, fisherfolk have differing beliefs on the most productive months for shrimping. The general consensus is that shrimp catch increases during the closed trawl season, which occurs from August 16 to October 5 annually and may allow more shrimp to come closer to the shore. Some fisherfolk also believe that the average productivity increases during the dry seasons in response to the white belly shrimps' spawning activity, which occurs from January to April and June to July (Pereira et al. 2017). Spawning seasons may also increase productivity as white belly shrimp may travel closer to shore to spawn in the mangroves. Figure K-5 shows average monthly productivity, calculated as total monthly productivity divided by total number of fishing trips taken per month. The following seasonal trends were observed:

- The least productive period was the secondary wet season of November 2019 to January 2020 with a combined average productivity of 92 kilograms (202 pounds). Of these months, the lowest productivity was observed in January 2020 with a productivity of 70.5 kilograms (155 pounds). Effort expended per fishing trip consistently declined over this period and reached the lowest point in January 2020.

- Productivity was also relatively low in the primary wet season in May to July 2019 with a combined average productivity of 174 kilograms (383 pounds). During this period, fisherfolk also consistently expended lower effort with each trip lasting for 6 hours on average.
- The two most productive months were April and August 2019 with average productivity of 268 kilograms (590 pounds) and 247 kilograms (545 pounds). The most productive months are part of the primary and secondary dry seasons, part of the closed trawl season, and April is part of the first spawning season. These were among the months in which the greatest effort was expended per trip. It may be assumed that fisherfolk increased efforts in these two months because productivity was observed to be greater per trip.

Disruptions to the activities in September and October 2019 and challenges in collecting data from the regional supervisor in March 2020 have hindered the emergence of any clear trends for productivity in the dry seasons (August to October and February to March), the closed trawl season, and the January to April spawning season. Additional data are required to better understand seasonal productivity of white belly shrimping.

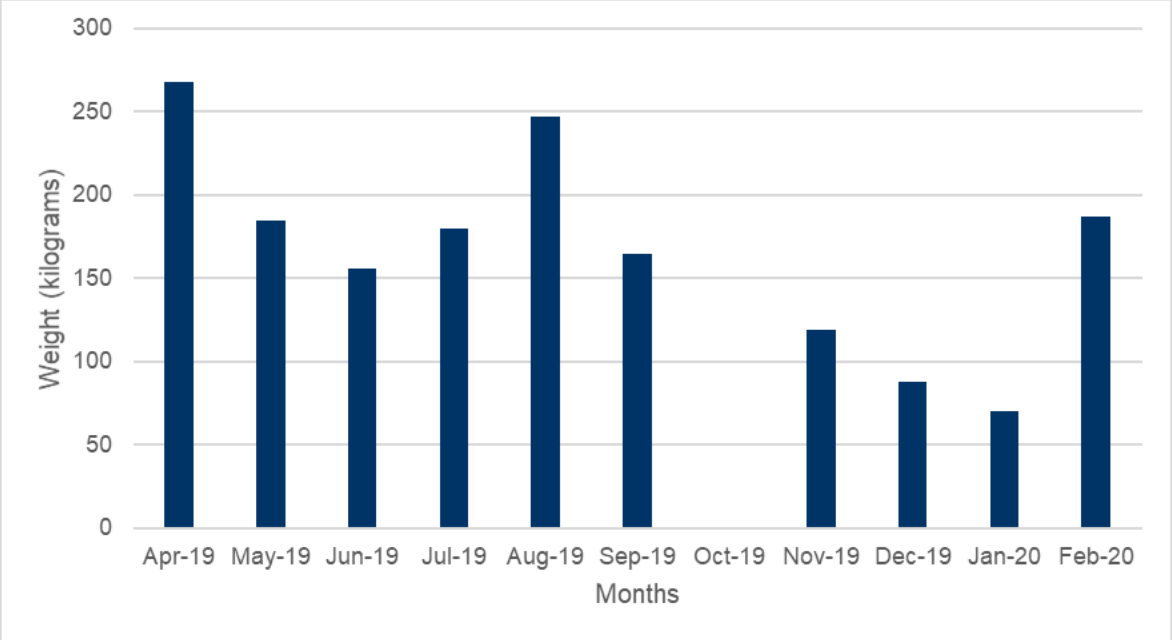


Figure K-5: Average Monthly Productivity of Fishing Trips at the Zeeburg Landing Site

2.4 Prices and Markets

Based on the data collected by the regional supervisor, cuma cuma was the highest-value fish with an annual average price of $331 GYD per kilogram ($1.60 USD per kilogram) as seen on Figure K-6. This fish is rarely caught at this landing site with a total haul weight of 4.5 kilograms (10 pounds) over the April 2019 to February 2020 period, and this may have contributed to the high price for which it was sold. The second, third, and fourth most abundant species caught were basha, corse shrimp/seabob, and trout. White belly shrimp, which is the target species and most abundant species caught, was the fifth most expensive species caught with an annual average price of $261 per kilogram ($1.30 per pound). Overall, hauls recorded at this landing site were valued at a total of $31,295,960 GYD ($150,461 USD).

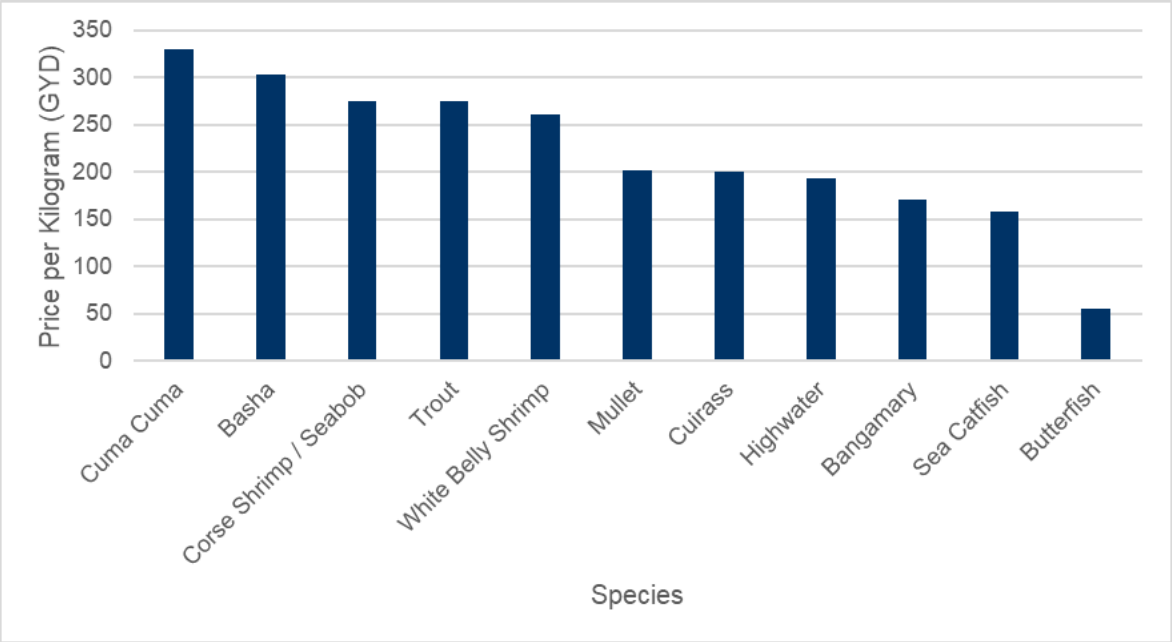


Figure K-6: Annual Average Prices per Kilogram of Fishes and Shrimps at the Zeeburg Landing Site

There are significant differences in the monthly minimum and maximum prices for the four most abundant species caught (see Figure K-7). Generally, fishes like trout, bangamary, and butterfish, among others, are less expensive at this landing site than at other landing sites, which may be due to the small size of the fishes for which there is typically less demand. Despite the differences in the minimum and maximum prices, average prices for bangamary were stable throughout the year because there are ready markets for “flat,” “fine,” or “shine” bangamary, which are the juveniles of this species. However, similar markets for juveniles of other species such as cuirass and trout do not exist and the smaller fishes of these species are typically not sought commercially.

In addition, most of the white belly shrimp is sold to vendors called huskers, who visit the landing site with trucks to purchase catch from fisherfolk and are known to bargain with fisherfolk for lower prices. Scarcity also influenced prices at this landing site as average and maximum prices for white belly shrimp, bangamary, and cuirass were among their highest in November 2019 to January 2020, which was also the least productive period. It is likely that these trends in pricing would also have been observed for all other species caught at this landing site.

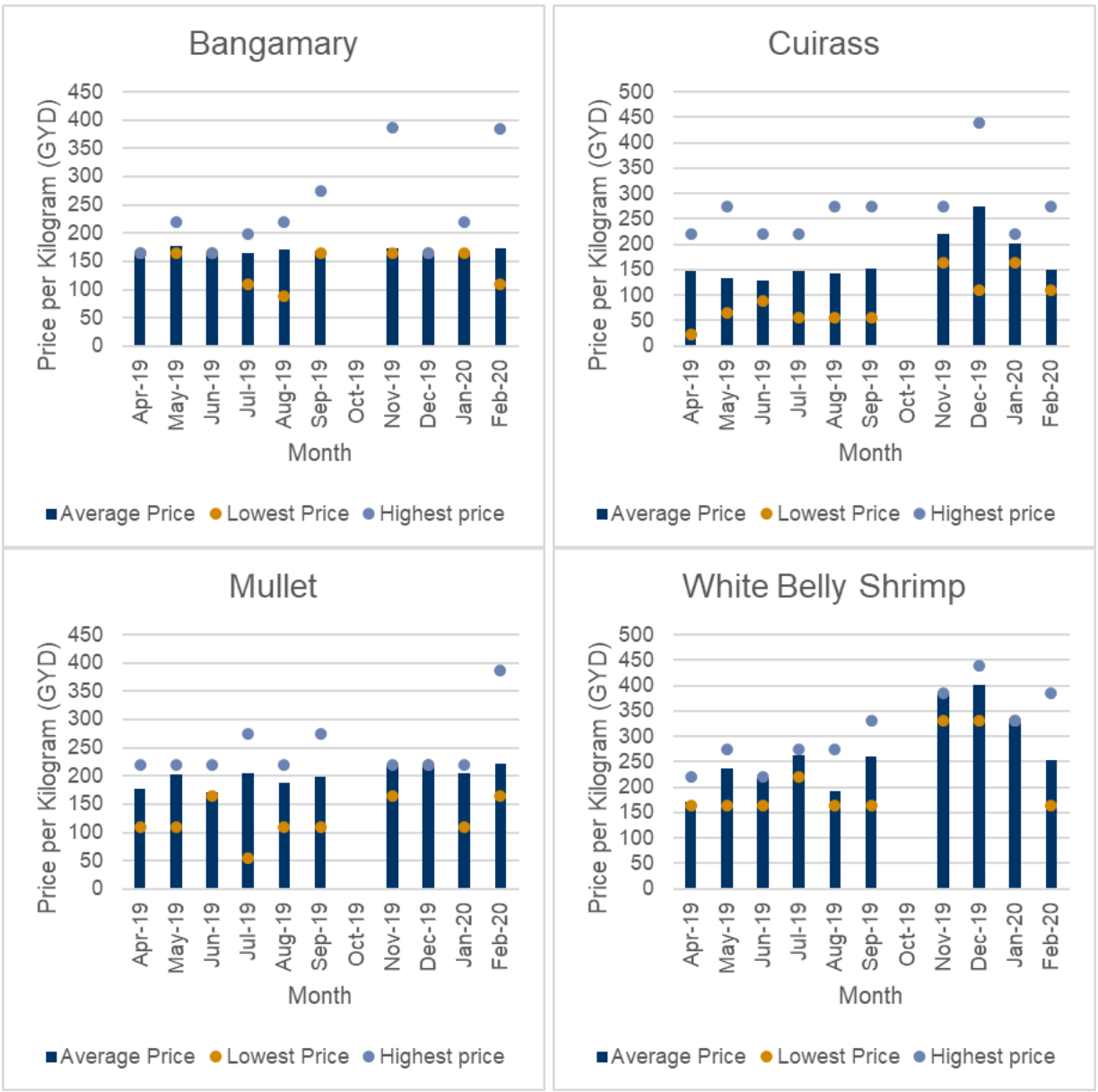


Figure K-7: Monthly Price Variations of the Four Most Abundant Species Caught at Zeeburg Landing Site

2.5 Biometrics

Only limited biometric data were collected by the regional supervisor as the fishes were small and their weights were too low to be accurately measured on the type of scale used for this study (see Figure K-8). Based on the photographs taken by the regional supervisor, and observations of the study team when visiting the landing site, most of the fishes caught were juveniles of their species. Small-bodied species such as mullet, which was the third most abundant species caught, were also abundant. Due to the challenges associated with obtaining accurate weights of small fishes, only larger specimens were weighed, but these were comparatively scarce and not representative of the sizes of fishes normally caught at this landing site. Given the mesh sizes of the Chinese seines used, there are not likely to be any significant differences in the sizes of fishes caught on a seasonal basis. For example, the largest

bangamary recorded was 22.5 centimeters and the largest cuma cuma was 17.5 centimeters, neither of which reached sexual maturity.

3 QA/QC DATA

During the QA/QC exercise in September 2019, one Chinese seine vessel was assessed. The vessel spent 5 hours at sea and soaked the Chinese seine once during that time. The vessel used a 15 hp outboard engine and fished in an area referred to as “Lanka.” These fishing practices are consistent with those reported by the regional supervisor for most of the vessels operating at the landing site.

Several of the commercially viable species reported by the regional supervisor were observed as part of the haul of the vessel assessed. The catch composition of commercially viable species was also consistent with the data collected by the regional supervisor. However, on the day of the visit, market prices were slightly lower than the average prices obtained during the reporting period. In general, most of the commercially viable fish species caught were too small to be weighed (see Figure K-9) or to be differentiated by sex. The regional supervisor recorded no biometric measurements of the fishes because of their small size. However, the study coordinator advised the supervisor to measure lengths of representative samples of landed fishes that are commercially viable and weights, where possible. This will enable greater understanding of the sexual maturity of the fishes caught by the Chinese seine vessels operating at this landing site.

During the QA/QC exercise in January 2020, another Chinese seine vessel was assessed. The vessel took a 12-hour fishing trip and soaked its seines twice. The vessel had a total haul of 50 kilograms (110 pounds), which was lower than the average weight of hauls of 70.5 kilograms (155 pounds) for vessels at this landing site. There was also a change in catch composition, as bangamary accounted for a larger percentage of the haul than white belly shrimp. Fisherfolk interviewed at the landing site indicated that there was a decline in white belly shrimp catch during this period. This contributed to the reduction of overall haul sizes in January 2020 as reported by the regional supervisor.

Prices recorded during the QA/QC exercise reflected those reported by the supervisor, but a variance was observed in the prices of white belly shrimp that was sold for $189 GYD ($0.90 USD) per kilogram during the QA/QC exercise compared to the $330 GYD ($1.60 USD) per kilogram. This was attributed to the fisherfolk trying to sell the relatively small haul quickly. The cuma cuma fish was the most expensive of the haul and this is consistent with the data collected by the regional supervisor.

In addition, the regional supervisor did not record bycatch species that were included as part of the haul. For the vessel assessed during the first QA/QC exercise, there were two species of bycatch namely banjaman and mud eels. Due to the lack of commercial value, fisherfolk at the Zeeburg landing site do not track these species. The study coordinator advised the regional supervisor to commence data collection on bycatch of the hauls in the future. This will enable greater understanding of bycatch from these vessels and also enable comparisons with bycatch reported by onboard supervisors at Windsor Forest (Region 3) and Ogle (Region 4). At the conclusion of the second QA/QC exercise, the study coordinator encouraged the supervisor to collect these data, and also used the opportunity to provide a refresher training on the collection of biometric data. Overall, the study coordinator was satisfied that the onboard supervisor was accurately recording the commercial species caught.

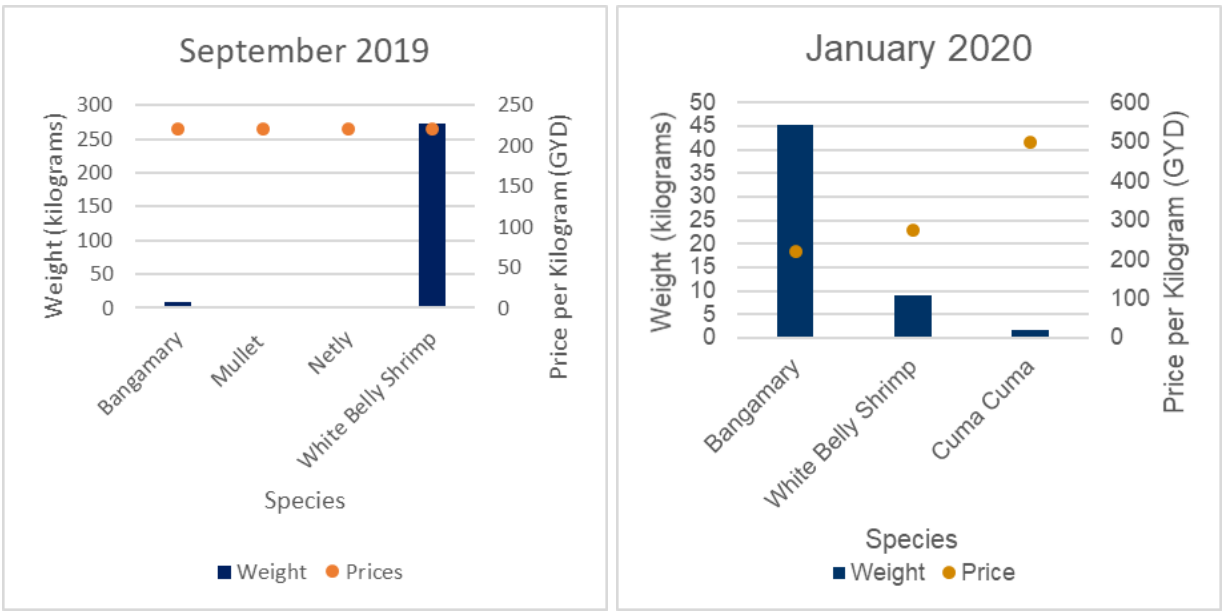


Figure K-8: Total Weight and Prices of Fishes Assessed during the QA/QC Exercises

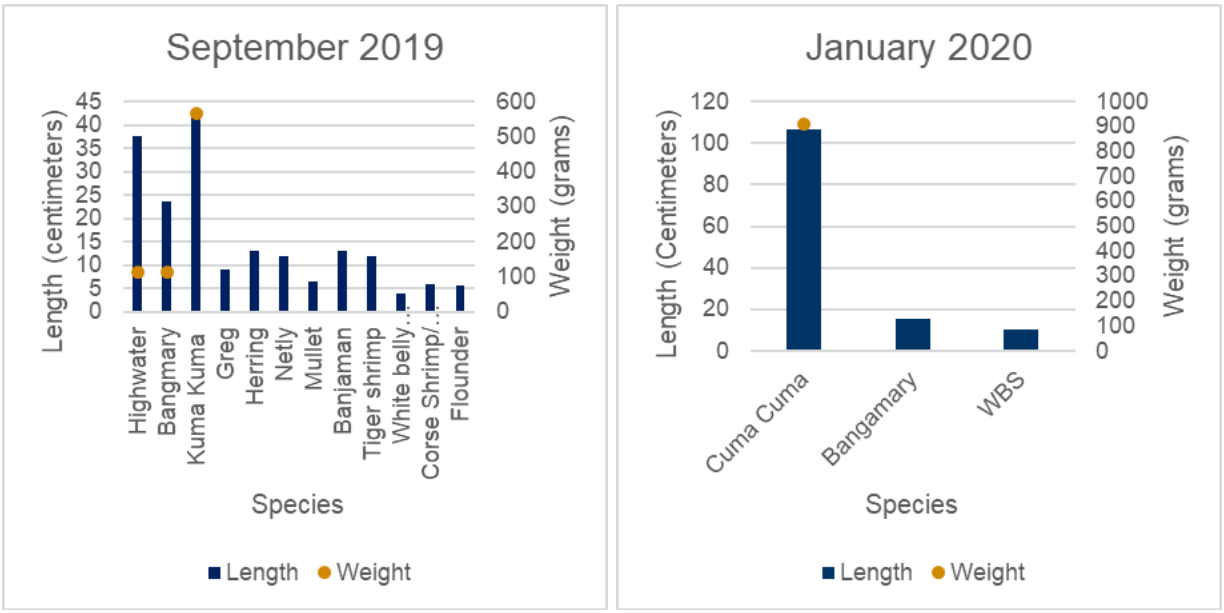


Figure K-9: Lengths and Weights of Species Measured during the QA/QC Exercises

APPENDIX L LA GRANGE (REGION 3)

1 LANDING SITE OVERVIEW

The La Grange landing site is one of the only landing sites in Guyana where almost all fisherfolk still use Cadell lines (demersal longlines) for commercial fishing. The landing site is located on the western bank of the Demerara River. The landing site is farther inland than the other landing sites surveyed, and fisherfolk traverse along the Demerara River to access fishing grounds along the Region 3 and 4 coastlines. Most vessels are outboard cruisers fitted with engines of 15 hp. Fisherfolk using Cadell lines make daily trips lasting from 2 to 16 hours per day. Fisherfolk in La Grange fish about 1 to 25 kilometers offshore at depths of 7 to 27 meters. The main expenses are fuel and fishing bait and each trip costs approximately $20,000 GYD ($96 USD).

Fisherfolk have indicated that the main species caught at this landing site are catfish, cuirass, snapper, trout, and shark. Yield is typically 2 to 4 tubs (1 tub weighs about 25 kilograms, or 50 pounds) of fishes that could be sold for $3,000 to 15,000 GYD ($14 to $72 USD) depending on the species. Fisherfolk also indicated that markets at the landing site and surrounding villages are inconsistent and demand is typically low. As a result, when returning from a fishing trip, most fisherfolk first land their vessels at the Meadowbank Wharf in Region 4 on the eastern bank of the Demerara River, where there are daily active fish markets. Hauls are typically sold to vendors but on occasion, fisherfolk sell directly to consumers. Some fisherfolk also opt to land at the Stabroek Market, also in Region 4 on the eastern bank of the Demerara River, where hauls are sold to vendors.

The main challenges encountered at this site are conflicts with drift seine fisherfolk on occasions when the Cadell lines and drift seines become entangled, and lack of markets. Fisherfolk have also indicated that variable weather patterns, including changes in season, which they state are associated with climate change, may be negatively affecting their activities.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor at this site uses Cadell lines to fish. Each fishing trip lasts 10 to 12 hours. On each fishing trip, approximately 500 Cadell lines are soaked for approximately 1 hour. Lines are soaked once or twice per fishing trip. The onboard supervisor travels farther offshore than any of the other onboard supervisors with fishing grounds located approximately 40 kilometers (23.9 miles) offshore. The vessel is an outboard cruiser fitted with a 15 hp engine. Travel time to the fishing grounds is approximately 4 hours. On commuting to the fishing grounds, the onboard supervisor typically meets with fisherfolk who use Chinese seines and drift seines around the mouth of the Demerara River. The onboard supervisor purchases small fishes and shrimp from these fisherfolk to be used as bait attached to the Cadell lines and has indicated that this is a common practice for Cadell fisherfolk. On the return trip, the supervisor typically lands first at the Meadowbank Wharf to sell the haul to vendors. The vessel is staffed with a four-member crew inclusive of the onboard supervisor. The onboard supervisor did not report any significant challenges that affected his fishing activities over the study period.

2.1 Target Species and Diversity

The total weights of combined hauls from the onboard supervisor's vessel over the April 2019 to February 2020 period was of 30,656 kilograms (67,585 pounds) from 1,367 hours of effort. As seen on Figure L-1, sea catfish was by far the most abundant species caught accounting for 85 percent of the total haul with 26,271 kilograms (57,918 pounds). This is similar to the haul of the onboard supervisor from Waramuri (Region 1) where sea catfish comprised 75 percent of the haul from Cadell lines. Hauls from fishing activities using Cadell lines targets species that are benthic feeders because the hooks attached to the lines lie on the seafloor. Cuirass, kokwari, and snapper were the second, third, and fourth most abundant

species caught with total weights of 2,099 kilograms (4,627 pounds), 1,126 kilograms (2,482 pounds), and 606 kilograms (1,336 pounds), respectively.

A total of 13 species were recorded by the onboard supervisor although nine were caught in relatively low quantities of lower than 500 kilograms (1,100 pounds). This is higher than the species diversity reported by the onboard supervisor at Waramuri where only five species were caught but lower than the species diversity of different seine types, in particular from seines with small mesh sizes. The eel caught is not sold as a commercial species, but is used by the onboard supervisor as bait. The difference in species diversity from La Grange to Waramuri could be attributed to the fishing grounds, relative distances at which fishing occurs from the shore, and the dynamics of different river systems. No bycatch was recorded by the onboard supervisor. Generally, there is little to no bycatch from this type of fishing.

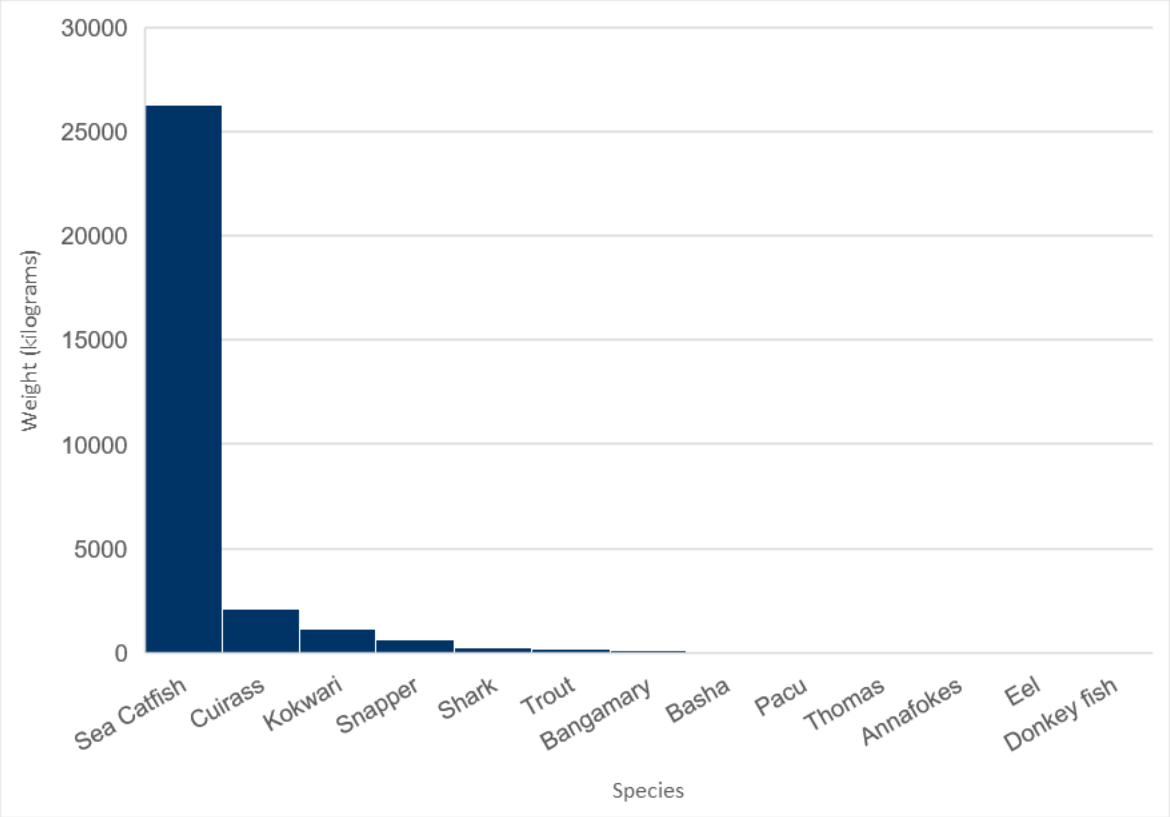


Figure L-1: Total Weight of Species Recorded by the Onboard Supervisor at the La Grange Landing Site

2.2 Fishing Area

The onboard supervisor's fishing points were clustered in a main fishing area, which covered 266 square kilometers (see Figure L-2). The onboard supervisor traveled 36 kilometers to access these fishing grounds from the landing site and 31 kilometers from the mouth of the Demerara River. In total, the onboard supervisor had a traveling range of 2,226 square kilometers which is farthest offshore of any of the onboard supervisors in the study.

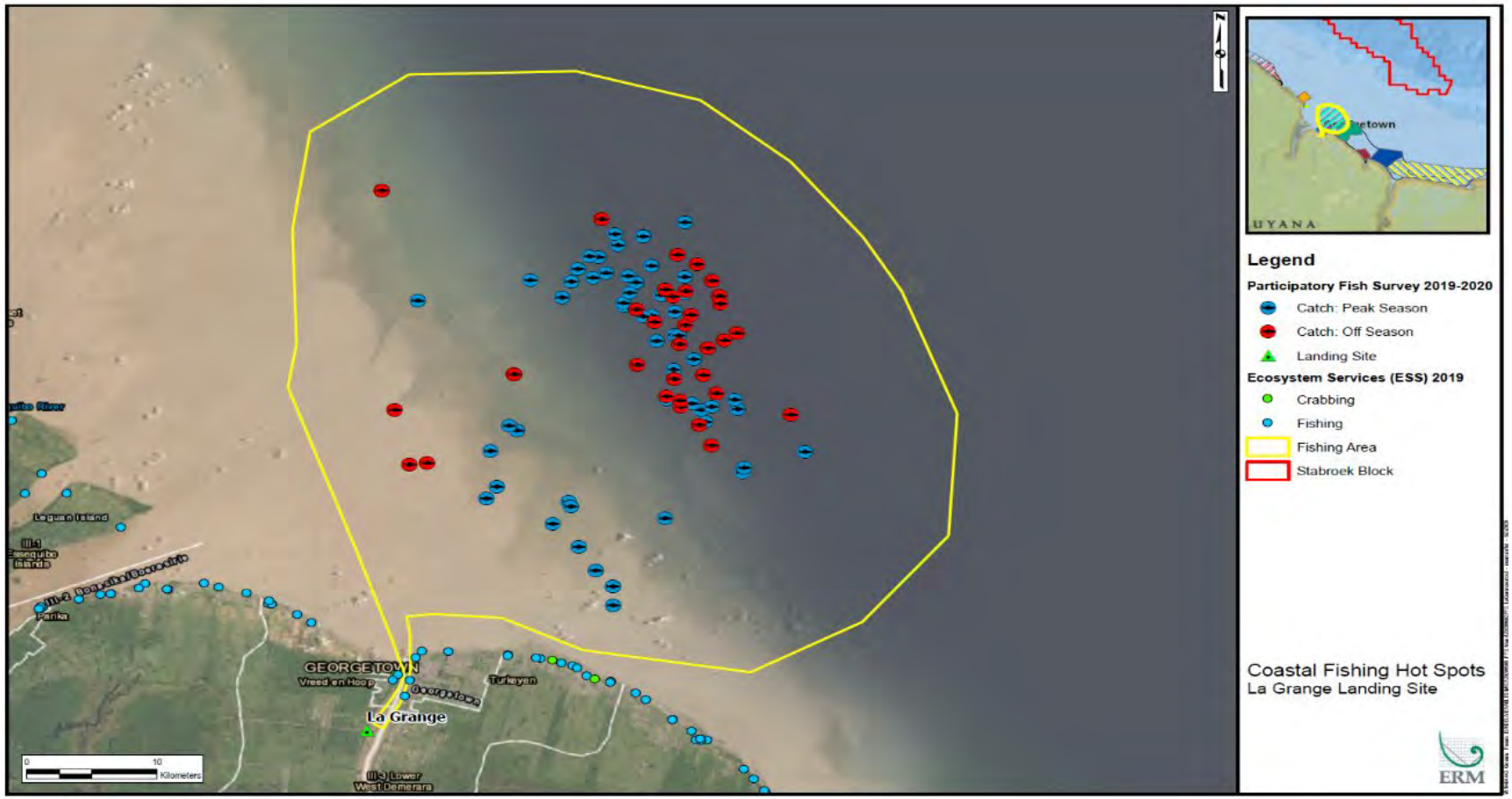


Figure L-2: Fishing Area and Fishing Points Used by the La Grange Onboard Supervisor

The onboard supervisor used fishing points closest (9.3 kilometers) and farthest (46.5 kilometers) from the shoreline during the good season. As a result, there are no clear seasonal trends on the distance at which fishing points were located throughout the study period. In addition, the most eastward fishing points were observed during the good season. The currents in fishing grounds move westward and as a consequence, it is likely that the supervisor traveled farther east against the currents during the good season when fisherfolk reported that waters are calmer and more conducive to fishing.

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

During the study period, the onboard supervisor spent an average at 124 hours per month fishing, but the effort expended per fishing trip varied on a monthly basis as seen on Figure L-3. For example, the highest effort was expended in October 2019 when 228 hours were spent fishing. By contrast, the lowest effort was expended in January 2020 when only 24 hours were spent fishing. Based on the onboard supervisor’s fishing practices, monthly effort of 228 hours suggests that there were at least 22 fishing trips in October 2019 while monthly effort of 24 hours suggests that there were only two fishing trips in January 2020. Figure L-4 and Figure L-5 show the total weight of hauls on a monthly basis and the average haul weight per soaking of the seine. In May and July 2019, the highest total hauls and average hauls per soaking were observed. The November 2019 to February 2020 period saw consistently low hauls.

Seasonal variations in effort and productivity were observed as follows:

- In the May to September 2019 good season, the total weight of hauls was 22,146 kilograms (48,824 pounds) with 611 hours spent at sea. On average, a soaking during this period yielded 455 kilograms (1,003 pounds). Total haul and average weight of hauls per soaking peaked in July 2019. In addition, May 2019 was the second most productive month. In both months, effort expended was in the medium range for this landing site with 116 hours in May and 119 hours in July. However, in August 2019, the monthly effort and total haul were the lowest of the good season and were comparable to levels observed during the hard season. The reason for this decline is unknown.

- In April 2019 and during the October 2019 to February 2020 hard season, the total weight of hauls was 8,805 kilograms (19,411 pounds) with 757 hours spent at sea. On average, a soaking in this period yielded 130 kilograms (287 pounds). Although the onboard supervisor expended the greatest effort in October 2019, total hauls and average weight of hauls per soaking declined compared to September. From November 2019, the effort and total haul consistently declined and reached the lowest levels in January 2020. In addition, average hauls per soaking were consistently low for most of the hard season in April 2019 and during the November 2019 to February 2020 period.

By comparison, seasonal trends in the wet and dry season were as follows:

- In August to October 2019, the primary dry season, the total weight of hauls was 7,864 kilograms (17,337 pounds) with 432 hours spent at sea. On average, a soaking during this period yielded 225 kilograms (496 pounds).

- In May to July 2019, the primary wet season, the total weight of hauls was 18,524 kilograms (40,838 pounds) with 407 hours spent at sea. On average, a soaking during this period yielded 608 kilograms (1,340 pounds).

- In February 2020 and April 2019, 2 months of the secondary dry season, the total weight of hauls was 2,320 kilograms (5,115 pounds) with 276 hours spent at sea. On average, a soaking in this period yielded 144 kilograms (317 pounds).
- In November 2019 to January 2020, the secondary wet season, the total weight of hauls was 3,513 kilograms (7,745 pounds) with 408 hours spent at sea. On average, a soaking during this period yielded 111 kilograms (245 pounds).

Based on the trends discussed above, the productivity of fishing activities was seasonal and adhered to the periods for the good and hard seasons. Average hauls per soakings were also greater during the good season as compared to the hard season. Climatic seasonality did not influence productivity. This also translated to greater productivity in the primary wet and dry seasons compared to the secondary wet and dry season. The trends also demonstrated that the relationship between effort expended and total haul is also ultimately determined by the seasons. In particular, greater effort is not a guarantee of greater productivity. Several factors influenced the onboard supervisor's decision to reduce fishing activity in January 2020. The onboard supervisor explained that low effort was expended due to the rough seas during the hard season and a decision to spend some time relaxing with family.

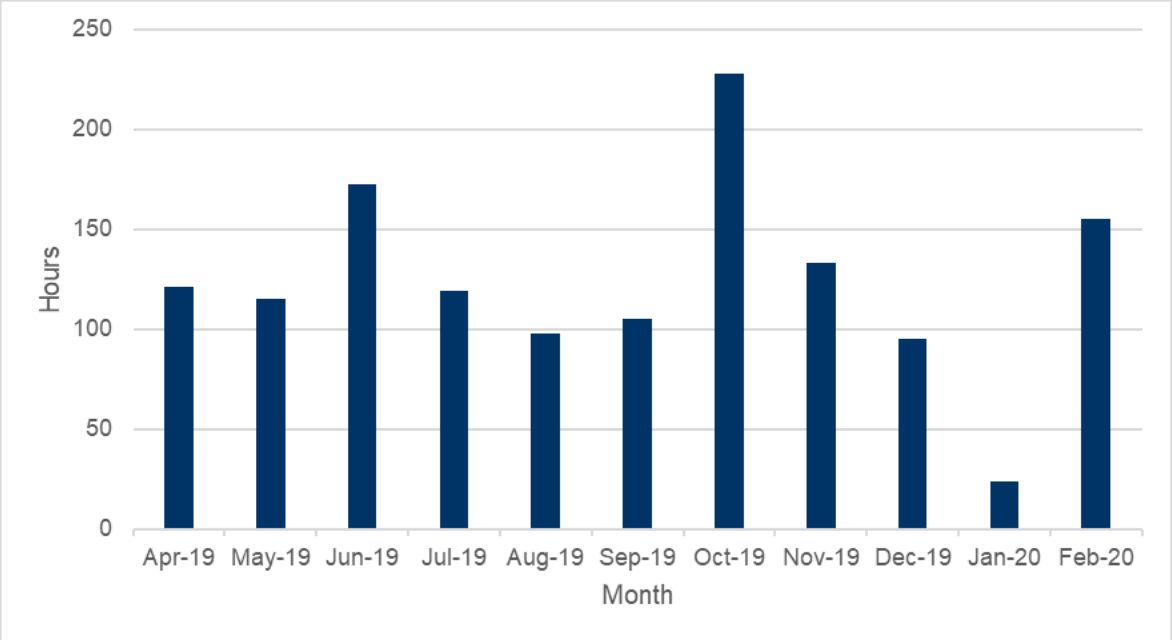


Figure L-3: Total Monthly Fishing Effort Recorded by the La Grange Onboard Supervisor

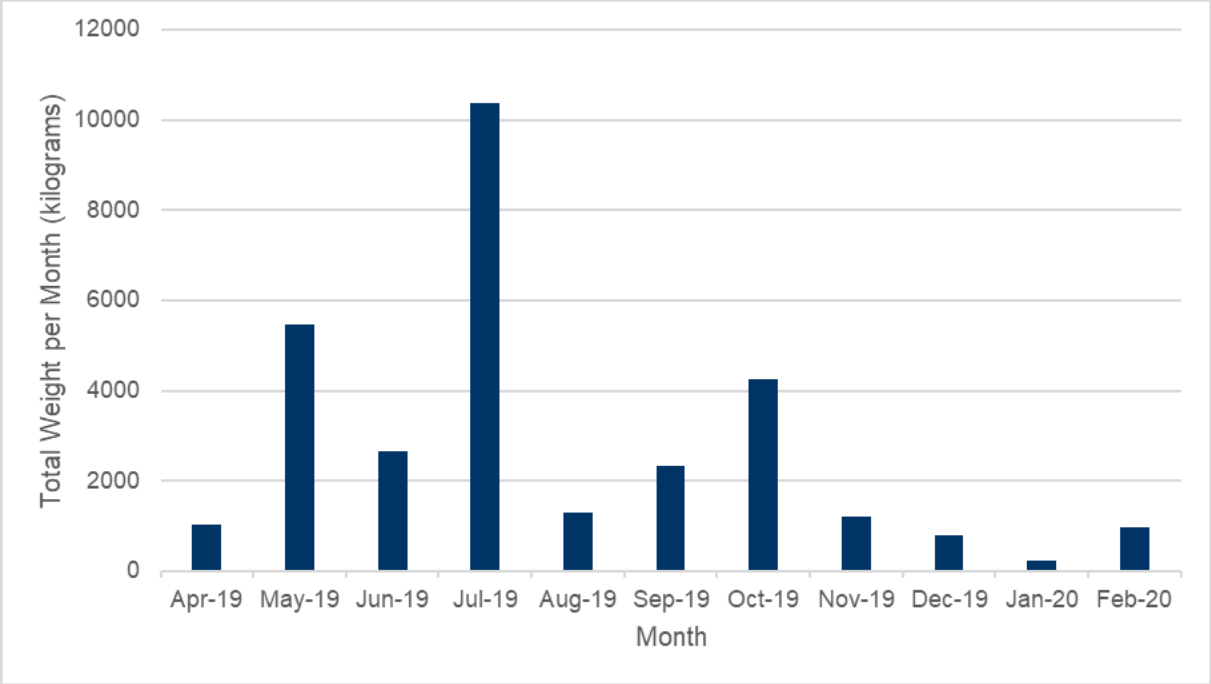


Figure L-4: Total Weight of Species Recorded by the La Grange Landing Site

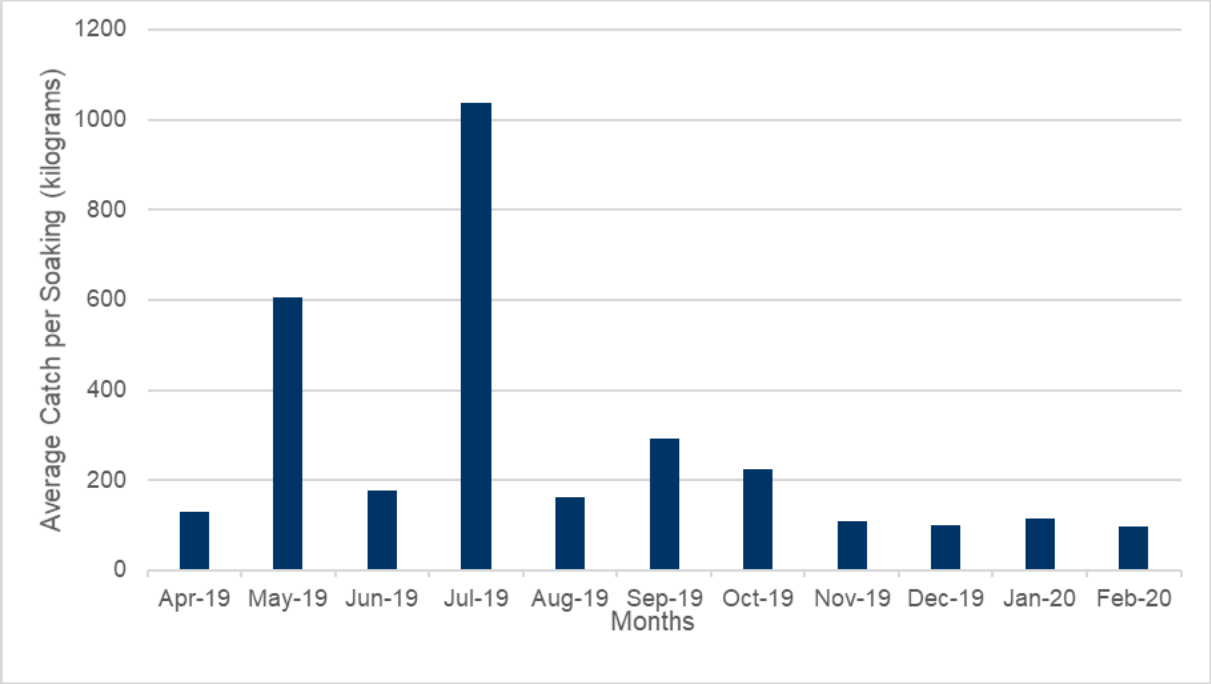


Figure L-5: Average Weight per Soakings Recorded by the La Grange Landing Site

2.4 Biometrics

The onboard supervisor measured the lengths and weights of representative fishes per haul and the annual average lengths and weights of these fishes are shown on Figure L-6. Based on the

measurements taken by the onboard supervisor, most of the fishes caught were sexually mature. It should be noted that the annual average lengths of basha and bangamary indicate that they were relatively small for their species, but had achieved mature sizes. Basha are considered sexually mature at a length of 25 centimeters, and the annual average length of the fishes caught was 28 centimeters. Bangamary are considered sexually mature at a length of 24 centimeters, and the annual average length of the fishes caught was 27 centimeters.

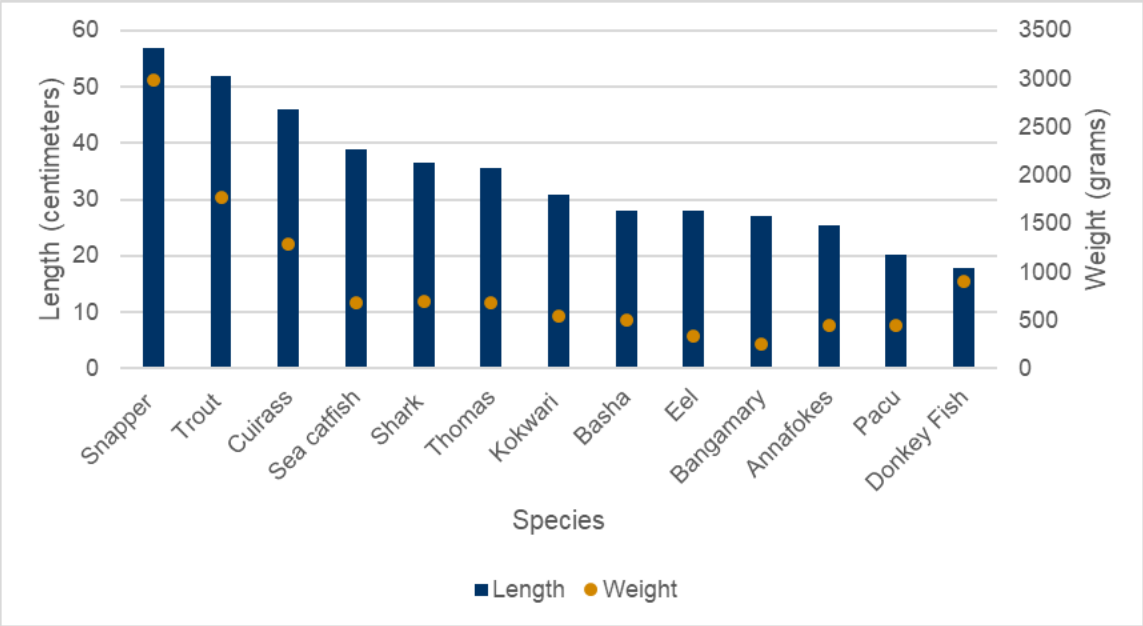


Figure L-6: Average Length and Weight of Fishes Caught by the La Grange Onboard Supervisor

The monthly average lengths and weights of the four most abundant species caught are presented on Figure L-7. Sea catfish, the most abundant species caught, representing 85 percent of the total haul, were largest in the May to September 2019 good season. The largest sea catfishes were caught in September 2019 and these fishes were likely spawning females. The July to September period is widely believed to be the spawning period and females caught are frequently carrying eggs, which contributes to larger fishes being caught at this time of the year. The onboard supervisor could not confirm whether larger fishes caught over the July to September spawning period were spawning females, as fish are not gutted prior to sale. When the spawning period ended, smaller fish were caught. In fact, the fish caught from October 2019 to February 2020 were consistently smaller than those caught between May and September 2019. Sea catfish caught in October, November, and December were below average lengths for this species.

Although snapper, cuirass, and kokwari were among the most abundant species caught in the total haul, they were not caught in every month (Figure L-7). Larger individuals of snapper and cuirass were caught in April to June 2019 and both species were at peak weights in April. By comparison, kokwari achieved peak weights in October. Given that the supervisor does not gut fishes prior to sale, it is not clear whether these larger fishes were spawning females. In addition, snapper caught in February 2020 were considered juveniles and cuirass caught in October, November, and December were below average lengths. None of the kokwari caught were considered juvenile.

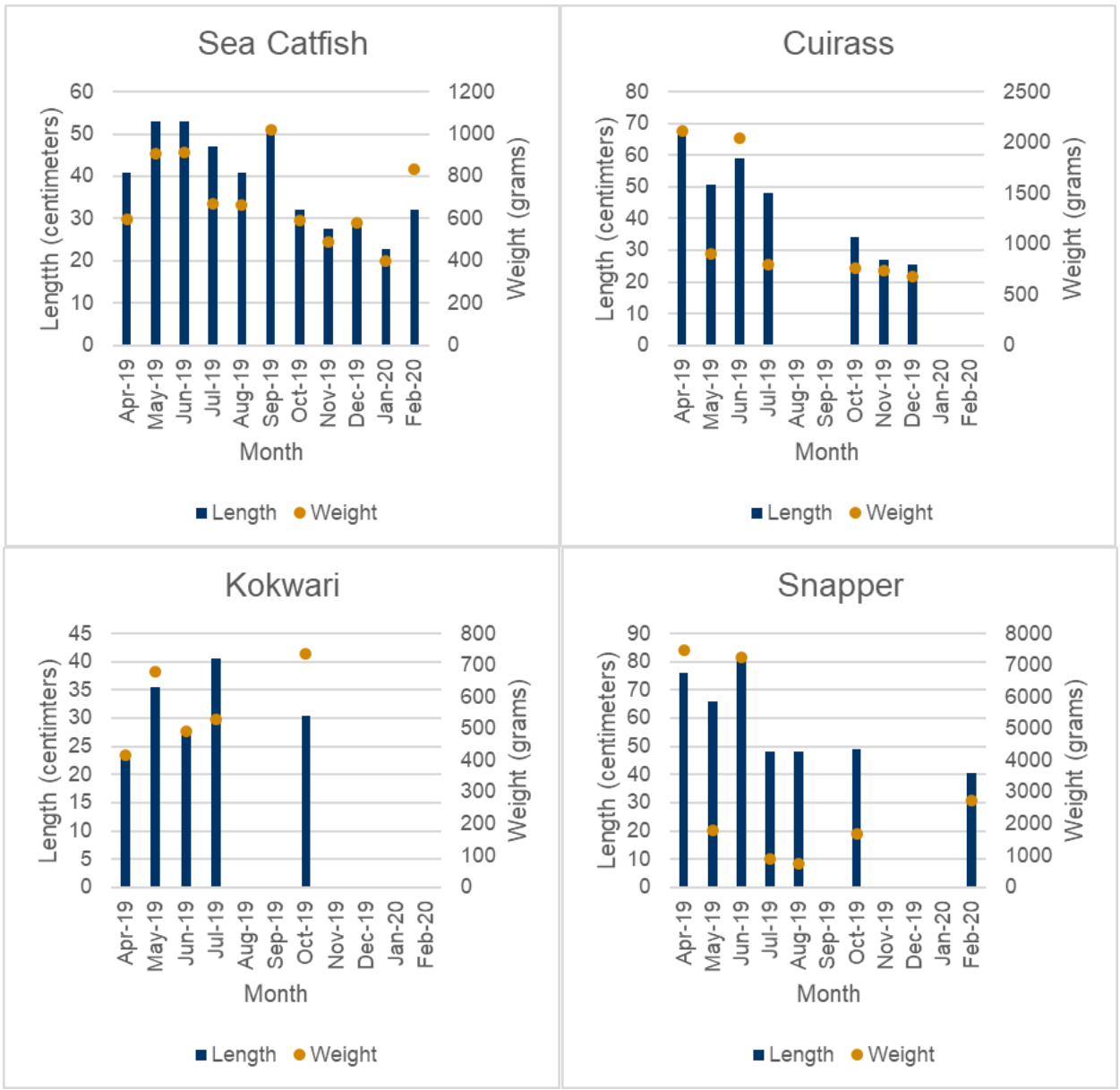


Figure L-7: Monthly Average Length and Weight of Most Caught Species at the La Grange Landing Site

3 QA/QC DATA

As part of the QA/QC exercise, a GoPro camera was mounted to the onboard supervisor's vessel (Figure L-8). Several key observations were made from the video monitoring that was conducted over the period of 24 to 26 September 2019.

- The onboard supervisor met with a Chinese seine fisherman at the mouth of the Demerara River to purchase bait to be attached to the Cadell lines. Subsequent discussions with the onboard supervisor revealed that purchasing bait from Chinese seine fisherfolk is a common practice by fisherfolk who use Cadell lines for fishing.

- The supervisor took 6 hours to travel from the La Grange landing site to the fishing ground used on the day of the observation. This included a 2-hour period that was used to collect bait from Chinese seine fisherfolk at the mouth of the Demerara River.
- The Cadell lines were then soaked for 1 hour before being picked up by the crew members.
- The supervisor was the navigator for the entire fishing trip. Two crew members pulled up the lines while one member sorted the catch.
- The supervisor sold the fishes caught at the Meadow Bank Wharf, which can be accessed along the Demerara River while the vessel was en route back to the La Grange landing site.

The haul could not be assessed by the study team because the onboard supervisor had sold it at the Meadow Bank Wharf before returning to the landing site. However, the supervisor kept three fishes on which the study coordinator could conduct biometric assessments. As seen on Figure L-9, the fishes were similar in size to those for which biometric data were collected by the onboard supervisor during the reporting period. Overall, the study team was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

Based on the data collected by the onboard supervisor for this trip, species composition for this haul was the same as reported during this trip. In addition, sea catfish comprised the largest percentage of the total haul, consistent with trends observed at this landing site during the study period.

During the second QA/QC exercise, the team was unable to collect data from the onboard supervisor's vessel because the onboard supervisor was on vacation and fishing activities by other fisherfolk at the landing site were limited.

Figure L-8: GoPro Being Mounted during QA/QC

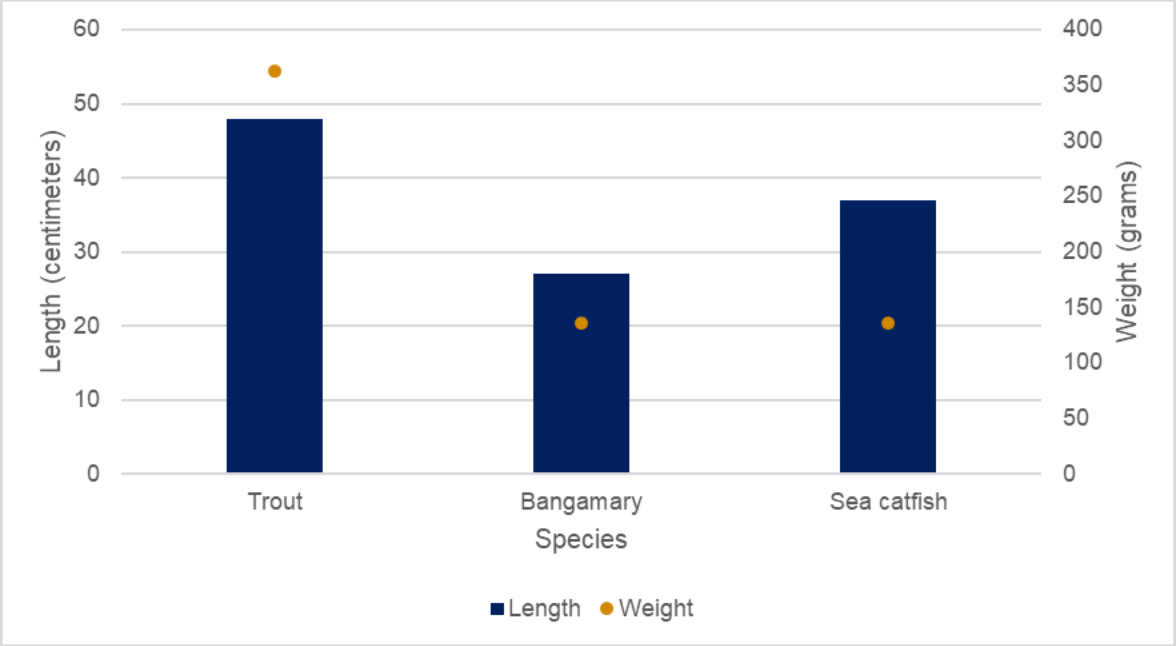


Figure L-9: Biometric Measurements Verified at the La Grange Onboard Supervisor

APPENDIX M WINDSOR FOREST (REGION 3)

1 LANDING SITE OVERVIEW

Windsor Forest is a medium-sized landing site on the west coast of Demerara in Region 3. Approximately 12 vessels use this landing site, all of which use Chinese seines with mesh sizes ranging from 2.5 to 10 centimeters (1 to 4 inches). Some of the fisherfolk use the Cadell method of fishing to augment the Chinese seines. All vessels are outboard cruisers equipped with engines of 15 to 40 horsepower (hp). Fisherfolk make daily trips to the Chinese seine "pens" located approximately 10 kilometers offshore. Fishing trips for Chinese seine vessels are dependent on the tides and a trip typically last for approximately 6 hours. The main expenditure for fishing trips is fuel since ice is not required for preservation of the haul. An average fishing trip costs $1,500 GYD ($7.20 USD).

A basket of "mixed fishes," typically comprised of bangamary, netly, Suriname mullet, and small herrings, is sold for approximately $120 GYD ($0.6 USD) per kilogram (depending upon season) to vendors who visit the landing site. Some vendors have refrigerated trucks, although this practice is not as prevalent at this landing site. Most of the haul is sold at the local marketplace.

The main challenge encountered by fisherfolk at this landing site is conflict with anchor seine vessels and sargassum.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor at the Windsor Forest landing site uses Chinese seines with mesh sizes of 2.5 to 10 centimeters (1 to 4 inches). The primary target species is white belly shrimp, and this is caught mainly with seines that have mesh sizes of 2.5 to 10 centimeters (1 to 4 inches). However, the supervisor uses Chinese seines with larger mesh sizes to catch fishes because hauls of white belly shrimp are variable and the good season is not long enough to make shrimping an economically viable livelihood activity. Fishing trips are tidal and the onboard supervisor used the high tide to travel to the pens to set the seine. The onboard supervisor has five pens located approximately 20 kilometers from the shore.

The supervisor also uses Cadell lines year-round. On a fishing trip, Cadell lines are soaked en route to the Chinese seine pens. This is similar to the onboard supervisor from the Lima landing site (Region 2) who uses other methods of fishing to augment Chinese seines with mesh sizes of 2.5 to 10 centimeters (1 to 4 inches). Each fishing trips lasts 7 to 8 hours, on average. The onboard supervisor's vessel has an estimated haul capacity of 500 kilograms (1,100 pounds). In general, the supervisor returns to the landing site after the seine has been hauled. The vessel has a two-member crew and is powered by a 15 hp engine. The main expense for fishing activities is fuel as there is no need for ice. The main challenge faced by the onboard supervisor was the proliferation of sargassum during the February to May period, which became entangled in the seines and constituted significant portions of the total haul.

2.1 Target Species and Diversity

The total weight of combined hauls during the data collection period was 40,727 kilograms (89,787 pounds). Although the primary target species was white belly shrimp, it was not the most abundant species caught. This is significantly different from hauls recorded by the onboard supervisor at the Lima landing site (Region 2) and the Zeeburg landing site (Region 3) where Chinese seines were also identified as the main fishing method and white belly shrimp was the most abundant species caught. Instead, as seen on Figure M-1, bangamary was the most abundant species caught, with a total weight of 9,817 kilograms (21,642 pounds), representing 24 percent of the total haul. Sea catfish and small banga were the second and third most abundant species caught, representing 14 and 11 percent of the total haul, respectively. The onboard supervisor disaggregates bangamary in the haul based on size. A reference to "bangamary" is to the larger fishes of this species that have, in general, reached sexual

maturity. “Small banga” is an umbrella term for a mixture of several species of small fishes that are typically juveniles, including bangamary, pilot fish, and herring among others. White belly shrimp, the primary target species, was the fourth most abundant species caught, with a total weight of 4,438 kilograms (9,784 pounds), representing 11 percent of the total haul.

Overall, the onboard supervisor recorded more than 12 different species of fish and shrimp (small banga represents at least three different species of fishes). The catch composition is reflective of the varied type of gear used throughout the year. For example, white belly shrimp are the target species of Chinese seines, sea catfish are the target species of Cadell lines, and bangamary, gillbacker, and trout are the target species of seines with a range of mesh sizes. Bycatch also accounted for a significant portion of the hauls, although weights were not recorded. Bycatch typically consisted of sargassum, jellyfishes, and rockhead fish.

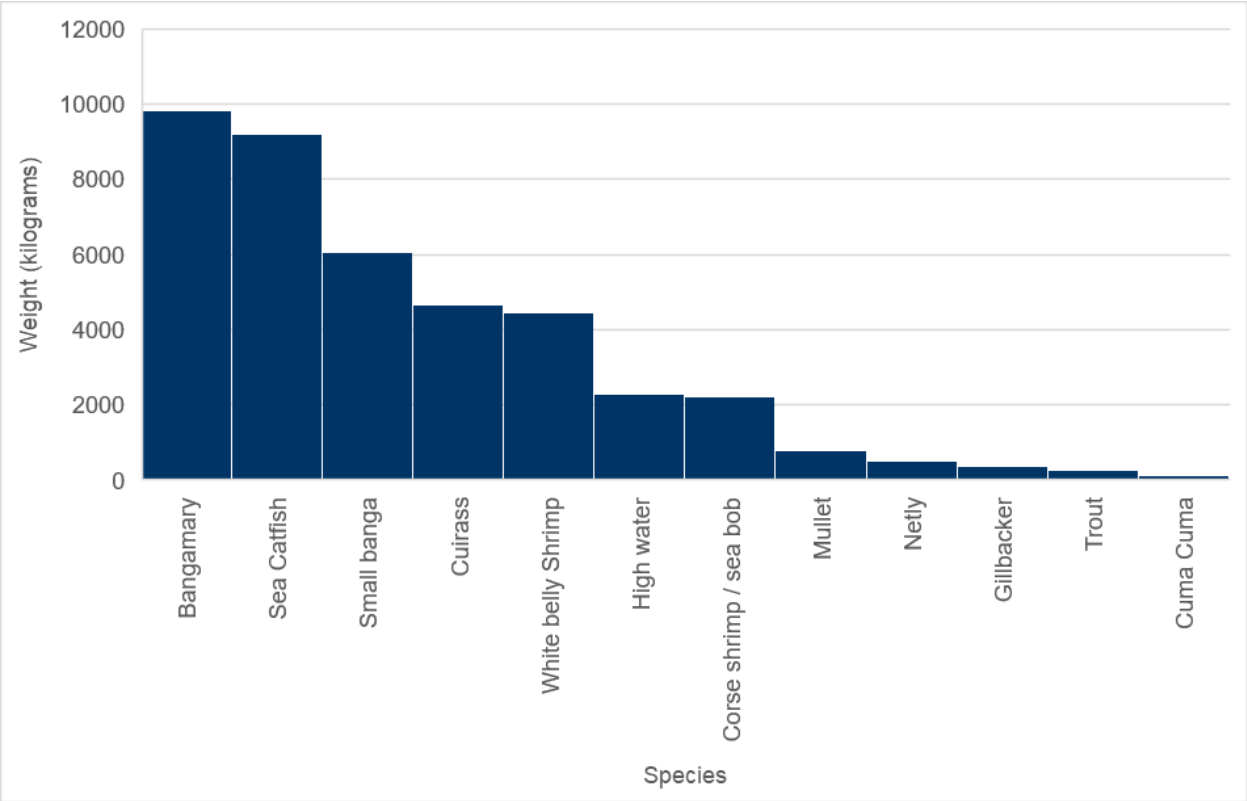


Figure M-1: Total Weight of Species Recorded by the Onboard Supervisor at the Windsor Forest Landing Site

2.2 Fishing Areas

The onboard supervisor uses a fishing area of 25 square kilometers (see Figure M-2). The fishing points used by the supervisor marks the locations of the Chinese seine pens that are used alternately by the onboard supervisor. The pens are located approximately 10.3 kilometers offshore. This is significantly farther than the pen used by the onboard supervisor at Lima to set Chinese seines. During the study period, the onboard supervisor also used Cadell lines for commercial fishing, but the locations at which these lines were soaked were not marked by the supervisor.

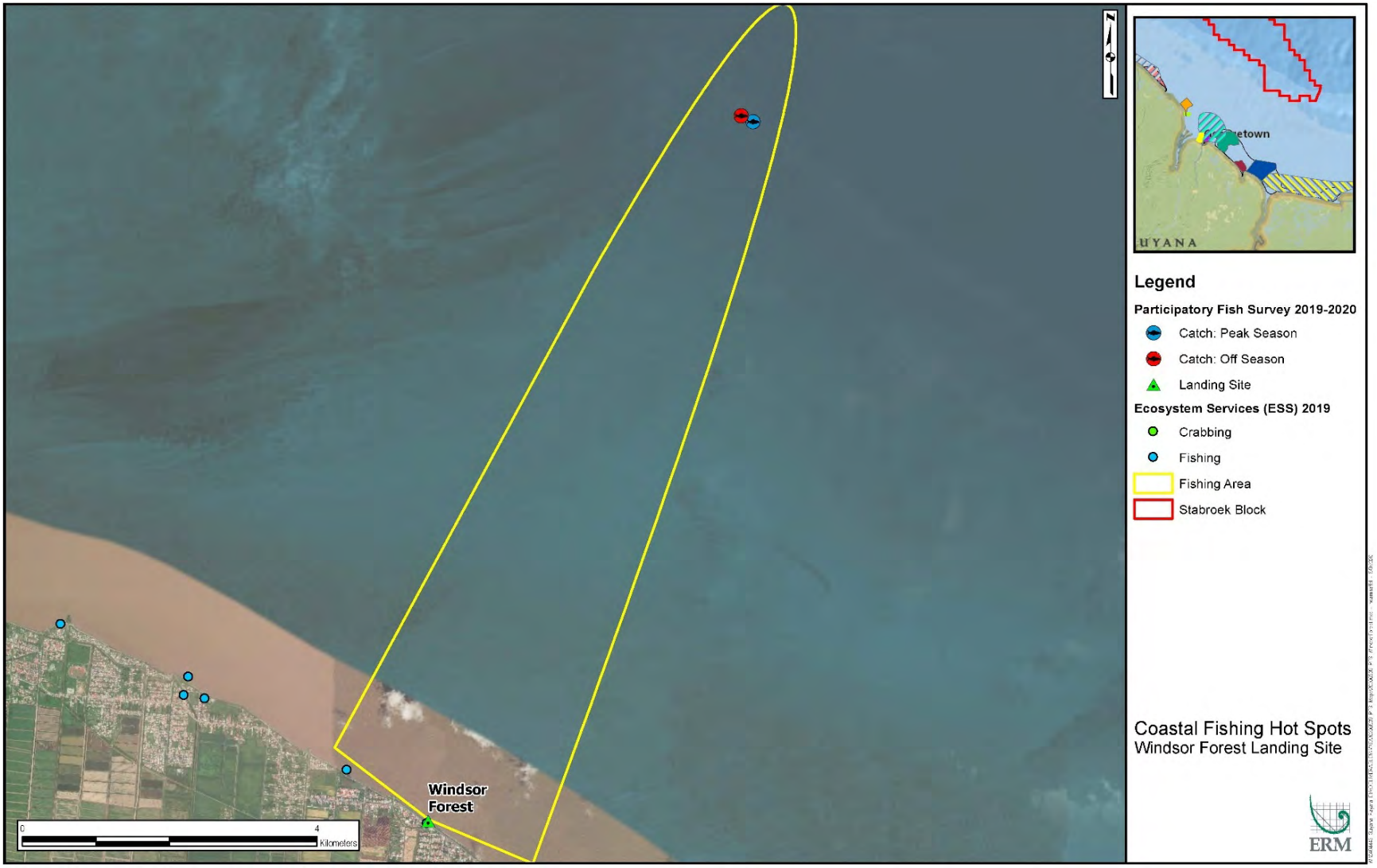


Figure M-2: Fishing Area and Fishing Points Used by the Windsor Forest Onboard Supervisor

2.3 Seasonal Productivity

Fisherfolk contend that the May to September period is the “good” season that peaks from July to September, and that October to March is the “hard” season. It is widely believed that waters are warmer and calmer during the good season, and that these conditions are more conducive to fishing. However, fisherfolk have varying beliefs on the most productive months for shrimping. At the Zeeburg landing site (Region 3), some fisherfolk indicated that shrimp catch generally increases during the closed trawl season, which occurs from 16 August to 5 October annually, and may allow more shrimp to come closer to the shore. Other fisherfolk indicate that the average productivity increases during the dry seasons of February to April and August to September because the waters are generally more saline compared to the wet season. Another common belief is that shrimp productivity increases during the spawning seasons of January to April and June to July (Pereira et al. 2017) when shrimp come closer to shore to spawn in the mangroves. Due to the varied fishing methods practiced by the onboard supervisor, it is unlikely that there are clear seasonal trends in either effort or hauls. This was also observed in the hauls from the onboard supervisor at the Lima landing site (Region 2) where drift seines, pin seines, and Cadell lines augment Chinese seine fishing.

The onboard supervisor spent an average of 129 hours at sea per month as seen on Figure M-3. The greatest effort was expended in November 2019 and February 2020, with 181 and 168.5 hours, respectively. By contrast, the least effort was expended in December 2019 when 109 hours were spent fishing. This is similar to the fishing practices of the onboard supervisor at the Lima landing site (Region 2) where the greatest effort was also expended in November 2019 and January 2020 and the least effort in December 2019. Although 40 hours were expended in April 2019, data collection did not begin until 16 April 2019, and as such, the monthly data pool may not be comparable.

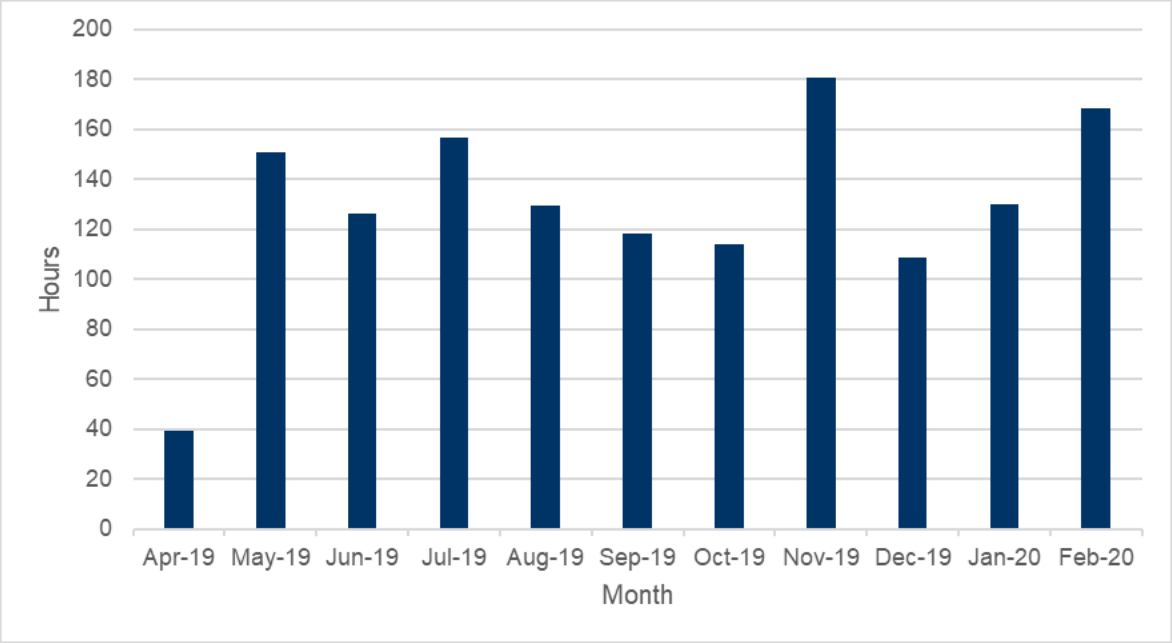


Figure M-3: Total Monthly Fishing Effort Recorded by the Windsor Forest Onboard Supervisor

As seen on Figure M-4, the highest average catch per soaking and greatest total haul were recorded in May 2019, with 13,678 kilograms (30,154 pounds) and 595 kilograms (1,312 pounds), respectively. The

second most productive month was July 2019 when average catch per soaking was 519 kilograms (1,144 pounds) and total haul was 10,373 kilograms (22,868 pounds). Low hauls were consistently recorded from August 2019 to February 2020, although effort in November 2019 and February 2020 were the highest levels of effort expended. Hauls in May and July 2019 were up to five times greater than the other months. The lowest total haul was seen in April 2019, but as previously noted, the data pool for this month was smaller and is not comparable. The lowest total haul of white belly shrimp was recorded in January 2020 with 181 kilograms (399 pounds), while the greatest total haul was in May 2019 with 2,556 kilograms (5,635 pounds).

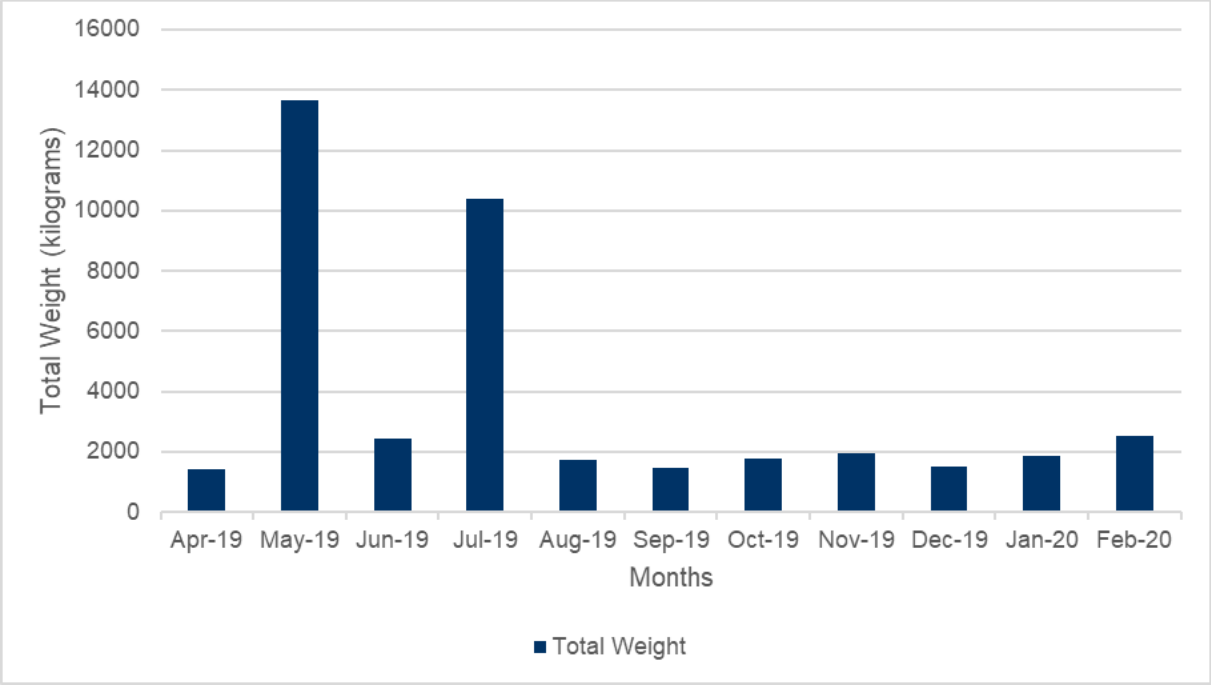


Figure M-4: Total Weight of Species Recorded by the Windsor Forest Onboard Supervisor

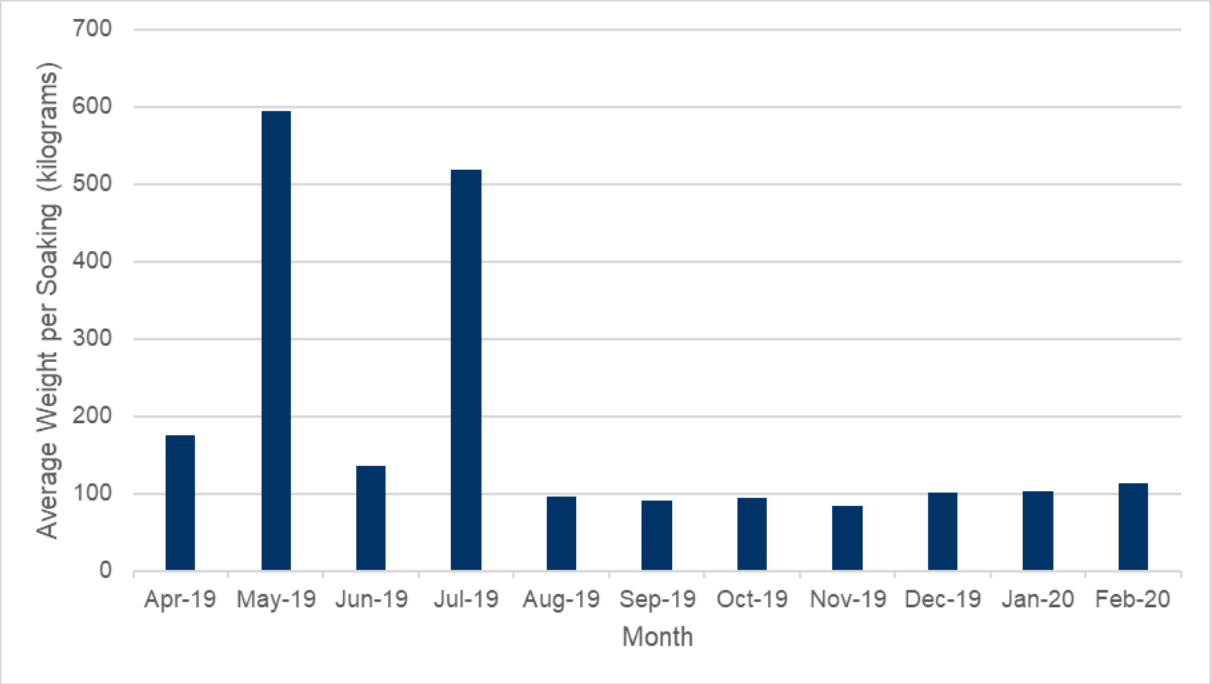


Figure M-5: Average Weight per Soaking Recorded by the Windsor Forest Onboard Supervisor

Seasonal comparisons of effort expended by the onboard supervisor and the hauls recorded are as follows:

- In the May to September 2019 good season, the total weight was 29,682 kilograms (65,438 pounds), with 683 hours spent at sea. On average, soaking of the seine during this period yielded 287 kilograms (633 pounds). In addition, the two most productive months, May and July, were part of this season.
- In April 2019 and the October 2019 to February 2020 hard season, the total weight was 11,044 kilograms (24,347 pounds) with 742 hours spent at sea. On average, soaking of the seine during this period yielded 112 kilograms (247 pounds).

Additional seasonal trends at this landing site are as follows:

- In August to October 2019, the primary dry season and the closed trawl season, the total weight was 4,972 kilograms (1,095 pounds) with 362 hours spent at sea. On average, soaking of the seine in this period yielded 94 kilograms (207 pounds).
- In February 2020 and April 2019, 2 months of the secondary dry season, soaking of the seine during this period yielded, on average, 145 kilograms (320 pounds). Total effort and hauls could not be accurately presented for this period because the data pool for April 2019 (having commenced on 16 April) is relatively small and data were not collected for March 2020 to complete this season.
- In the January to February 2020 and April 2019 period, which is the first shrimp spawning season, soaking of the seine during this period yielded, on average, 131 kilograms (289 pounds). Similarly, total effort and hauls were not presented for this period because the data pool for April 2019 is relatively small and data were not retrieved for March 2020 to complete this season.

- In the June to July 2019 period, which is the second shrimp spawning season, the total weight was 12,826 kilograms (28,276 pounds) with 284 hours spent at sea. On average, soaking of the seine during this period yielded 327 kilograms (721 pounds).
- In the May to July 2019 period, the primary wet season, the total weight was 16,132 kilograms (35,565 pounds) with 139 hours spent at sea. On average, soaking of the seine during this period yielded 416 kilograms (917 pounds). In addition, the two most productive months, May and July, were part of this season.
- In November 2019 to January 2020 period, the secondary wet season, the total weight was 5,324 kilograms (11,737 pounds) with 420 hours spent at sea. On average, soaking of the seine during this period yielded 96 kilograms (212 pounds).

It is particularly illustrative of the various seine types used by the onboard supervisor that the seasonal trends aligned closely with the good and hard seasons for fishing instead of shrimping. The greatest total haul of white belly shrimp was also recorded in May 2019, at the commencement of the good season for fishing that is between the months of May to September 2019. Based on the other seasonal trends examined, the greatest productivity was observed in the wet seasons May to July 2019 and second spawning season June to July 2019. The greatest effort was expended in the secondary wet season November 2019 to January 2020, while the lowest effort was expended during the primary wet season May to July 2019. However, it should be noted that the second spawning season significantly overlaps with the primary wet season. Productivity also peaked in May and July 2019 at the La Grange landing site (Region 3) where Cadell lines are the principal fishing methods used.

Increased productivity during the wet seasons may also be related to the proximity of the fishing grounds to the mouth of the Demerara River. In the May to July primary wet season, increased nutrients flow from the mouth of the Demerara River and may influence the feeding behaviors of fishes by attracting greater quantities of fishes to these areas, leading to increased productivity.

2.4 Biometrics

The onboard supervisor measured the average lengths and weights of representative fishes of the species caught per fishing trip. Annual average lengths and weights indicate that both mature and immature fishes were caught (Figure M-6). The mature species included gillbacker, cuirass, trout, highwater, cuma cuma, and sea catfish that had annual average lengths of 71, 64, 57, 51, 29, and 29 centimeters, respectively. These fishes were likely caught by fishing methods other than the Chinese seine, as generally the mesh sizes of 2.5 to 10 centimeters (1 to 4 inches) would have been too small to allow for capturing the larger fishes. In addition, with annual average lengths of 8 centimeters and 5 centimeters, netly and mullet were considered to be mature. Finally, the annual average lengths of bangamary indicate that these fish were sexually mature. However, the annual average lengths of small banga demonstrated that the fishes classified were juveniles. Based on observations by the study team, small fishes discarded as bycatch were principally juveniles of their species.

The average monthly lengths of bangamary, sea catfish, and cuirass caught over the study period were all considered mature (see Figure M-7). However, the sizes of these fishes were observed to increase as the year progressed with the largest fishes all caught in the hard season. This is unusual and does not follow the trend observed at other landing sites where larger fishes are observed in the July to September spawning season, following which size decreases. The onboard supervisor from the La Grange landing site (Region 3) also recorded the largest sea catfish (caught from Cadell lines) in February 2020. Size increases for cuirass as the year progresses could be attributed to their seasonality, as the mating season for these fishes is during the secondary wet season. Further research is required to ascertain why

size variability of fishes caught at this landing site was not consistent with seasonal patterns observed elsewhere.

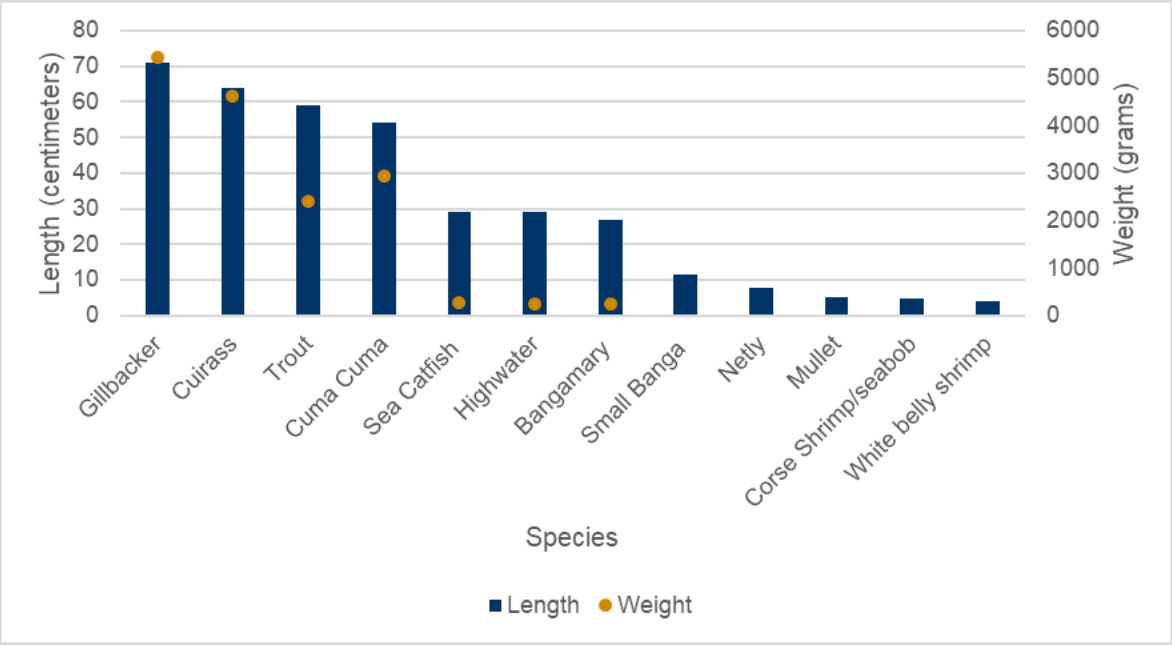


Figure M-6: Average Length and Weight of Fishes Caught by the Windsor Forest Onboard Supervisor

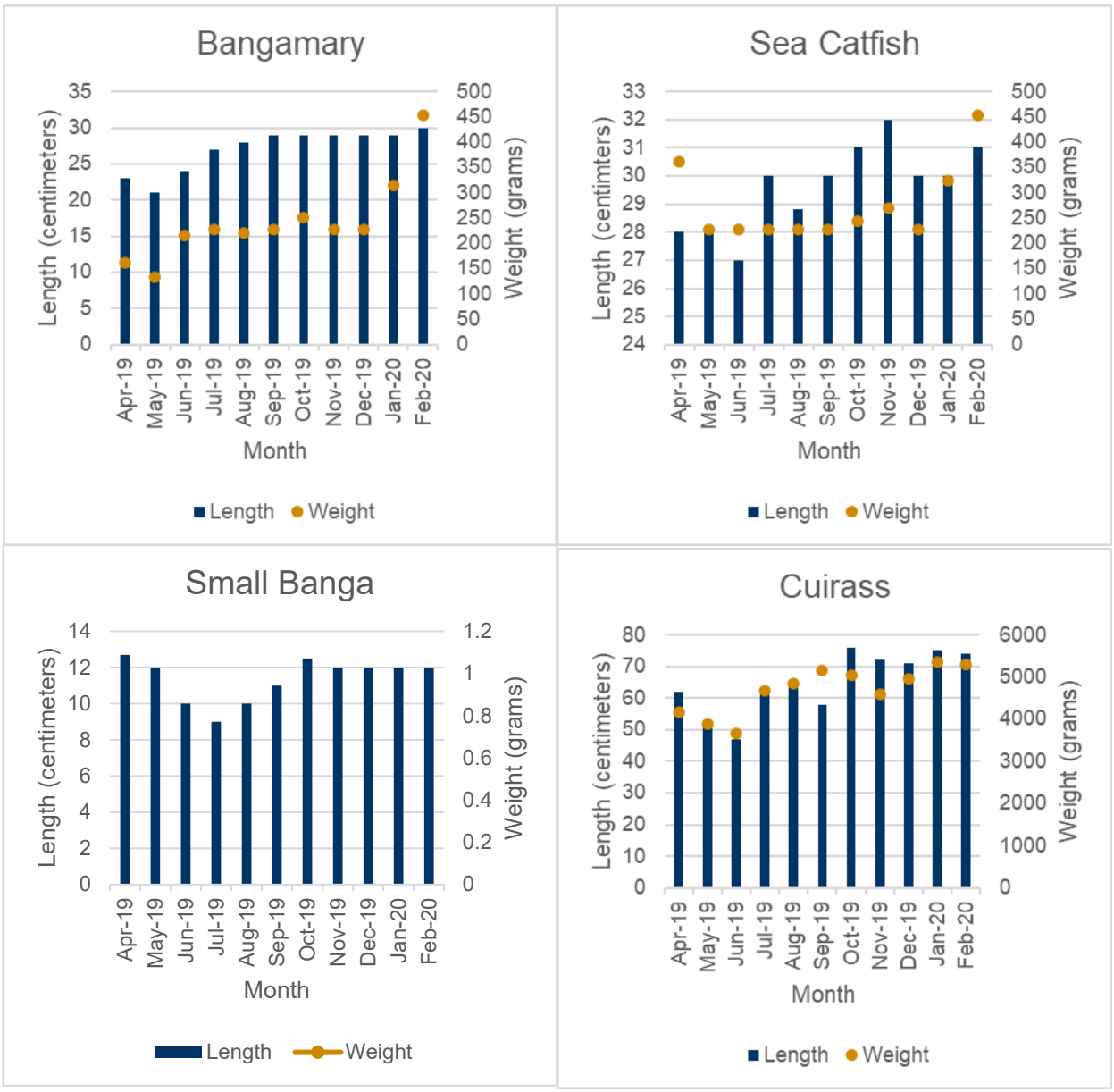


Figure M-7: Monthly Average Length and Weight of Most-Caught Species by the Onboard Supervisor[3]

3 QUALITY ASSURANCE/QUALITY CONTROL DATA

During the first quality assurance/quality control (QA/QC) exercise conducted in September 2019, one of the fishing trips conducted by the onboard supervisor's vessel was assessed. During the trip, the vessel used an outboard engine of 40 hp and spent 12 hours at sea. During the time at sea, the Chinese seine was soaked one time. The species diversity for the trip was five (Figure M-8), which was lower than the species that were reported caught during the July to September reporting period. Most of the species caught were fishes and this is similar to the trends observed in the data collected for the July to

[3] Weights of individual Small Banga are too low to be measured with the scales used by the field team.

September study period, where fishes comprised the majority of the haul. However, the study coordinator observed that juveniles of four different species were categorized as small banga by the onboard supervisor. These species were snapper, bangamary, butterfish, and Chinese butterfish juveniles. As seen on Figure M-9, the fishes collectively referred to as small banga were extremely small as biometric measurements conducted by both the onboard supervisor and the study coordinator recorded lengths of less than 10 centimeters. The bycatch caught was not brought to shore as sorting or "picking" of the commercial species from bycatch was done offshore on the vessel.

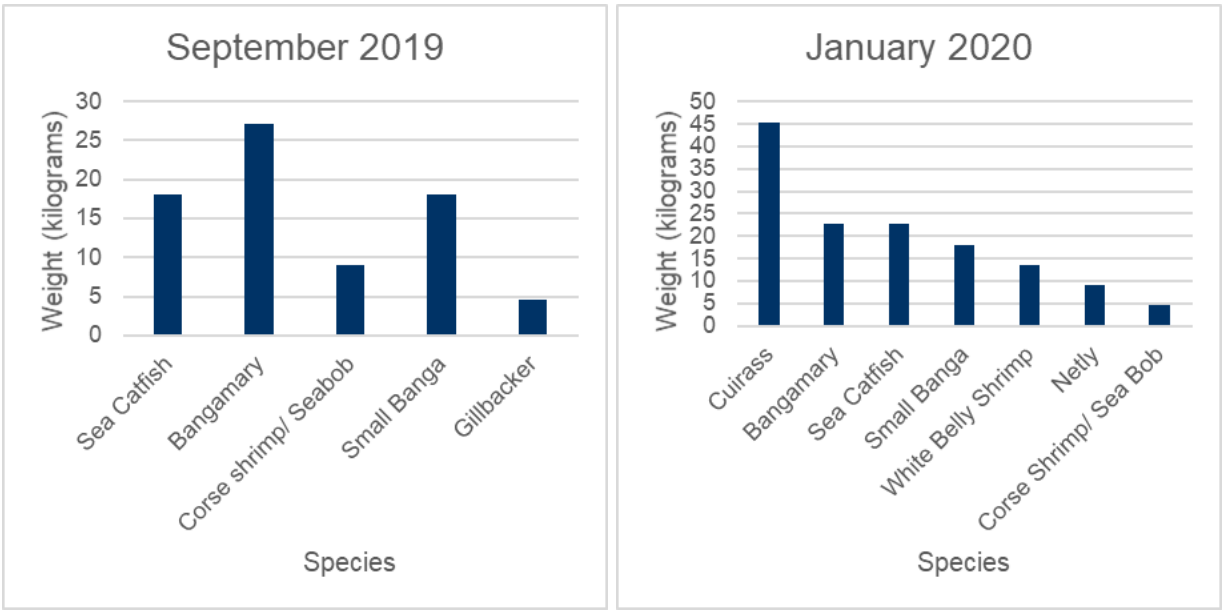


Figure M-8: Catch Composition of Commercially Viable Species during the QA/QC Exercises

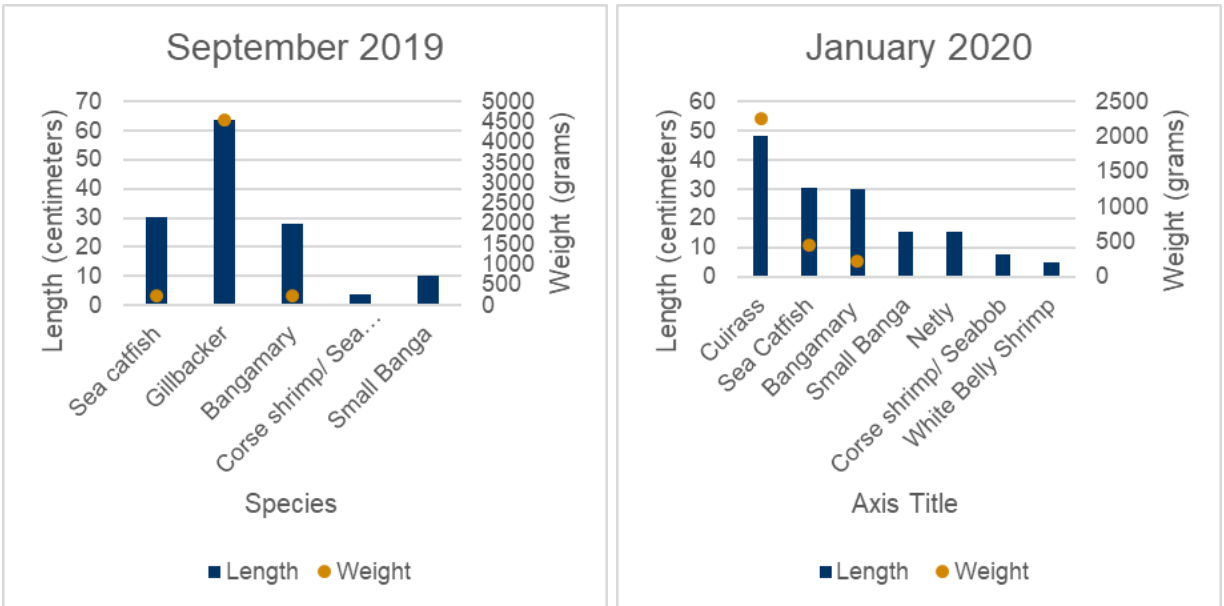


Figure M-9: Lengths and Weights of Species Measured during the QA/QC Exercises

During the second QA/QC exercise in January 2020, a GoPro camera was mounted on the onboard supervisor's vessel (see Figure M-10). Several key observations were made from the video monitoring:

- Similar to the onboard supervisor at the Ogle landing site (Region 4), Chinese seine fishing was complemented by the use of Cadell lines. This accounts for the relatively high catch percentage of sea catfish in the onboard supervisor's hauls.
- The vessel took 1 hour to travel from the Windsor Forest landing site to the Chinese seine pen used on the day that the QA/QC exercise was conducted. However, while en route to the pen, the supervisor stopped to soak the approximately 100 Cadell lines approximately 15 minutes away from where the Chinese seine was soaked.
- The Chinese seine was soaked for 3 hours while the Cadell lines were soaked for 6 hours.
- A large amount of bycatch comprised principally of jelly fishes and silverbelt and other species of mainly juvenile fishes was "picked" from the commercial haul while at sea. The supervisor carried a sorting board on the fishing trip that was used to sort the fishes. All bycatch was thrown into the sea.
- A total of seven commercially viable species were caught, most of which were fishes. Only two species, sea catfish and cuirass, were caught using the Cadell lines. This is consistent with the findings of the first QA/QC exercise and the catch composition reported by the onboard supervisor.
- Similar to the Ogle landing site (Region 4), when the bycatch is thrown into the sea, a number of sea birds would come to the area to feed.

In total, the supervisor collected 136 kilograms (79 pounds) of haul during the second QA/QC exercise. This was 28 kilograms (62 pounds) greater than the average catch recorded by the supervisor in January 2020. In addition, white belly shrimp accounted for 11 percent of the total haul, similar to the findings of the QA/QC exercise at Zeeburg landing site (Region 3). The onboard supervisor indicated that the productive season for white belly shrimp was expected to commence soon.

From the biometric data collected, the data collected by the onboard supervisor in January 2020 aligned completely with that collected during the QA/QC. Average lengths of bangamary were 29 centimeters based on data collected by the onboard supervisor and 30 centimeters during the QA/QC exercise. Sea catfish measured 30 centimeters in both instances. However, small banga and cuirass measured during the QA/QC exercise were 12 and 75 centimeters, respectively, compared to average lengths of 15 and 59 centimeters based on data collected from the supervisor. However, this variance is not a cause for significant concern. Overall, the study coordinator was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

Figure M-10: Mounting the GoPro Camera on the Onboard Supervisor's Vessel at the Windsor Forest Landing Site

APPENDIX N RIVERVIEW (UNITY, MAHAICA) (REGION 4)

1 LANDING SITE OVERVIEW

Riverview (Unity, Mahaica) is one of the largest landing sites in Region 4. Fisherfolk estimate that approximately 30 vessels, all of which are outboard cruisers equipped with engines ranging from 5 to 48 hp, utilize this landing site. Most vessels use drift seines with mesh sizes of 7 centimeters (2.75 inches), known as bangamary seines, to target bangamary. A few vessels use drift seines with mesh sizes of 10 centimeters (4 inches) to target snapper. In addition, some vessels use both types of seines on an alternating basis. Approximately 0.5 kilometer west of the main landing area is another site on the foreshore used primarily for boat building and repairs, and infrequently as a landing area.

Vessels from this landing site fish along the coast of Regions 4 and 5. Generally, larger vessels have engines of at least 40 hp and make fishing trips that last for up to 3 days. These vessels also use drift seines of 10 centimeters (4 inches) to target trout and to a lesser extent snapper. By contrast, smaller vessels have engine sizes of less than 40 hp and make trips lasting approximately 12 hours using bangamary seines. Depending on the engine size of the vessel, fishing occurs approximately 1 to 25 kilometers from the coastline at depths of 2 to 28 meters. Seines are soaked from 3 to 10 hours per fishing trip. Typically, the larger vessels expend more effort per fishing trip by traveling farther offshore and spending longer at sea. These vessels also target higher-value species like snapper and trout.

Fisherfolk indicated that the main challenges they encounter are rough seas, sharks destroying seines when they are set, and conflicts with trawlers that at times sail over seines, which destroy them, cause loss of catch, and require significant seine mending. Fisherfolk have contended that trawlers intentionally destroy seines because they compete for preferred fishing grounds.

2 REGIONAL SUPERVISOR RESULTS

At the outset of the project, fisherfolk were reluctant to volunteer as regional and onboard supervisors citing various reasons, foremost of which was the belief that the data collected could be used to adversely affect fishing activities at the landing site. One regional supervisor was selected to participate in the study but challenges occurred when the study team determined that the regional supervisor was falsifying data, with the consequence that data collected during July to early September were not credible. As such, this final report does not include data for the July to September period as collected by the regional supervisor. Another volunteer was trained as the regional supervisor and data collection resumed in October of 2019.

2.1 Effort and Haul

Over the periods for which data were collected, an average fishing trip lasted 43 hours from April to June, 2019, and 31 hours from October 2019 to February 2020 (Figure N-1). The greatest effort was expended in April 2019 when a fishing trip lasted for more than 2 days on average. Lower effort was consistently expended during the October 2019 to February 2020 period when a fishing trip lasted for approximately 30 hours on average. The increased effort in the April to June is attributed to calmer waters during this period that allowed fisherfolk to stay out longer at sea.

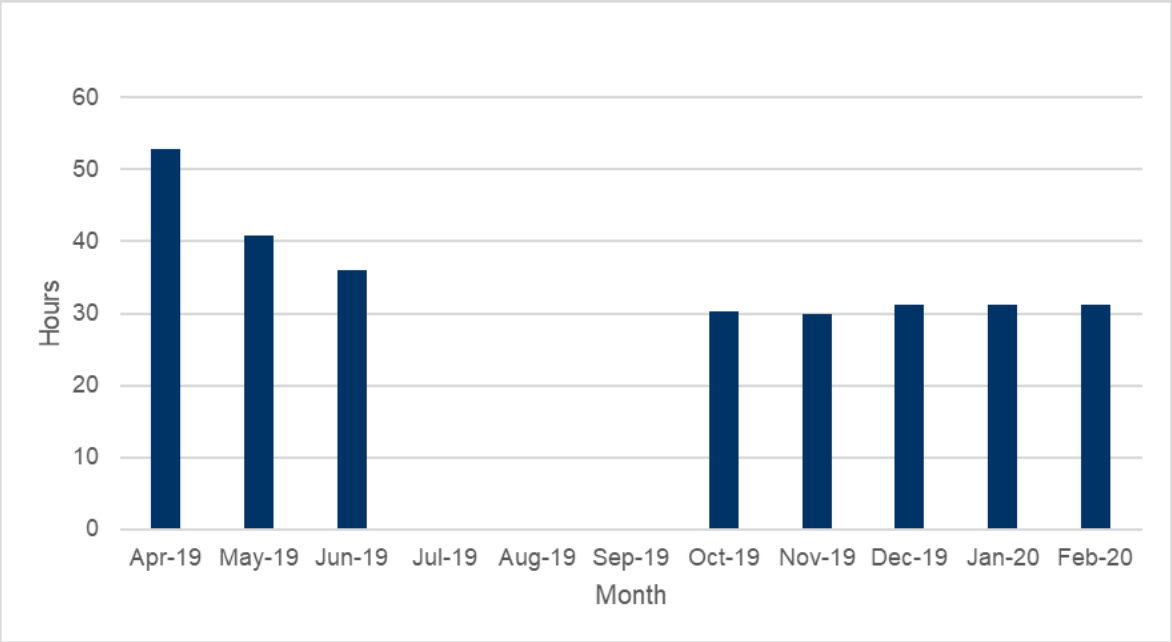
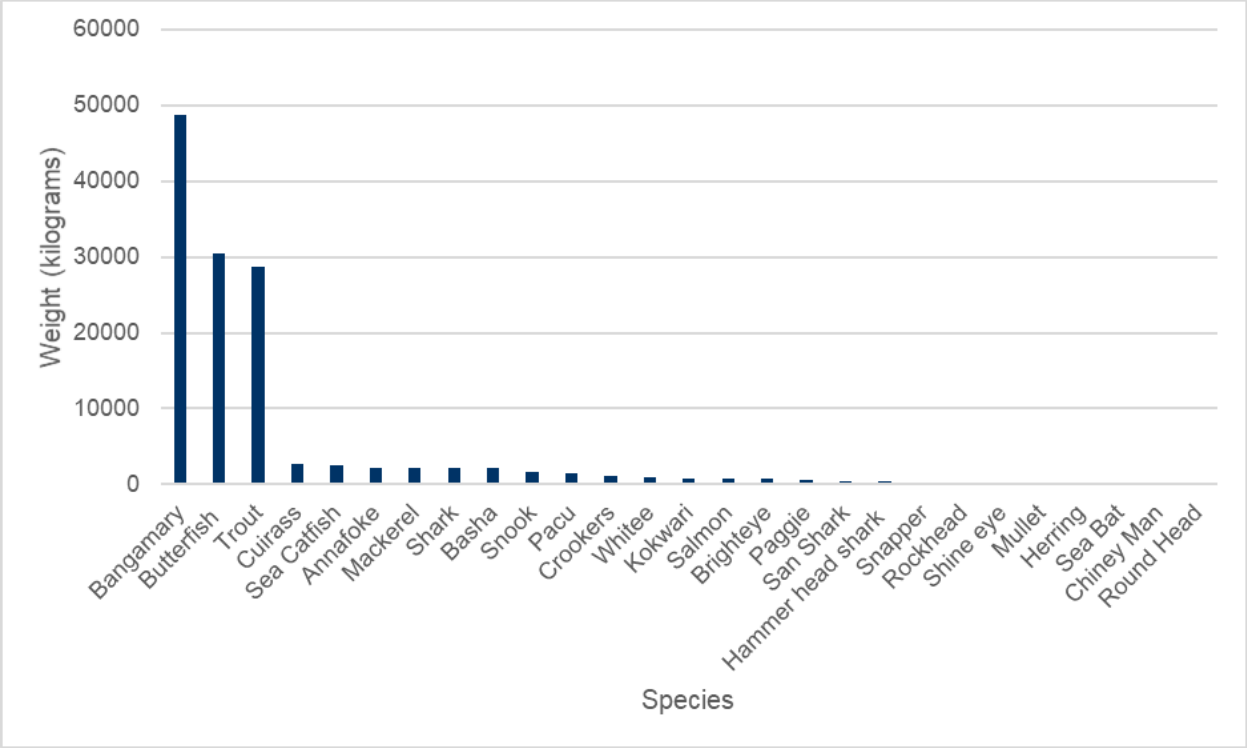


Figure N-1: Average Monthly Fishing Effort at the Riverview Landing Site

Based on the data collected by the regional supervisor, 54 different species of fishes were caught with a total weight of 133,977.5 kilograms (295,369 pounds). If data were included for the July to September period, it is expected that the total weights of fishes caught would have significantly increased. As seen on Figure N-2, bangamary was the most abundant species caught by weight with a total of 48,719 kilograms (107,407 pounds) taking up 36 percent of total haul. The second and third most abundant species caught were butterfish and trout with total weights of 30,532 kilograms and 28,765 kilograms (67,312 pounds and 63,416 pounds), respectively which represented 23 and 21 percent of total weight of fishes caught at this landing site. This pattern was expected, as bangamary is overwhelmingly the most abundant species caught in “bangamary seines”, followed by smaller quantities of butterfish and trout. A similar species distribution is also observed in data collected by the onboard supervisor at this landing site and by the regional supervisor at the Mahaicony Bridge landing site (Region 5) where data were reported exclusively for hauls from bangamary seines. Cuirass was the fourth most abundant species caught at the Riverview landing site. However, with total weights of 2,626 kilograms (5,789 pounds), it was caught in significantly lower quantities than bangamary, butterfish, and trout.



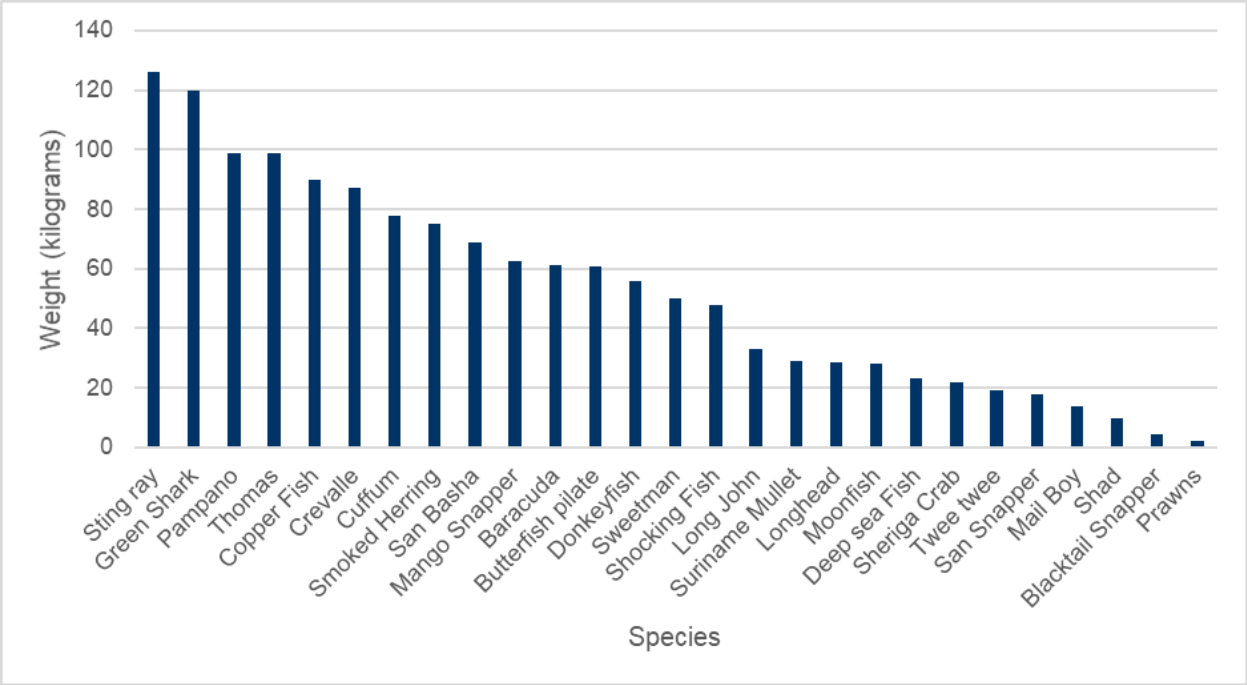


Figure N-2: Total Weight of Species Caught at the Riverview Landing Site

2.2 Target Species and Diversity

Although a total of 54 commercial species were caught at this landing site, 36 were caught in low quantities with an aggregated total weight of 500 kilograms (1,102.3 pounds), several of which were not reported at any of the other landing sites included in the study. Moreover, multiple species within a single

species group were also reported at this landing site. For example, several species of snapper were reported including (grey) snapper, mango snapper, san snapper, and blacktail snapper. Similarly, several species of shark were reported including green shark, sand shark, other shark species (includes several species, including blacktip shark at this landing site, which is an endangered, threatened, or protected species), and hammerhead shark (some species of which are classified as vulnerable by the IUCN). Species of shark caught at other landing sites were not reported and the species reported by the Riverview regional supervisor are likely representative of species commonly caught by artisanal fisherfolk elsewhere. Stingrays, some endangered, threatened, or protected species, were also recorded in the hauls.

Nearshore species, such as pacu, and species found on mudflats, such as sheringa crabs, were also reported in the hauls from this landing site. No gillbacker was reported at this landing site and the reason for this is not clear. Large quantities of bycatch were not reported at this landing site and this may be attributed to the relatively large mesh sizes of the seines used.

Species diversity of hauls was observed to change seasonally with a greater number of species caught in the October 2019 to February 2020 period, than in the April to June 2019 period (Figure N-3). This may be attributed to changed fishing practices during the hard season from October to February 2020 and the good season in April to June 2019. In particular, hauls in the hard season included fishes typically caught farther offshore, such as sand sharks, green sharks, and deep-sea fish compared to fishes reported in the good season. By contrast, in the good seasons, fisherfolk have reported achieving optimum hauls without needing to travel as far offshore. Seasonal variations in the productivity at the landing site are discussed further below. The seine size, which is considered a mid-range size, allows for a wide variety of fishes of varying sizes to be caught. Moreover, like Smith's Creek and Morahwanna, several migratory species were caught during October 2019 to December 2019 including pompano, moonfish, and chiney man. These migratory species were only reported by the regional supervisors at this landing site, and at Smith's Creek and Morahwanna.

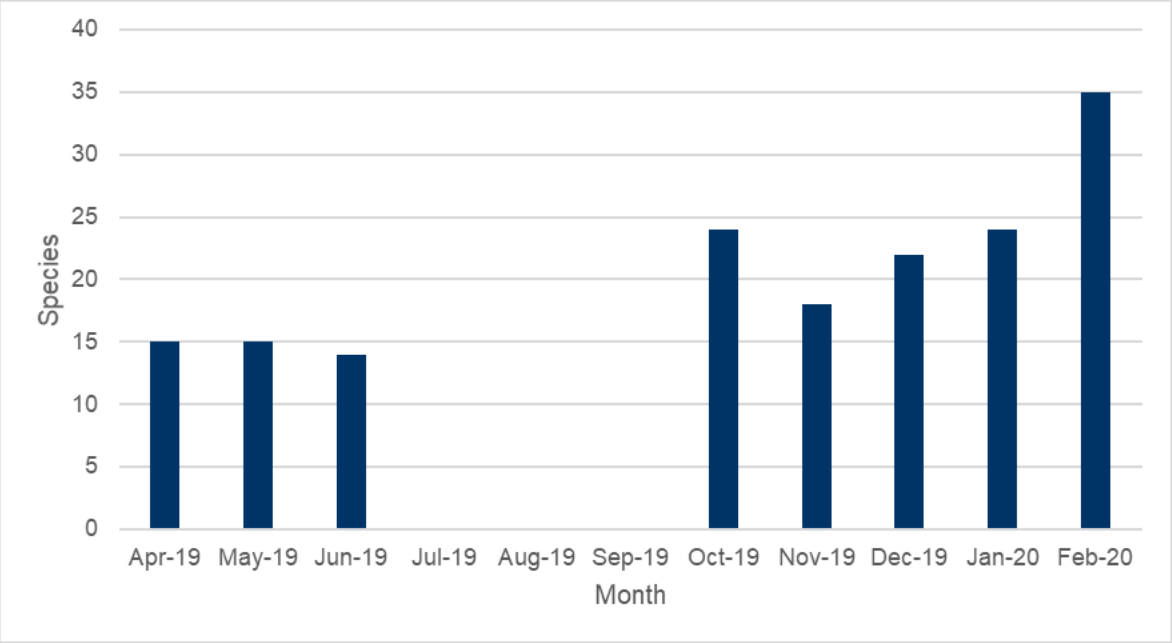


Figure N-3: Species Diversity at the Riverview Landing Site

2.3 Seasonal Productivity

As previously discussed, fisherfolk contend that the peak season for fishing activities occurs from May to September and the off-peak season from October to April. Although there is a data gap for July to September 2019 at this landing site, this seasonal variation in productivity appears to hold true for this landing site (Figure N-4). Average productivity consistently increased from April to June 2019 with a peak in June. Based on data available, average productivity sharply declined from October 2019 to February 2020. Overall, combined average productivity for the 2-month period of May to June 2019 was 1,499 kilograms (3,305 pounds) and was higher than combined productivity for the 6-month period of October 2019 to February 2020 and April 2019, with 1,389 kilograms (3,062 pounds). If data were available for July to September 2019 (the remaining months of the good season) the difference in productivity would likely have been significant. Seasonal productivity at this landing site has no discernible trend based on Guyana's wet and dry seasons and the data gap for July to September 2019 hinders a robust comparative analysis.

It should be noted that data collected by the onboard supervisor at this landing site (Section 4.2), showed a similar trend of consistently increasing productivity from April to June. For the onboard supervisor, this was followed by a peak in July 2019 after which productivity sharply declined and remained low until February 2020. Most vessels at this landing site would likely have adhered to this trend, and productivity at the landing site would have peaked in July 2019. Additional data are required to better understand seasonal productivity of fishing activities at this landing site.

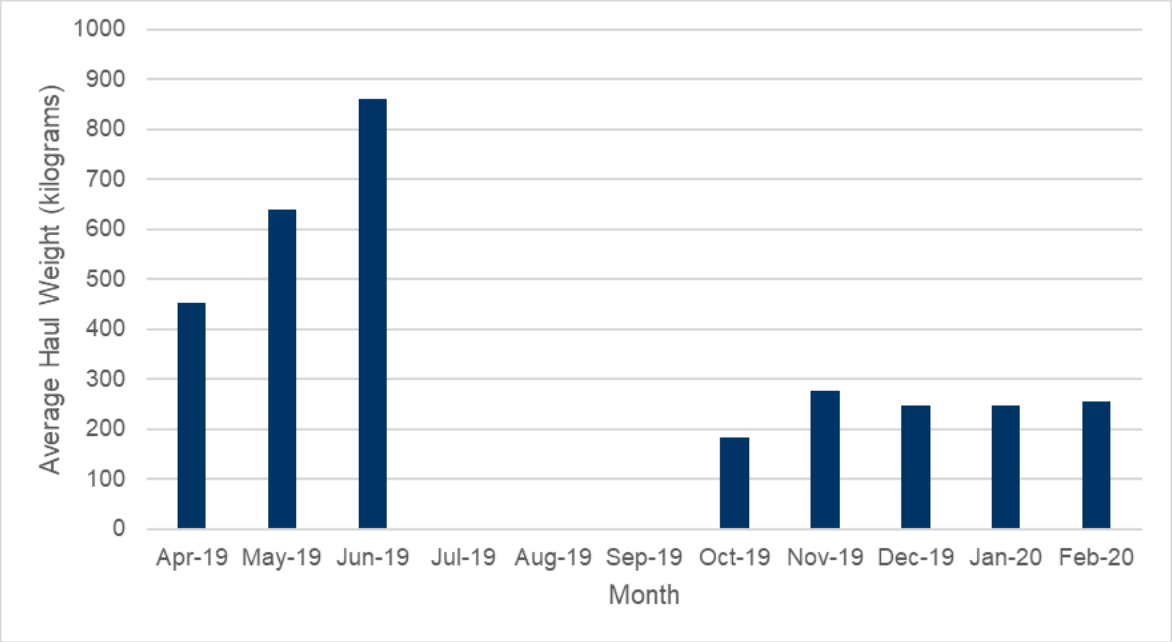


Figure N-4: Average Monthly Productivity of Fishing Trips at the Riverview Landing Site

2.4 Prices and Markets

Similar to most of the landing sites in the study, snapper are the highest-value fishes at this landing site. Based on the data collected by the regional supervisor, the blacktail snapper was the highest-value species with an annual average price of $750 GYD per kilogram ($3.60 USD per kilogram) as seen on Figure N-5. This was the least abundant species caught with a total haul weight of 4.5 kilograms

(10 pounds) during the 8 months for which data were collected, and this may have also contributed to the high price at which it was sold. Grey snapper, commonly referred to as snapper, was the second highest-value species with an annual average price of $679 GYD ($3.30 USD). The two other snappers, the mango snapper and san snapper, were recorded by the regional supervisor and were medium-value species with annual average prices of $191 GYD ($0.90 USD) and of $132 GYD ($0.60 USD), respectively.

Species valuation at this landing site is also demonstrably different than from those at other landing sites. Sea bats, which would not be considered commercially viable at most of the landing sites in the study, were the fourth highest-value species with an annual average price of $661 GYD ($3.20 USD). Sharks were also highly valued at this landing site with the green shark being the third highest-value species with annual average prices of $390 GYD ($1.90 USD). Sand shark and hammerhead shark were also high-value species, and the blacktip shark was an upper medium-value species. This is uncommon as sharks were low-value species at other landing sites where it was reported such as Smith's Creek and Morahwanna (Region 1); Charity (Region 2); and Mahaicony Bridge (Region 5) where annual average prices were $157 GYD ($0.8 USD); $129 GYD ($0.6 USD); and $216 GYD ($0.96 USD), respectively. Bangamary, the target species of most fisherfolk at this landing site and the most abundant species caught, was a medium-value species with annual average prices of $223 GYD ($1 USD). The two secondary target species, butterfish and trout, were more highly valued with annual average prices of $345 GYD ($1.70 USD) and $620 GYD ($3 USD). Although glue from trout and snapper are high value and high demand, there is no established market for these by-products at this landing site because fishes are typically sold un-gutted. Approximately 14 species were low-value at this landing site with annual average prices of less than $100 GYD ($0.48 USD) per kilogram, all of which were also infrequently caught. In total, fishes sold at this landing site were valued at $45,323,998 GYD ($217,904 USD).

Fishes landed at this site are sold to trucks that visit the landing site on a daily basis. Vendors from these trucks typically buy the target species of bangamary, butterfish, and trout, and high-value species such as snapper and shark. Vendors both export fishes and sell in local marketplaces. Locals from Riverview and other neighboring communities also visit the landing site to purchase fishes directly from fisherfolk when the vessels land. Although 54 species were considered to be commercially viable by fisherfolk, there were only markets for 50 species. Species for which there were no markets included sheringa crabs, donkey fish, prawns, and stingrays. Although there were also no markets for stingrays at this landing site, these were sold at Smith's Creek and Morahwanna as a lower-value species in those markets. Species not sold would either be donated to locals or used by the fisherfolk who caught them.

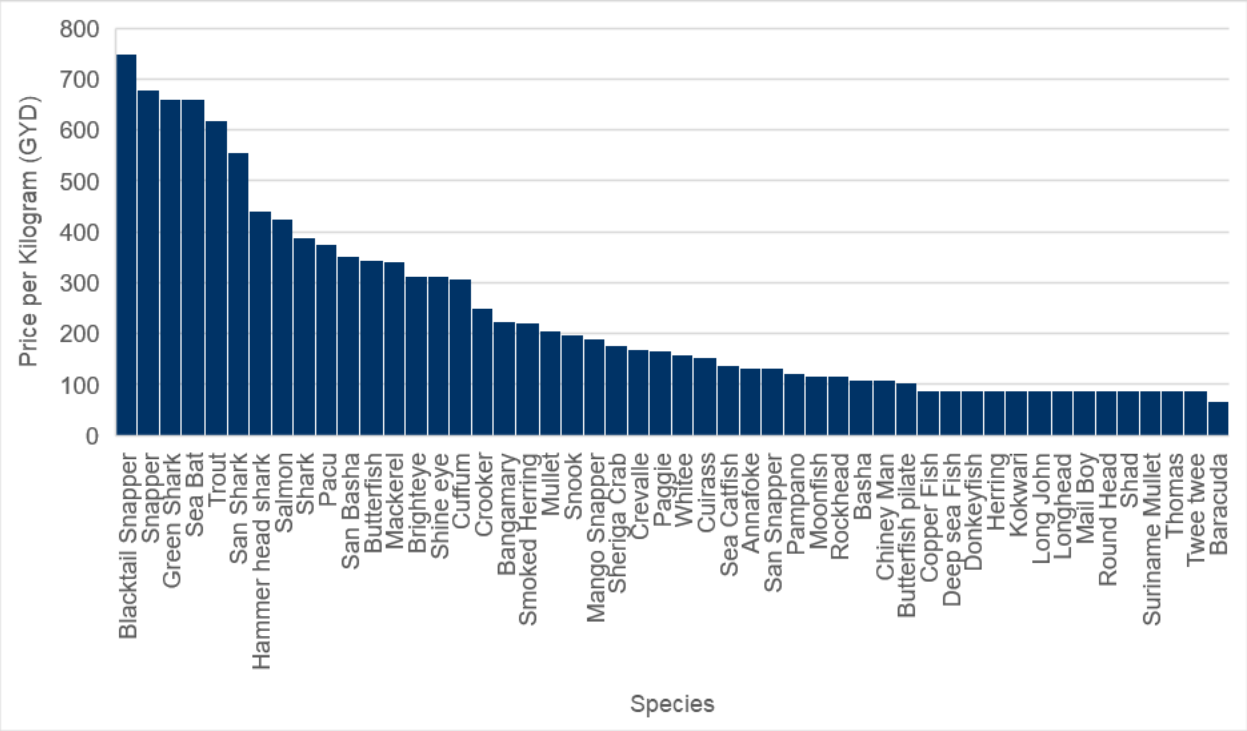


Figure N-5: Annual Average Prices of per Kilogram Fishes Sold at the Riverview Landing Site

The minimum, maximum, and average prices for the four most frequently-caught species are shown on Figure N-6. Average prices for bangamary and butterfish were relatively stable while average prices for trout and cuirass fluctuated significantly throughout the year. Most of the price variances at this site can be attributed to bargaining among fisherfolk, vendors, and local community members who visit the landing site to purchase fishes. In addition, seasonal changes in prices may be influenced by the interplay of demand and supply for fishes on a seasonal basis.

Maximum and average prices for bangamary peaked in May 2019 and subsequently dipped, remaining relatively low throughout the hard season. Similarly, the highest prices for trout were observed during the good season but then declined and remained consistently low throughout the hard season. This trend in pricing for trout was also observed at the Charity landing site (Region 2) where the lowest prices were recorded during the October 2019 to February 2020 hard season. In addition, at the Mahaicony Bridge landing site (Region 5), prices for trout declined after June 2019 and remained at consistently low levels throughout the year. It is likely that this was influenced by a decline in the demand for glue harvested from un-gutted trout due to an increased supply in the local markets during the peak season. Pricing in general follows demand and supply rules unless affected by fuel pricing. The demand is influenced by both international and local markets and marketing practices. Price declines for bangamary were also observed at the Mahaicony Bridge landing site (Region 5) in June 2019. This was also linked to increased supply leading to price reduction during this season.

By contrast, maximum prices for butterfish peaked in May and June 2019, and average prices remained at the highest levels during the hard season because there is greater demand for butterfish than bangamary, particularly given its relative scarcity. However, there was a sharp decline in February 2020. Prices for cuirass were significantly higher during the hard season; however, the reason for this trend is unknown.

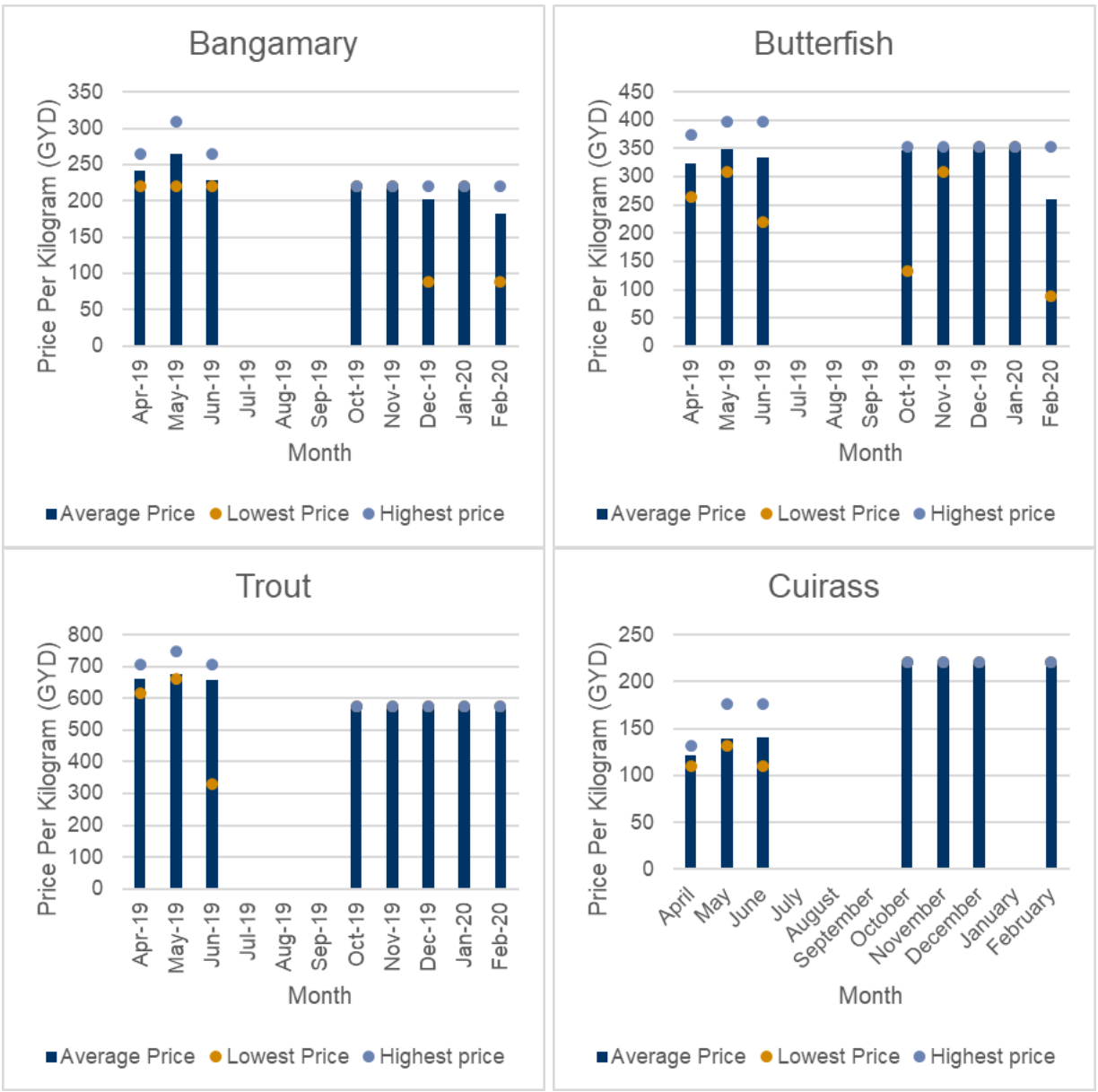


Figure N-6: Monthly Price Variations of the Four Most Abundant Fishes Caught at the Riverview Landing Site

2.5 Biometrics

The regional supervisor measured the lengths and weights of fishes that were representative of hauls for which data were collected. The annual average length and weight of these fishes are presented on Figure N-7. The largest fish caught was the blacktip snapper, which had an annual average length of 74 centimeters and annual average weight of 4,536 grams. The smallest fish species caught was the smoke herring, which had an annual average length of 20 centimeters and annual average weight of 113 grams.

Most of the species caught at this landing site had achieved sizes of sexual maturity with the exception of the shark species, all of which were immature:

- The blacktip shark, an endangered, threatened, or protected species, are sexually mature at 157 centimeters, but species recorded had an annual average length of 45 centimeters.
- The hammerhead shark, some species of which are considered vulnerable by the IUCN, are sexually mature at 90 centimeters, but species recorded had an annual average length of 42 centimeters.
- The sand shark and green shark are sexually mature at 72 centimeters and 159 centimeters, but species recorded had an annual average length of 43 centimeters and 40 centimeters, respectively.

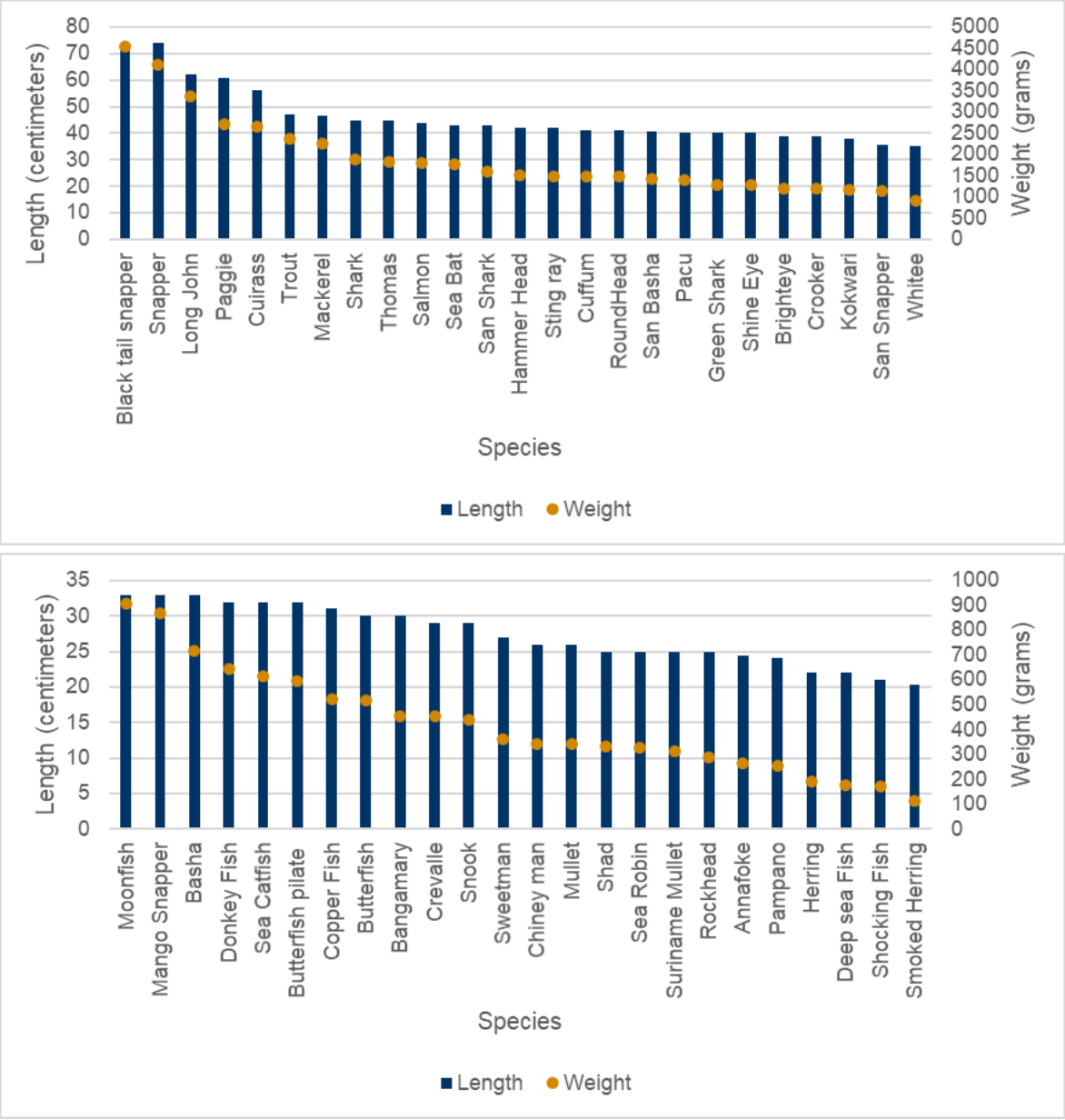


Figure N-7: Annual Average Lengths and Weights for Fishes Measured at the Riverview Landing Site

There is some variability in the monthly average lengths and weights of the four most abundant species caught (Figure N-8), but most of the species were considered sexually mature. The largest fishes of the

four most abundant species caught were recorded from April to June. Fishes were significantly smaller in the October 2019 to February 2020 period. Marginal increases in size were observed during the hard season. For example, larger fishes were recorded in November 2019 for all species but there was no common trend in size variations on a monthly basis. This is similar to the data collected by regional supervisors at the landing sites in Smith's Creek and Morahwanna (Region 1), Charity (Region 2), and Mahaicony Bridge (Region 5), all of which use drift seines in their fishing activities.

Seasonal variability in the fishing activities may be attributed to two factors. First, fisherfolk come closer to shore during the rainy seasons because nutrient flow is increased in these areas and trade winds are lower, which also supports their movement. This supports observations of larger fishes of the four most abundant species caught that were recorded in the rainy seasons for which data were collected. Regional supervisors in Regions 1, 2, and 5 also reported larger fishes caught in July and September as the good season progressed; this may be attributed to these fishes coming closer to shore to spawn in the estuaries. If data were available for the July to September 2019 period at the Riverview landing site, it is expected that it would have followed these trends of larger fishes being caught.

During the April to June 2019 period, the supervisor collected data from more vessels using drift seines with mesh sizes of 10 centimeters (4 inches) than in the October 2019 to February 2020 period when data were collected from more vessels using seines with mesh sizes of 7 centimeters (2.75 centimeters). Drift seines with larger mesh sizes capture larger fishes and this may have also partially contributed to larger fishes being reported from April to June 2019. Nonetheless, although smaller fishes were reported in the hard season, fishes were generally sexually mature.

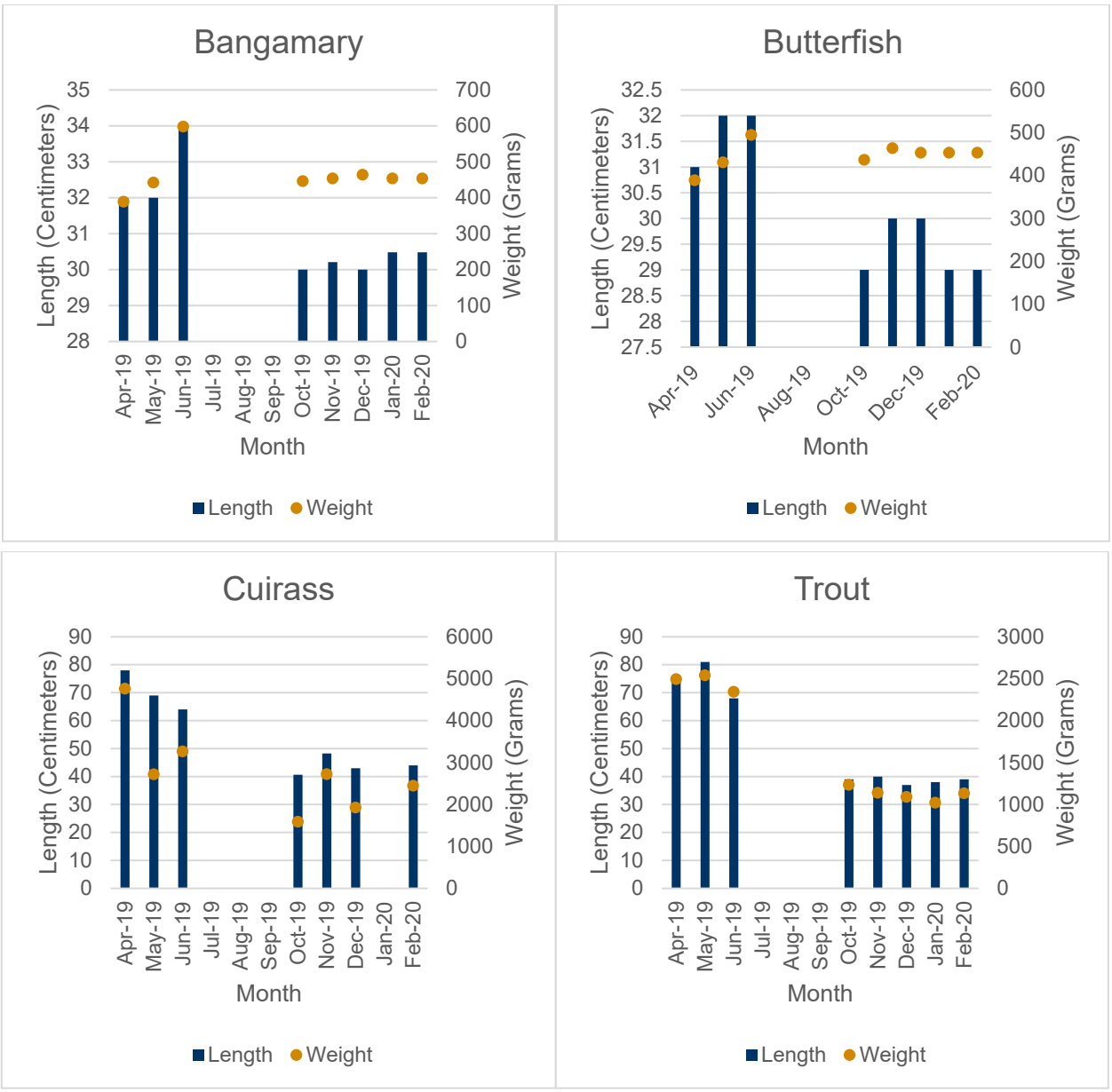


Figure N-8: Monthly Average Lengths and Weights of the Most Abundant Species Caught

3 ONBOARD SUPERVISOR RESULTS

At the outset of the project, fisherfolk were reluctant to volunteer as regional and onboard supervisors citing various reasons, foremost of which was the belief that the data collected could be used to adversely affect fishing activities at the landing site. Indeed, two individuals who volunteered as onboard supervisors and received training on data sheet completion and on the use of the GPS unit and digital camera, subsequently opted to withdraw. As a consequence, the onboard supervisor did not commence data collection until the end of April 2019.

The onboard supervisor at this site uses a drift seine with mesh sizes of 7 centimeters (2.75 inches), i.e., the “bangamary seines” to target bangamary. Typically, fishing trips last for 12 hours at sea. The vessel

has a haul capacity of 2,045 kilograms (4,508 pounds) and is powered by a 40 hp engine. Each fishing trip requires a two-member crew inclusive of the onboard supervisor. Fuel is the most significant expense per fishing trip for the onboard supervisor and generally, fishes are not iced before returning to shore. Most of the haul is sold to the vendors who visit the landing site with refrigerated trucks. During the study period, the most significant challenges faced by onboard supervisor were the proliferation of sargassum weed from February to May, which became entangled in seines resulting in reduced catch. Time is also lost as fisherfolk need to remove the entangled sargassum seaweed in seines, which is a time consuming exercise. In addition, over the months of September to November, a proliferation of 'slime' in the waters accelerated fish rot. Fisherfolk have reported that slime is commonly experienced at this landing site. Due to its role in rotting fish, slime may be bacterial, but its scientific name is unknown.

3.1 Fishing Area

The onboard supervisor has a traveling range of 1,041 square kilometers. The fishing points used by the onboard supervisor were comprised of two main clusters (see Figure N-9):

- The first cluster of points was located relatively close to the shore and covered an area of 163 square kilometers. These fishing grounds were used frequently during both the good and hard seasons. Overall, most of the fishing points in the hard season were in this cluster.
- The second cluster was located farther offshore and covered an area of 92 square kilometers. These fishing points were used mainly in the good season. Only four fishing points in this cluster were used during the hard season.

The farthest distance the onboard supervisor traveled was approximately 33 kilometers offshore during the hard season. The onboard supervisor indicated that the hauls from fishing points closer to the shore were not productive and as a result, the crew opted to brave rougher seas to fish farther offshore. The closest location to shore at which fishing occurred was 0.4 kilometer and this was also recorded during the hard season.

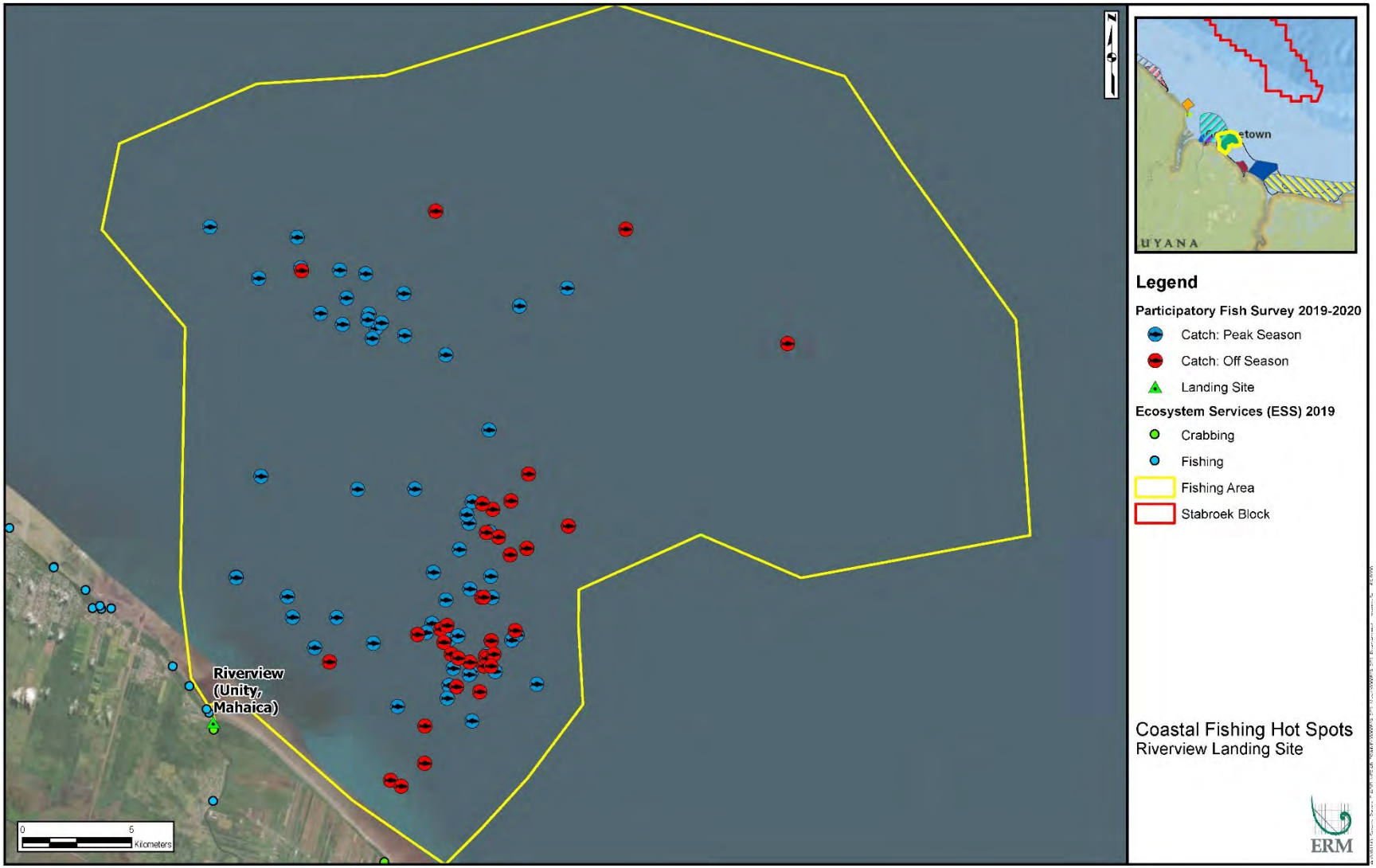


Figure N-9: Map of Fishing Area and Fishing Points Used by the Riverview Onboard Supervisor

3.2 Effort and Haul

The total weights of combined hauls from the onboard supervisor's vessel over the period April 2019 to February 2020 was 44,601 kilograms (98,328 pounds). Bangamary, the target species at this landing site, was the most abundant species caught by a significant margin (Figure N-10). The onboard supervisor caught a total of 23,936 kilograms (52,770 pounds) of bangamary representing 53 percent of the total haul. In addition, butterfish and trout were the second and third most abundant species caught with 6,379 kilograms (14,063 pounds) and 4,028 kilograms (8,880 pounds) caught, respectively. Bangamary, butterfish, and trout were also the three most abundant species caught at the Riverview landing site (as reported by the regional supervisor), and at every other landing site where the bangamary seines were used, namely Mahaicony Bridge (Region 5) and Albion (Region 6). The fourth most abundant species caught was sea catfish.

Overall, 56 different species were reported by the onboard supervisor. Of this, 47 species collectively represented less than 1 percent of the total haul. In spite of being caught in small quantities, these species are still deemed commercially viable. The onboard supervisor reported several of the species that were also reported by the regional supervisor at this landing site including several endangered, threatened, protected, and vulnerable species such as blacktip shark and hammerhead shark, and migratory species such as the moon fish and pampano. However, the onboard supervisor also caught additional species that were not reported by the regional supervisor for this landing site, such as swordfish and grouper. High-value fishes like snapper, gillbacker, and green shark were only caught in small quantities. Moreover, some of the highest-value species at this landing site like the blacktail snapper and sea bat were not caught by the onboard supervisor. The species composition showed that several smaller species were caught including annafokes, Suriname mullet, and prawns. This species diversity can be attributed both to the type of seine used and the species valuation at the landing site. Overall, given the wide range of species that are considered commercially viable at this landing site, bycatch quantities were low. When recorded, bycatch included sargassum, skates, and rays. Sea robin is also generally reported as bycatch, but is used on a subsistence basis by the onboard supervisor and other locals to whom they are donated.

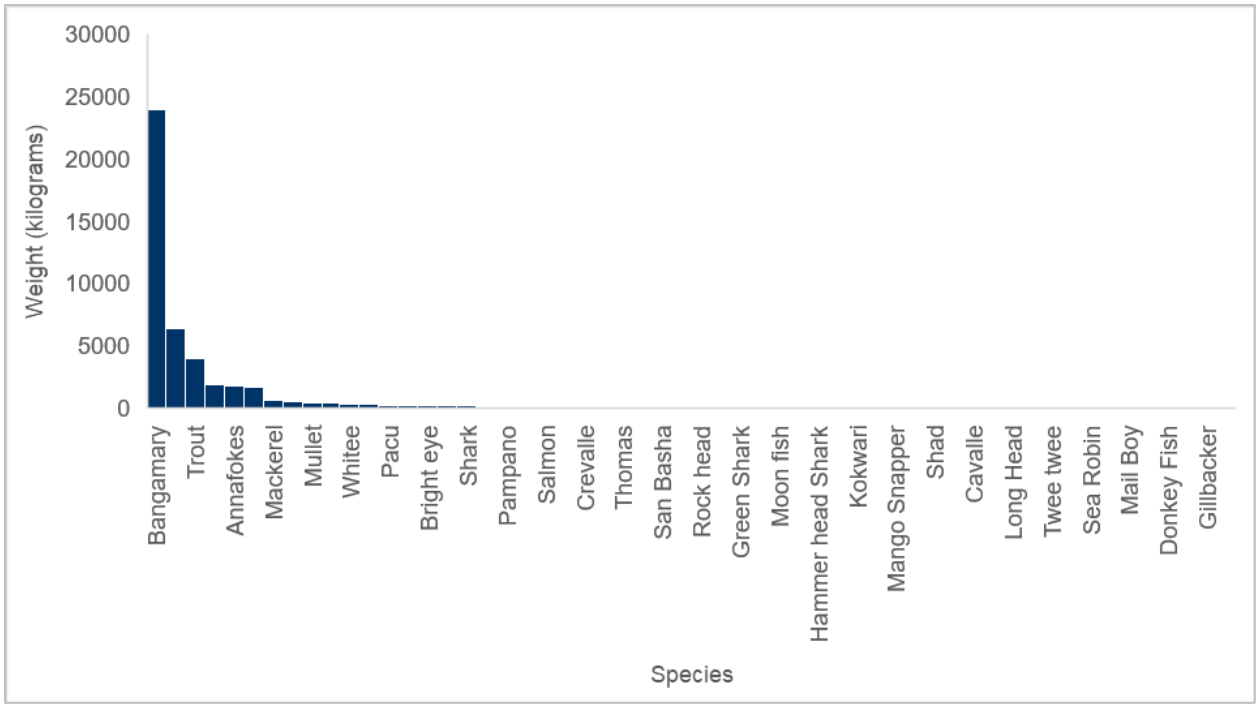


Figure N-10: Total Weight of Species Recorded by the Riverview Onboard Supervisor

3.3 Seasonal Productivity

The onboard supervisor, like the other artisanal fisherfolk included in the study, believes that there are good and hard seasons for fishing. According to these beliefs, May to September is the good season that peaks in July to September and October to March is considered the hard season. It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

During the study period, the onboard supervisor spent an average of 1,815 hours per month fishing, but the effort expended varied per fishing trip on a monthly basis as seen on Figure N-11. The onboard supervisor's monthly effort peaked in November 2019 with 210.5 hours of fishing activity. Several other onboard supervisors expended peak effort in November including at landing sites in Lima (Region 2), Windsor Forest (Region 3), La Grange (Region 3), and Ogle (Region 4). The lowest effort was expended in September 2019 when 81 hours were spent fishing. Although 13 hours were expended in April 2019, data collection did not begin until April 27, 2019, and as such, no comparable monthly data are available for this month.

As seen on Figure N-12 and Figure N-13, July 2019 was by far the most productive month when the highest average catch per soaking was 18,982 kilograms (41,484 pounds) and the greatest total monthly haul was 1,186 kilograms (2,615 pounds). The second most productive month was June 2019 when average catch per soaking was 315 kilograms (694 pounds) and total haul weight was 5,034 kilograms (11,098 pounds). Hauls in July 2019 were up to five times greater than June 2019 and over six times greater than the other months. Low hauls were consistently recorded from August 2019 to February 2020, although effort was high for most months during that period. The lowest total haul was seen in April 2019, but as previously noted, the data pool for this month is too small to be compared. Overall, the trends in productivity match those reported by the regional supervisor for this landing site. Similar to the trend

observed by the regional supervisor, hauls started to steadily increase in May and peak in July 2019. Hauls from the onboard supervisor sharply declined in August 2019 and stayed relatively low through February 2020. Trends at the landing site likely follow this pattern of low hauls over the August to September 2019 period.

Seasonal variations in effort and productivity were observed as follows:

- In the May to September 2019 good season the total weight of hauls was 30,810 kilograms (66,535 pounds) with 858 hours spent at sea. On average, soaking of the seine during this period yielded 398 kilograms (877 pounds). Total haul and average weight of hauls per soaking peaked in July 2019. In addition, May 2019 was the second most productive month. In both months, effort expended was in the upper range for this landing site with 186 hours in May and 206 hours in July. However, in September 2019, monthly effort and total haul were the lowest for the good season and were comparable to levels observed during the hard season. The reason for this dip is unknown. Similar trends were observed at the La Grange landing site (Region 3), with the key difference being that the dip in effort and productivity occurred in August 2019.

- In the October 2019 to February 2020 hard season, the total weight of hauls was 13,681 kilograms (30,161 pounds) with 944 hours spent at sea. On average, soaking of the seine during this period yielded 185 kilograms (408 pounds). Although the onboard supervisor expended the greatest effort in November 2019, total hauls and average weight of hauls per soaking declined compared to September. For November 2019, effort and total haul did not increase from October 2019, neither did it subsequently decline in December 2019. In addition, average hauls per soaking were consistently low for most of the hard season. Data for April 2019 were not considered, since the data pool is too small.

By comparison, seasonal trends in the wet and dry season were as follows:

- In the August to October 2019 period, which is the primary dry season, the total weight of hauls was 7,255 kilograms (15,995 pounds) with 443.5 hours spent at sea. On average, soaking of the seine during this period yielded 178 kilograms (392 pounds).

- In the May to July 2019 period, which is the primary wet season, the total weight of hauls was 26,477 kilograms (58,371 pounds) with 595 hours spent at sea. On average, soaking of the seine during this period yielded 555 kilograms (1,224 pounds).

- In February 2020 and April 2019, 2 months of the secondary dry season, total weight of hauls was 2,101 kilograms (4,632 pounds) with 201 hours spent at sea. On average, soaking of the seine during this period yielded 121 kilograms (267 pounds).

- In November 2019 to January 2020, the secondary wet season, total weight of hauls was 8,768 kilograms (19,330 pounds) with 575.5 hours spent at sea. On average, soaking of the seine during this period yielded 194 kilograms (428 pounds).

Based on the trends discussed above, the productivity of fishing activities was seasonal and adhered to the periods for good and hard seasons. Average haul per soakings were also greater during the good season as compared to the hard season. However, climatic seasonality also influenced productivity. The most productive seasons were the primary and secondary wet seasons. These were also the seasons in which the greatest haul per soaking and the greatest effort were expended by the onboard supervisor. This is unusual since, at most landing sites, greater productivity in the good season typically translates to the primary wet and dry seasons being the most productive.

At the landing sites in Rosignol (Region 5) and Complex 66 (Region 6), the hauls were more productive during the wet season. At those landing sites, uptick during the rainy season was likely attributed to fishing grounds being located at the mouths of rivers where feeding grounds are expected to be more fertile during the wet seasons. However, the closest major river to which the onboard supervisor fishes is the Demerara River, which is approximately 30 kilometers away. It should be noted that similar trends of productivity were not observed by the onboard supervisor from the La Grange landing site (Region 3) who utilizes fishing grounds offshore of the Demerara Rive mouth. Additional data are needed to determine whether these trends are typical for hauls from the onboard supervisor.

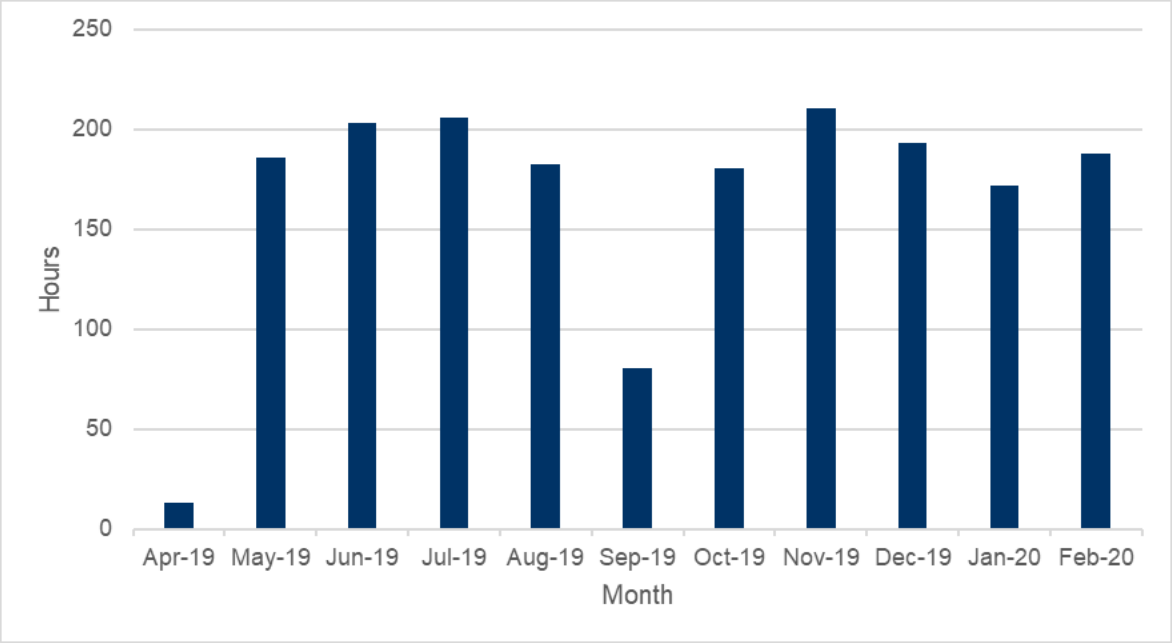


Figure N-11: Total Monthly Fishing Effort Recorded by the Riverview Onboard Supervisor

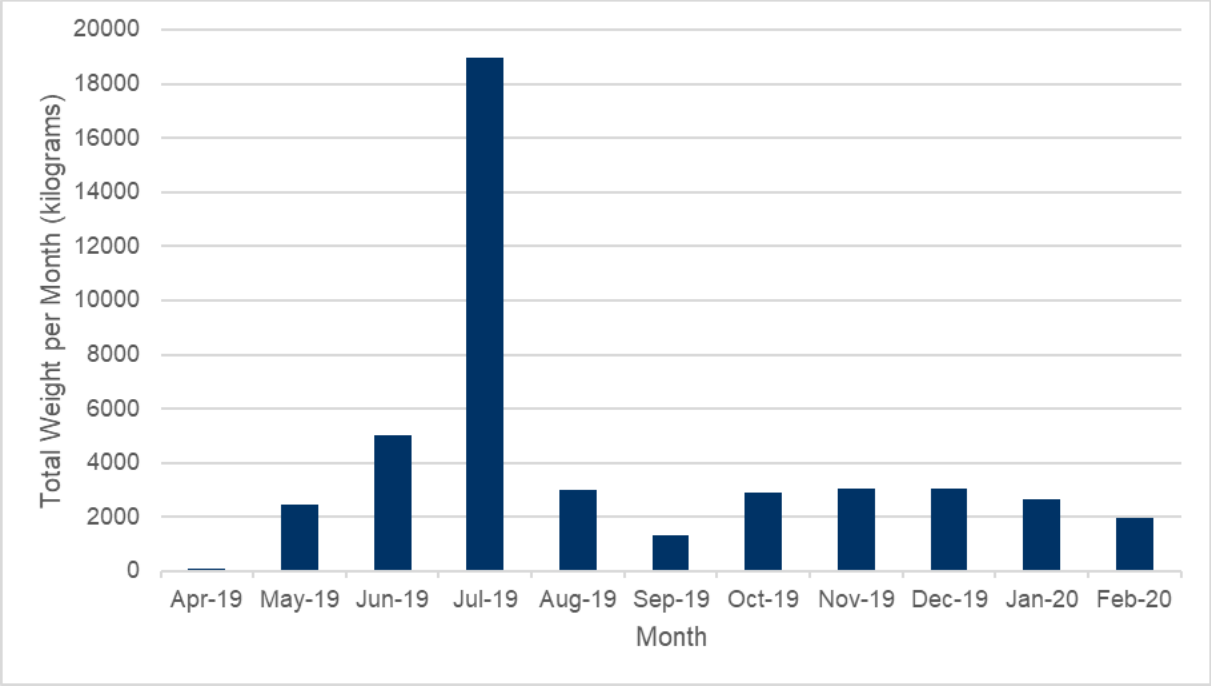


Figure N-12: Total Monthly Weight Recorded by the Riverview Onboard Supervisor

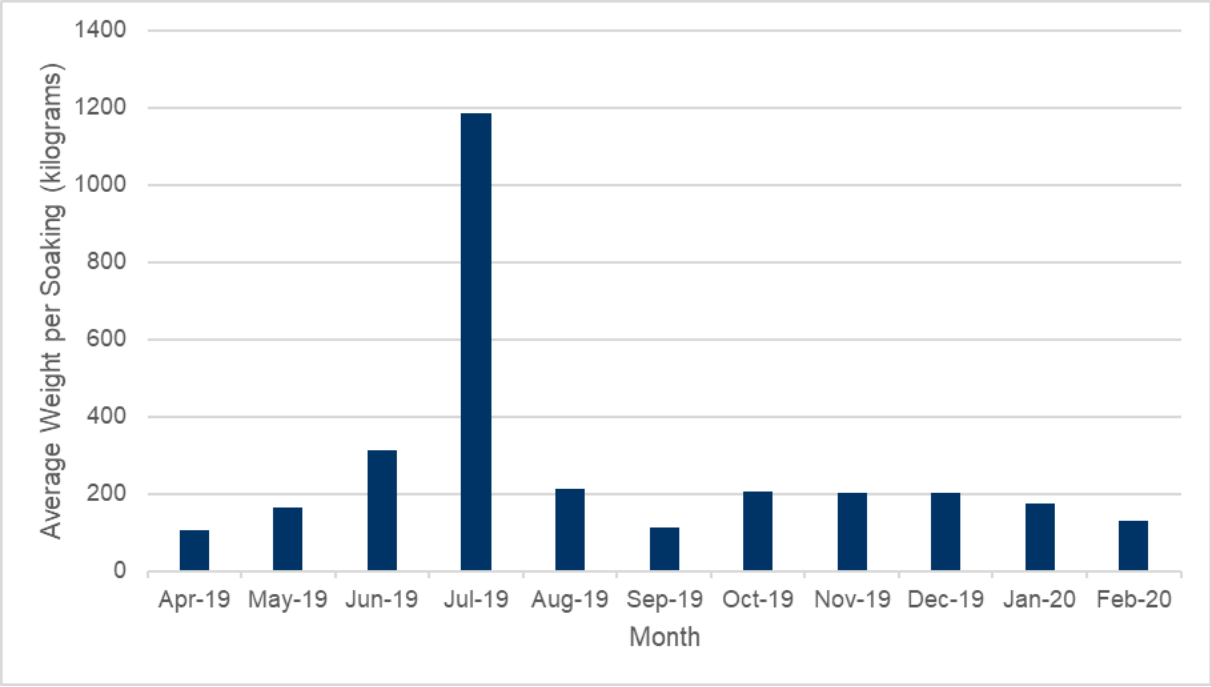


Figure N-13: Average Weight per Soaking Recorded by the Riverview Onboard Supervisor

3.4 Biometrics

The onboard supervisor measured the lengths and weights of representative fishes per each haul and the annual average lengths and weights of these fishes are shown on Figure N-14. Based on the measurements taken by the onboard supervisor, most of the fishes caught were sexually mature. In addition, there was a significant size variance of species caught with the largest being the swordfish at 71 centimeters and the smallest species was prawns at 13 centimeters. Annual average lengths of bangamary and butterfish indicate that these two species had reached sexual maturity. The annual average lengths of trout, which was the third most abundant species caught indicate that this species did not reach sexual maturity. In addition, similar to the trends observed in the data collected by the regional supervisor, all shark species recorded were juveniles of their species. All other species would be considered sexually mature.

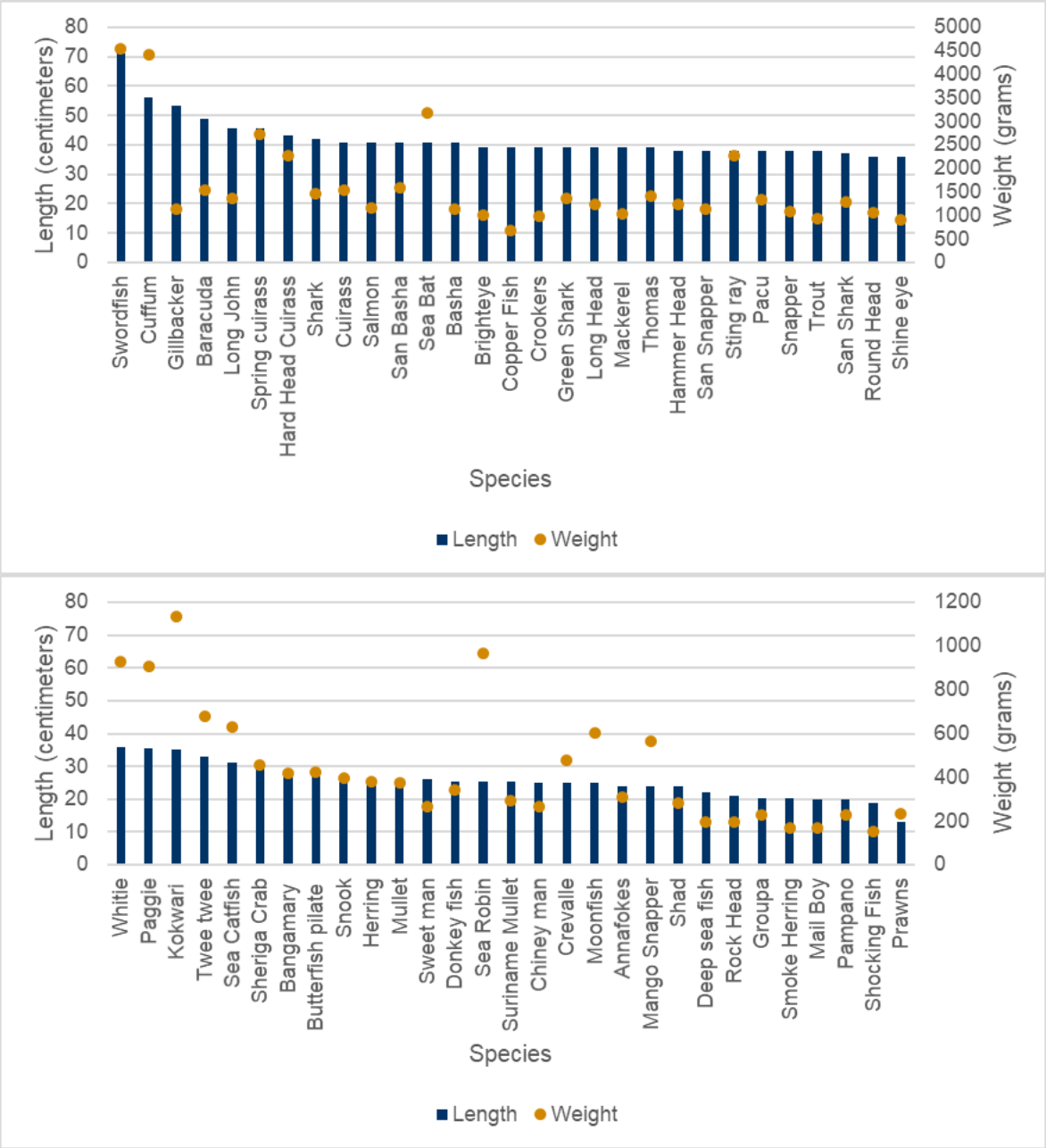


Figure N-14: Average Length and Weight of Fishes Caught by the Riverview Onboard Supervisor

The monthly average lengths and weights of the four most abundant species caught are presented on Figure N-15. Although the mesh size of the drift seine used by the onboard supervisor was smaller than drift seines used at other landing sites, such as Hampton Court and Charity (Region 2), the average annual lengths of the most abundant species caught was greater than 30 centimeters indicating that these species have matured. This is in direct contrast to the hauls at landing sites from Chinese seines. At landing sites in Lima (Region 2), Zeeburg and Windsor Forest (Region 3), and Ogle (Region 4), most of the fishes are smaller than 30 centimeters due to the mesh size.

Trout achieved peak sizes in May 2019 while the largest, bangamary, butterfish, and sea catfish, were caught in June 2019. This may be attributed to these species coming closer to shore to spawn at these times. The onboard supervisor could not confirm whether larger fishes caught over the July to September spawning period were spawning females as fish are not gutted prior to sale. The sizes of these fishes subsequently declined, which is consistent with trends observed at other landing sites of smaller fishes being recorded following the spawning season. However, the sharp decline in sizes in August 2019 was unusual and the likely reason for this dip is unknown. During the hard season from October 2019 to February 2020, the length of species plateaued and remained fairly constant for bangamary, butterfish, and sea catfish; this was anticipated. It is also important to note that the size of sea catfish did not increase in February 2020 as was observed in hauls from onboard supervisors at La Grange and Windsor Forest in Region 3.

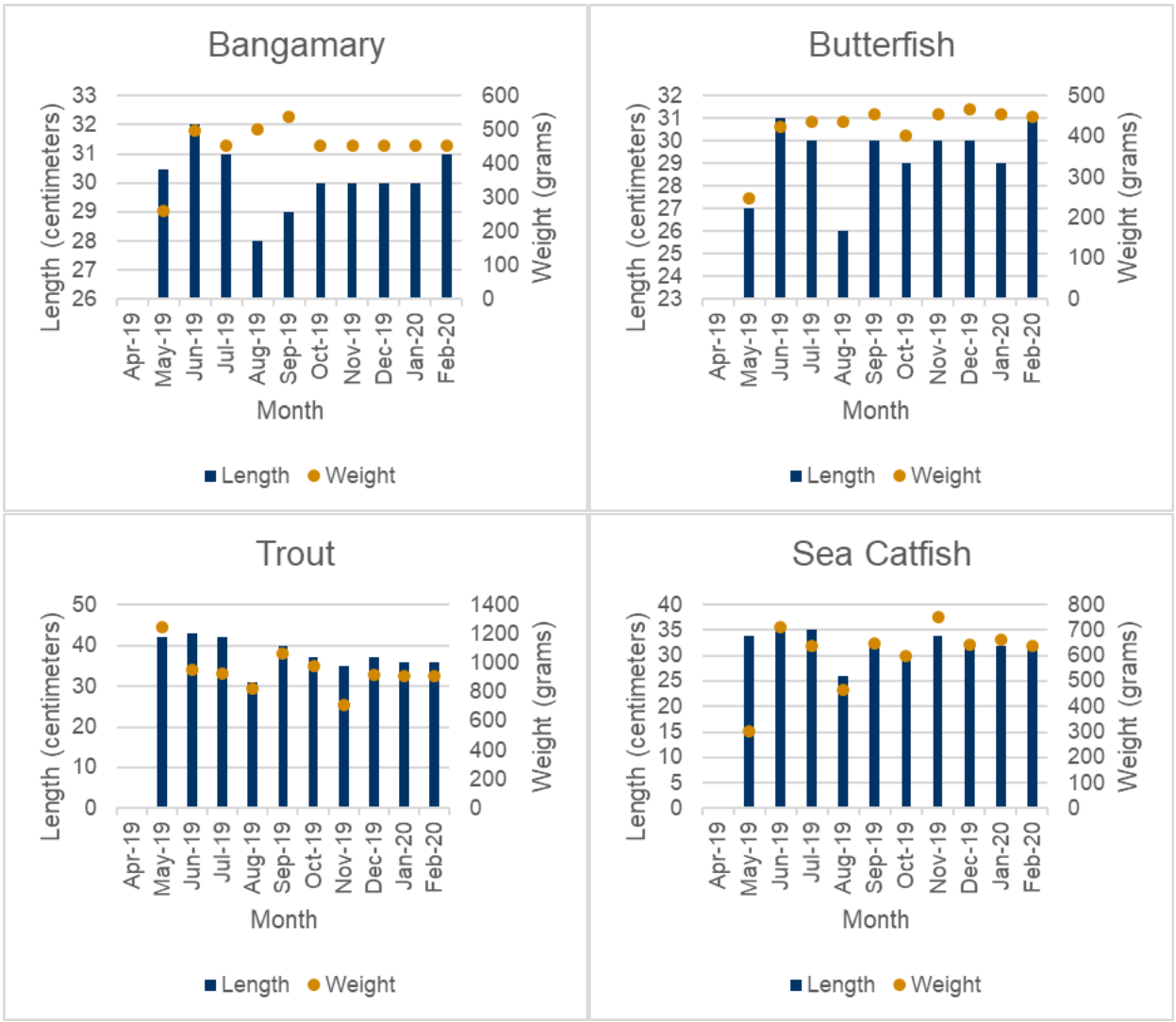


Figure N-15: Monthly Average Length and Weight of Most Caught Species at the Riverview Landing Site

4 QA/QC DATA

The first QA/QC exercise at this landing site was intended to determine whether the data collected by the supervisors was representative of fishing activities at this landing site. As a result, the study coordinator decided to assess the haul of a selected vessel at the landing site. The selected vessel was representative of vessels and fishing practices at the landing site to enable haul comparisons with data collected by the regional supervisor for a typical fishing trip. Further, this would also allow for comparisons with the haul recorded by the onboard supervisor. The vessel assessed used a bangamary seine and was powered by a 40 hp outboard engine. The vessel was returning from a 3-day fishing trip where the seine was soaked five times along the Mahaica coast.

As seen on Figure N-16, bangamary was the most abundant species caught and was the largest proportion of the haul by a wide margin. This aligns with the haul composition typically expected from a vessel using a bangamary seine and follows the haul composition of data collected by the onboard supervisor from the Riverview (Unity, Mahaica) landing site. Based on the findings of the QA/QC exercise, the decision was made not to renew the volunteer agreement with the regional supervisor at the landing site because of significant discrepancies which were revealed in the data. These discrepancies were:

- Analysis of the data recorded by the supervisor for July 2019 revealed almost equal proportions of butterfish, trout, and bangamary in total hauls of bangamary vessels. Typically, it is expected that the most abundant species caught by bangamary vessels is bangamary. The second and third most abundant species caught are typically butterfish and trout. At the time of the QA/QC assessment, catch compositions recorded by the onboard supervisor at this landing site who also operates a bangamary vessel demonstrated the expected trends. In addition, data collected for bangamary vessels by the regional supervisor at the Mahaicony landing site in Region 5 also demonstrated these expected trends. These vessels all use proximate fishing grounds and such a significant divergence in catch composition is unlikely.
- Further analysis of data submitted by the regional supervisor revealed that photos and biometric data were only collected on 8 days for the month of July but data sheets were submitted for 20 discrete days.
- Based on these analyses, the PFS team visited the landing site on August 23, 2019 to observe vessel landing. The supervisor was not present at the site to record haul data or take biometric measurements. However, data sheets were completed for these two dates by the regional supervisor.
- Finally, the PFS team conducted a QA/QC exercise on September 25, 2019 and the data collected further proved the data provided by the regional supervisor were not valid because it did not correspond to total hauls and catch composition per haul. See Sections 4.4.2 and 7.4.1 for further details of trends observed.

In October 2019, a new regional supervisor commenced data collection for this landing site. On the other hand, the haul composition and biometric measurements from the selected vessel showed a consistent trend with the data collected by the onboard supervisor (Figure N-16). The main difference between the assessed vessel and the data collected by the onboard supervisor was the species diversity. However, it is likely that more species of fishes were caught by the vessel assessed, but were not considered commercially viable and disposed as bycatch before the vessel returned to the landing site.

The study coordinator adopted a similar methodology for the second QA/QC exercise conducted in January 2020 at this landing site. The vessel assessed used a bangamary seine and had spent 2 days at sea during which time the seine was soaked twice. The vessel had a total haul of 114 kilograms (251 pounds), which was significantly lower than the average weight of hauls from the onboard supervisor of 177 kilograms (390 pounds). However, the vessel assessed during the QA/QC exercise did not catch

trout, which would have increased the weight significantly. The fisherfolk operating the QA/QC vessel also indicated that hauls were consistently low during this season.

The pricing of the haul was also consistent with the data collected by the regional supervisor. For example, bangamary prices recorded by the regional supervisor were $220 GYD per kilogram ($1 USD) while the prices from the QA/QC vessel were $264 GYD per kilogram ($1.3 USD). Similarly, the prices recorded by the regional supervisor per kilogram of butterfish were $45 GYD ($0.2 USD) higher than the prices at which hauls were sold from the QA/QC vessel. The bangamary and butterfish measured during the QA/QC exercise were 31 centimeters for both species compared to the average lengths of 30 and 29 centimeters, respectively, recorded by the regional supervisor at the landing site, as shown on Figure N-17.

The study coordinator also observed the completion of the data forms and measurements of biometrics by the onboard supervisor, and was satisfied that the data collection methods followed guidance provided thereby ensuring the accuracy and reliability of the data. Overall, the study coordinator was satisfied that the regional supervisor and the onboard supervisor were accurately recording the commercial species caught and following guidance in taking biometric measurements.

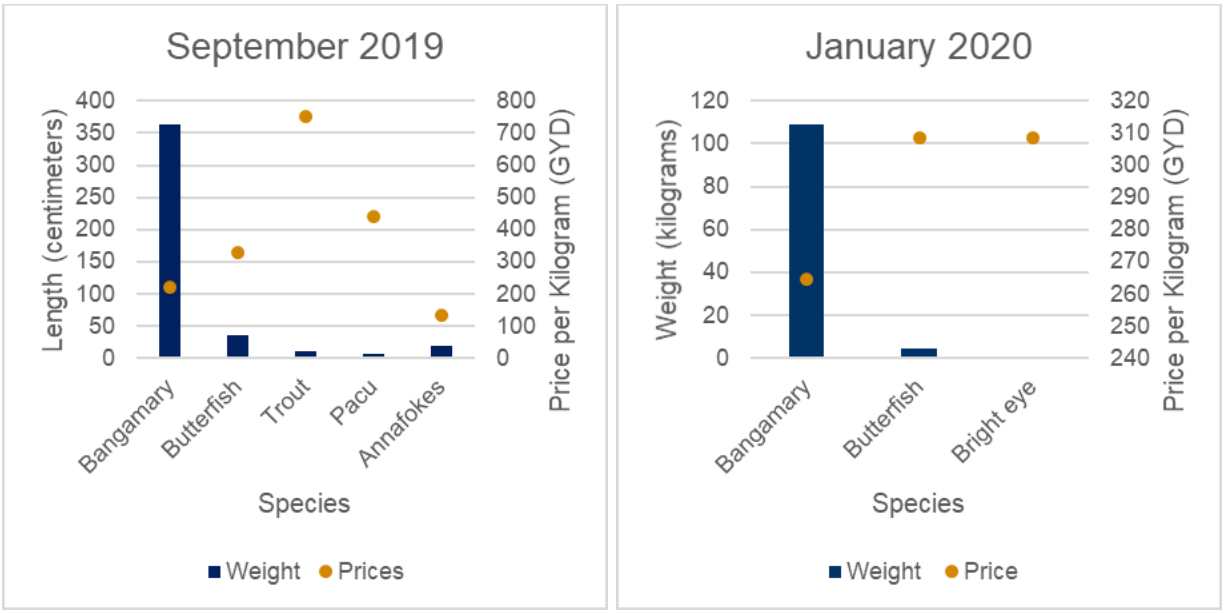


Figure N-16: Catch Composition of Commercially Viable Species during the QA/QC Exercises

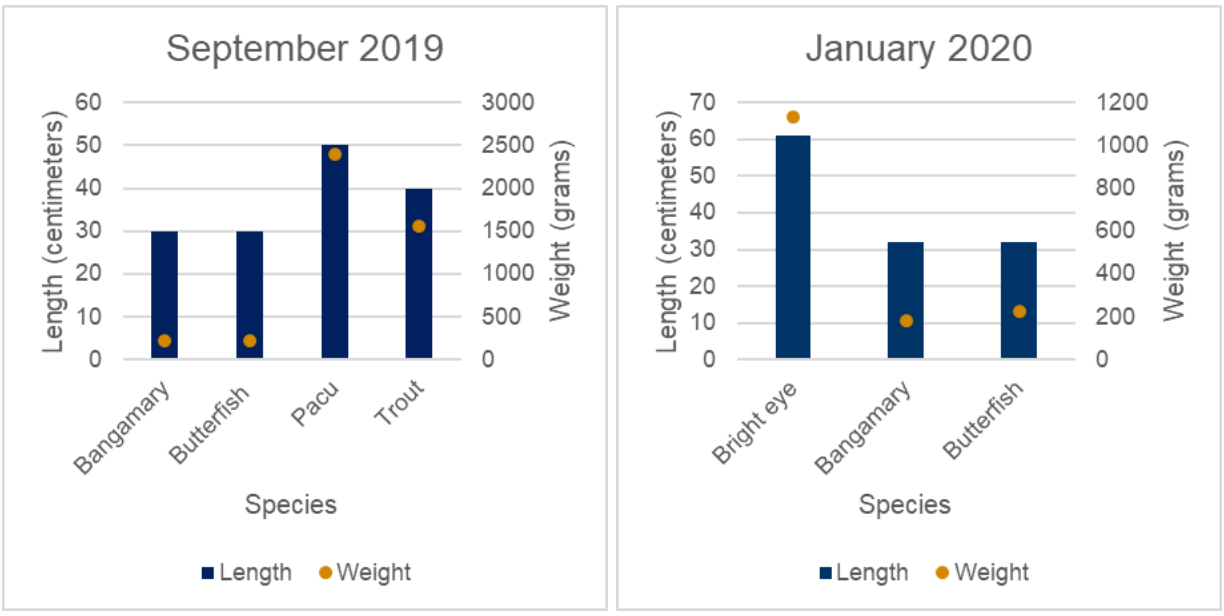


Figure N-17: Lengths and Weights of Fishes Measured during the QA/QC Exercises

APPENDIX O OGLE (REGION 4)

1 LANDING SITE OVERVIEW

The Ogle landing site is one of the largest landing sites in Region 4 for vessels using Chinese seines. Fisherfolk estimate that approximately 30 vessels use this landing site, all of which are outfitted with outboard cruisers of 15 hp. All vessels use Chinese seine with mesh sizes of 2.5 to 10 centimeters (1 to 4 inches). Fisherfolk travel to the Chinese seine "pens" approximately 3 to 10 kilometers offshore from Ogle to the mouth of the Demerara River. Fishing occurs at depths of 5 to 7 meters. Fishing trips typically last for 4 to 6 hours. The main expenses are fuel and ice that is used to store the catch for sale; the fishing activities cost $3,000 GYD ($14 USD) per trip.

Fisherfolk interviewed at the landing site indicated that species caught at this site are characterized as mixed fishes comprising bangamary, basher, cuirass, sea catfish, and shrimp. During peak fishing seasons, catch averages 100 kilograms (220 pounds) of mixed fish and shrimp. Fish can retail for $140 GYD ($0.6 USD) per kilogram and is generally sold to trucks at the landing site or other vendors.

Fishing with Chinese seines typically requires less effort than other types of fishing for two main reasons. First, "pens" are established relatively close to the shore and therefore less time and fuel are required to travel to and from their fishing grounds. In addition, travel to and from the pens is largely dependent on the 6-hour tidal cycles resulting in less time spent at sea than other types of fishing. Second, vessels that use Chinese seines have relatively low haul capacities and as a result, the duration of a fishing trip is usually shorter as vessels will not be able to transport hauls from multiple soakings of the seine on a single trip.

Fisherfolk indicated that the main challenge they experience at this landing site is accretion of mud in the channel that is not cleared. Significant accretion can prevent fisherfolk from going to sea and can also hinder easy passage back to the landing site when the vessel is laden with the haul. Some fisherfolk also indicated that seasonal variability of haul challenges the economic viability of their fishing practice.

2 ONBOARD SUPERVISOR RESULTS

2.1 Target Species and Diversity

The onboard supervisor who participated in the study used Chinese seines with mesh sizes of 2.5 to 10 centimeters (1 to 4 inches) to target seabob, which is referred to locally as corse shrimp. Fishing trips are tidal and the onboard supervisor used the high tide to travel to the "pens" to set the seine. The onboard supervisor used three pens located approximately 8 kilometers from the shore. A few Cadell lines are also used year-round and are soaked in the waters around the Chinese seine but fishes caught from these lines are not typically considered part of the commercial haul from this vessel. Instead, fishes caught by the Cadell lines are used for subsistence by the onboard supervisor and the other crew members.

Each fishing trip lasts, on average, 4 to 6 hours. The onboard supervisor's vessel has an estimated haul capacity of 500 kilograms (1,100 pounds). In general, the supervisor returns to the landing site after the seine has been hauled. The vessel has a three-member crew and is powered by a 30 hp engine. The main expense for fishing activities is fuel and ice, which is not used for preservation on fishing trips, but for storing landed hauls before they are sold. The main challenge faced by the onboard supervisor during the study period was the proliferation of sargassum that became entangled in the seines and constituted significant portions of the total haul during the February to May period.

The total weight of combined hauls from the period for which data were collected was 20,473 kilograms (45,135 pounds). Corse shrimp, the target species, accounted for 71 percent of the total haul with

14,620 kilograms (32,232 pounds) as seen on Figure O-1. Bangamary was the second most abundant species caught accounting for 12 percent of the haul with 2,520 kilograms (5,555 pounds). At the other landing sites where Chinese seines were used, the target species was white belly shrimp, although small quantities of corse shrimp were also reported. However, at the Ogle landing site where corse shrimp is the target species, white belly shrimp was the third most abundant species caught with a total haul of 995 kilograms (2,194 pounds) representing 4 percent of the total haul. The fourth and fifth most abundant species caught were netly and prawns, which are both smaller species. The onboard supervisor at the Windsor Forest landing site (Region 3) reported small quantities of netly in the hauls, but this species was not reported by any of the other Chinese seines landing sites. Hauls including prawns were also not reported by any of the landing sites where Chinese seines were the principal method used. In sum, the haul at Ogle was comprised of five crustaceans, namely corse shrimp, white belly shrimp, prawns, brown shrimp, and tiger shrimp, which is an invasive species. None of the other fisherfolk who use Chinese seines as the primary method of fishing reported such a diversity of crustacean species.

The onboard supervisor caught 31 different commercial species. This is the greatest species diversity reported by any of the fisherfolk using Chinese seines as the main method of fishing. Of this, 26 species were caught in low quantities and collectively represented less than 1 percent of the total haul. This included high- and medium-value species like snapper and trout. The onboard supervisor explained that the high diversity of species that are considered commercially viable is largely due to the primary market at which his produce is sold. In particular, the supervisor reportedly sold most of the hauls to Chinese customers who are willing to buy most of the species caught. Nonetheless, the supervisor also reported that bycatch typically comprises a significant percentage of hauls. Bycatch typically includes species such as jelly fishes, rockhead, and stingrays (endangered, rare, and threatened species). In addition, silver belt is considered commercial if it is in demand and customers are willing to buy. If there are no available markets, silver belt is considered bycatch and discarded.

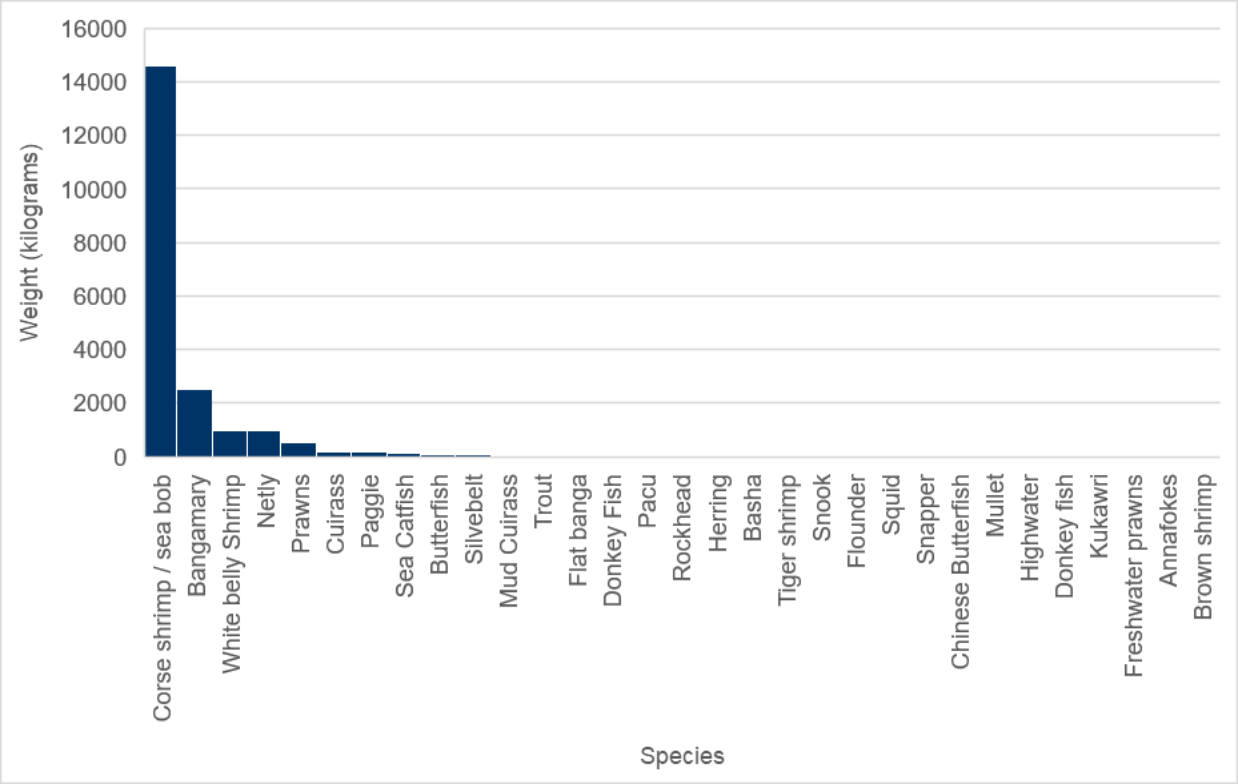


Figure O-1: Total Weight of Species Recorded by the Ogle Onboard Supervisor

2.2 Fishing Area

The onboard supervisor at this landing site has a traveling range of 151 square kilometers (see Figure O-2). The onboard supervisor fishes relatively close to shore and utilizes three clusters of pens that have been established for soaking of Chinese seines. The first cluster is just 2 kilometers offshore and the second is 4 kilometers offshore, while the third cluster is 13 kilometers offshore. These clusters are relatively close to shore, hence the effort for Chinese seine fisherfolk is relatively low. Since these structures are permanent, there is not a significant seasonal variation in fishing grounds. Unlike at the Lima and Windsor Forest landing sites, the Ogle supervisor has several pen locations at different distances offshore that the supervisor uses at different times of the year.

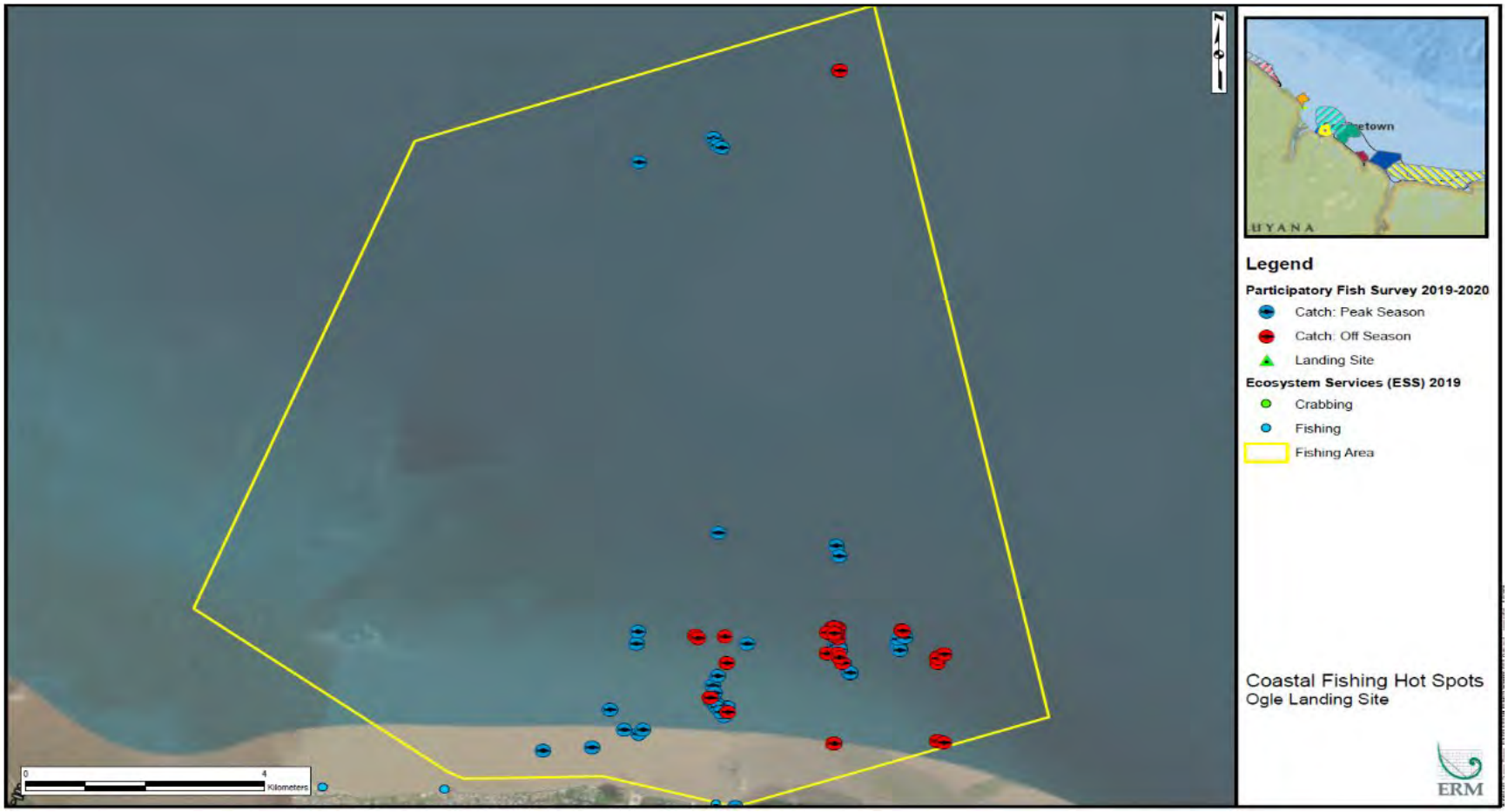


Figure O-2: Map of Fishing Area and Fishing Points Used by the Ogle Onboard Supervisor

2.3 Seasonal Productivity

Fisherfolk have varying beliefs on the most productive months for shrimping. At the Zeeburg landing site (Region 3), some fisherfolk indicated that shrimp catch generally increases during the closed trawl season, which occurs from August 16 to October 5 annually, and may allow more shrimp to come closer to the shore. Other fisherfolk indicate that the average productivity increases during the dry seasons of February to April and August to September because the waters are generally more saline compared to the wet season. Another common belief is that shrimp productivity increases during the spawning seasons of January to April and June to July (Pereira et al. 2017) when shrimp come closer to shore to spawn in the mangroves. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

The onboard supervisor spent an average of 93 hours at sea per month. The greatest effort was expended in November 2019 with 139 hours. Higher effort was also expended in August and December 2019 when the supervisor spent 127 and 126 hours, respectively, at fishing activity as seen on Figure O-3. By contrast, the lowest effort was expended in May and December 2019 when 60 and 62 hours were spent fishing. This is similar to the fishing practices of the onboard supervisors at the Lima (Region 2) and Windsor Forest (Region 3) landing sites where the greatest effort was expended in November 2019, and the least effort in December 2019.

As seen on Figure O-4, the highest average catch per soaking and greatest total haul were recorded in July with 433 kilograms (955 pounds), 5,197 kilograms (11,457 pounds), respectively. The second most productive months were October and November 2019 when the average catch per soaking was 145 kilograms (320 pounds) and 144 kilograms (317 pounds), respectively, which is significantly lower than the average weight of a haul per soaking in July. The total haul weights in October and November were 2,752 kilograms (6,067 pounds) and 3,018 kilograms (6,654 pounds), respectively; this is also significantly lower than the July peak.

Seasonal comparisons of effort expended by the onboard supervisor and the hauls recorded are as follows:

- In the May to September 2019 good season for fishing, the total weight of hauls was 10,632 kilograms (23,440 pounds) with 430 hours spent at sea. On average, soaking of the seine during this period yielded 145 kilograms (320 pounds).
- In April 2019, and the October 2019 to February 2020 hard season for fishing, the total weight of hauls was 9,841 kilograms (21,696 pounds) with 590 hours spent at sea. On average, soaking of the seine during this period yielded 90 kilograms (198 pounds).

Additional seasonal trends at this landing site are as follows:

- In August to October 2019, the primary dry season and the closed trawl season, total weight of hauls was 5,703 kilograms (12,573 pounds) with 351 hours spent at sea. On average, soaking of the seine during this period yielded 96 kilograms (212 pounds).
- In February 2020 and April 2019, two months of the secondary dry season, soaking of the seine during this period yielded, on average, 76 kilograms (168 pounds). Total effort and hauls were not presented since data were not retrieved for March 2020 to complete this season.
- In the January to February 2020 period and April 2019, which is the first shrimp spawning season, the total weight of hauls was 1,842 kilograms (4,060 pounds) with 213 hours spent at sea. On average, soaking of the seine during this period yielded 47 kilograms (104 pounds).

- In the June to July 2019 period, which is the second shrimp spawning season, total weight of hauls was 6,744 kilograms (14,868 pounds) with 66 hours spent at sea. On average, soaking of the seine during this period yielded 259 kilograms (571 pounds).
- In May to July 2019, which is the primary wet season, the total weight of hauls was 7,681 kilograms (16,933 pounds) with 192 hours spent at sea. On average, soaking of the seine during this period yielded 193 kilograms (425 pounds). In addition, the two most productive months, May and July, were part of this season.
- In November 2019 to January 2020 period, which is the secondary wet season, the total weight of hauls was 5,814 kilograms (12,818 pounds) with 326 hours spent at sea. On average, soaking of the seine in this period yielded 102 kilograms (225 pounds) as shown on Figure O-5.

Based on the seasonal effort and productivity presented above, the most productive season was the good season where hauls were greater although lower effort was expended. However, based on other seasonal trends examined, the most productive periods were the second spawning season and the wet seasons. The second spawning season also significantly intersects with the primary wet season. Increased productivity in the wet seasons, and as a consequence the second spawning season, were also observed by the onboard supervisors at the Lima (Region 2) and Windsor Forest (Region 3) landing sites, both of whom also used Chinese seines as the principal gear type. However, at those landing sites, the greatest effort was expended during the secondary dry season, whereas the greatest effort was expended during the primary dry season by the Ogle onboard supervisor. Due to the relatively constant level of effort expended per fishing trip, it is not likely that total effort expended per fishing trip influences productivity. Instead, total hauls are dependent upon the average haul per soaking, which also follows the trends in seasonal productivity discussed above. Additional data are needed to determine whether these trends are typical of the hauls from this supervisor.

In addition, it is of interest that July 2019 was also the most productive month at the landing sites in La Grange and Windsor Forest (Region 3) and the Riverview landing site (Region 4). At all of these landing sites, productivity sharply declined in August 2019. The onboard supervisor also indicated that these periods are not typically as productive and the reasons for this difference are not known. At the La Grange, Windsor Forest, and Riverview landing sites, productivity remained relatively low from August 2019 to February 2020. However, subsequently, all of these landing sites had a marginal uptick of total haul in October 2019 compared to September 2019. However, further data are required to enhance understanding of seasonality of fishing versus shrimping and whether fishing grounds may also play a role in determining seasonality and productivity.

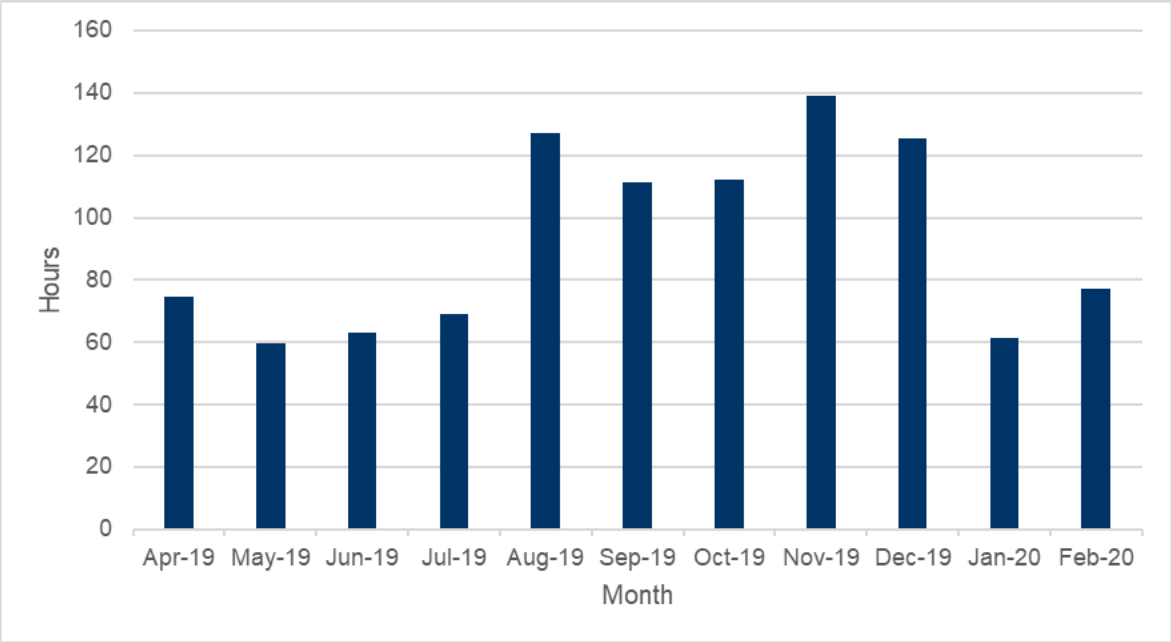


Figure O-3: Total Monthly Fishing Effort Recorded by the Ogle Onboard Supervisor

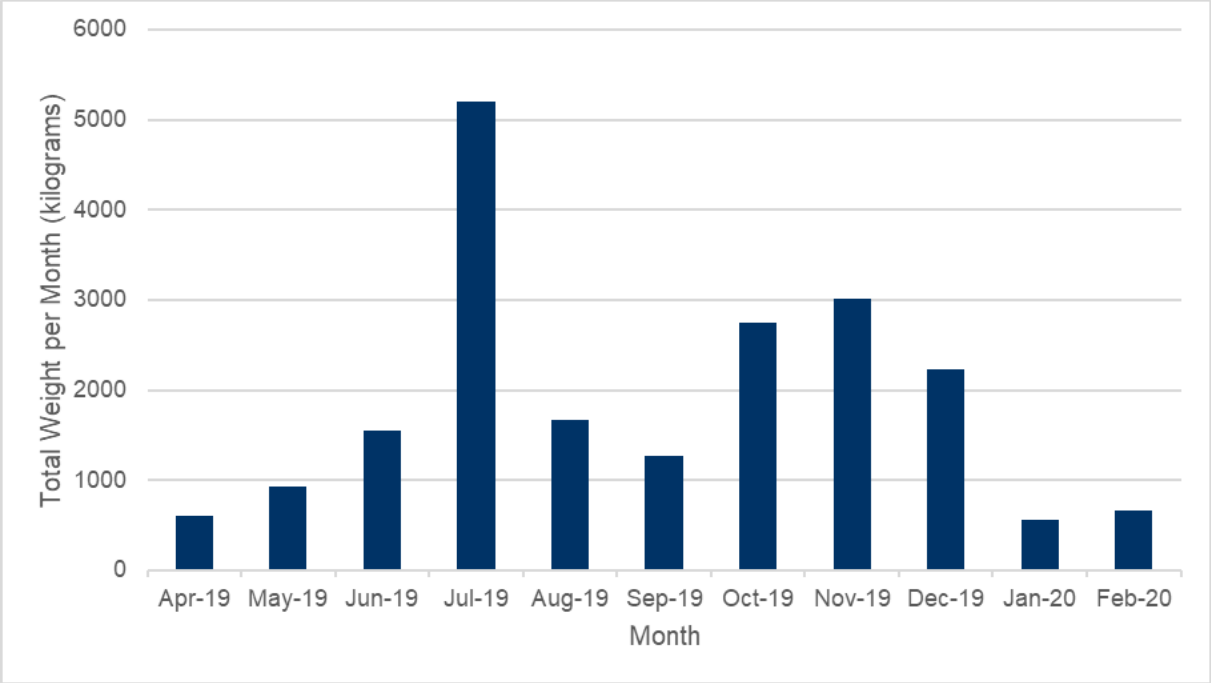


Figure O-4: Total Monthly Weight Recorded by the Ogle Onboard Supervisor

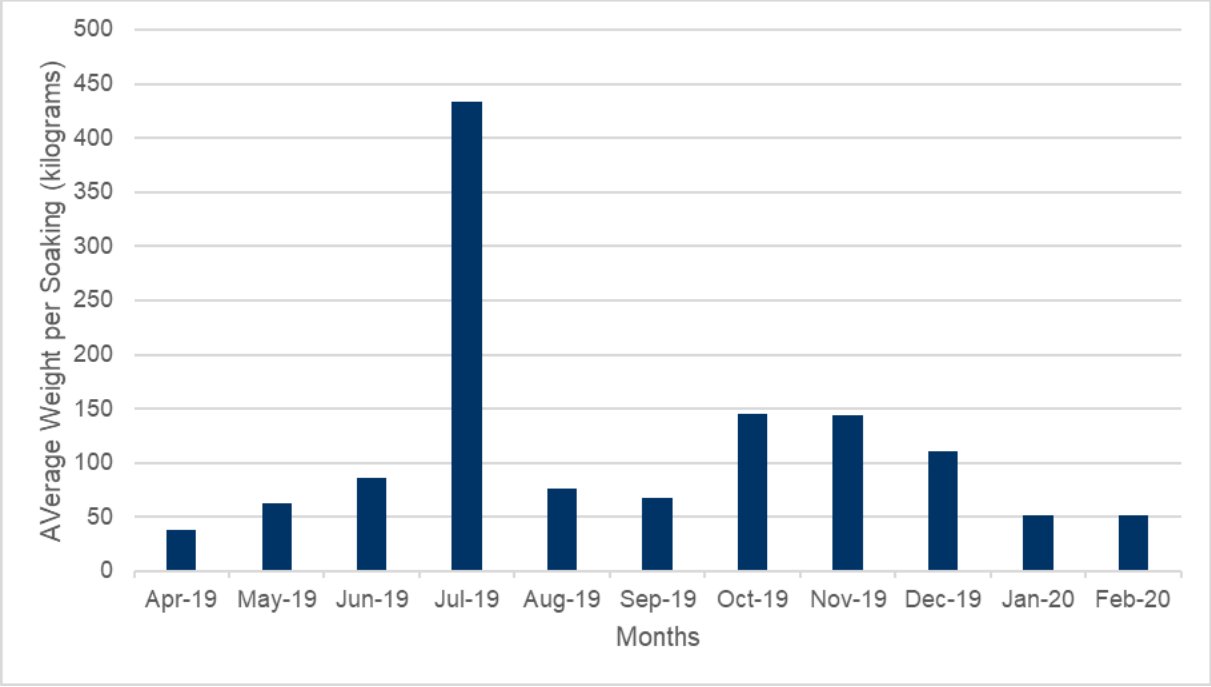


Figure O-5: and Average Weight per Soaking Recorded by the Ogle Onboard Supervisor

2.4 Biometrics

The onboard supervisor measured the average lengths and weights of representative fishes of the 47 species that were caught (see Figure O-6). However, markets were not available for some of these species and as a result they were all considered bycatch and discarded. These 16 species included electric ray, eel, blue rem sluch, butterflop, Chinese butterfish, pinto, and jellyfish. The onboard supervisor caught several species that he classified as ‘flat banga’ to represent a combination of juvenile species typically too small to be considered marketable. This label is similar to the onboard supervisor from Windsor Forest considering several species of juvenile fishes as ‘small banga’. However, based on observations by the study team, the ‘flat banga’ caught by the Ogle onboard supervisor were considerably smaller and more diverse than the ‘small banga’ caught at Windsor Forest. Expert judgement based on an external visual observation of the species called ‘flat banga’ also raised concerns that they may not have developed gonads.

In general, the commercial species caught were immature and this is directly attributed to the mesh sizes on the Chinese seines. Seines with smaller mesh sizes are expected to capture the smaller species and smaller fishes that pass through and escape seines, which have larger mesh sizes. The onboard supervisor’s commercial hauls were comprised of several smaller species that may be considered immature including netly, annafokes, mullet, and the five species of shrimp. Of the larger commercial species, trout captured at Ogle had often reached sexual maturity based on annual average lengths and weights, but species like bangamary, butterfish, cuirass, and sea catfish—for which annual average lengths and weights indicated that they had reached sexual maturity in hauls from relatively proximate landing sites (La Grange, Windsor Forest and Riverview)—were all immature at Ogle.

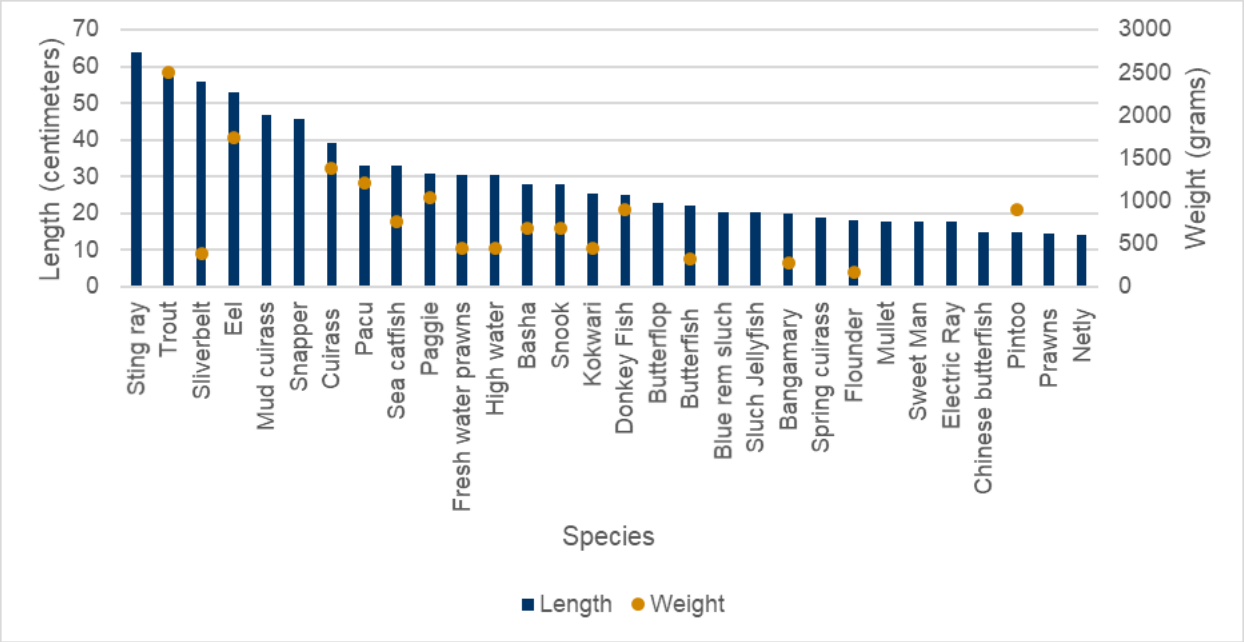


Figure O-6: Average Length and Weight of Fishes Caught by the Ogle Onboard Supervisor

The monthly average lengths and weights of the four most abundant species caught are presented on Figure O-7. Three of the four most abundant species caught were smaller and although there were monthly size variations, they were all considered mature. However, there are no clearly defined seasonal trends in the sizes of these species caught. The largest corse shrimp, the most abundant species caught, were recorded in the primary rainy season (May to July 2019) and the October to December 2019 period. These were also among the most productive periods for the onboard supervisor and the May to July period follows the first spawning season (January to April) and overlaps with the second (June to July). The October to December period also follows the closed trawl season. Additional data would be needed to determine whether these factors influence the sizes of fishes caught. However, it should be noted that similar trends in size variations were observed for white belly shrimp for which the largest was caught in May 2019, but sizes were constant for all other months in which measurements were taken.

The size of netly was relatively stable throughout the study period, but the smallest individuals were caught in January and February 2020. This is similar to corse shrimp where the smallest were also reported in January and February 2020. Bangamary was the only species of the four most abundant species that showed major variation in biometric data. The largest bangamary were caught in October 2019 while the smallest were caught in April, July and August 2019, and February 2020. These size variations are not consistent with observations at any of the proximate landing sites. Despite the variations in size, none of the measured bangamary had reached sexual maturity.

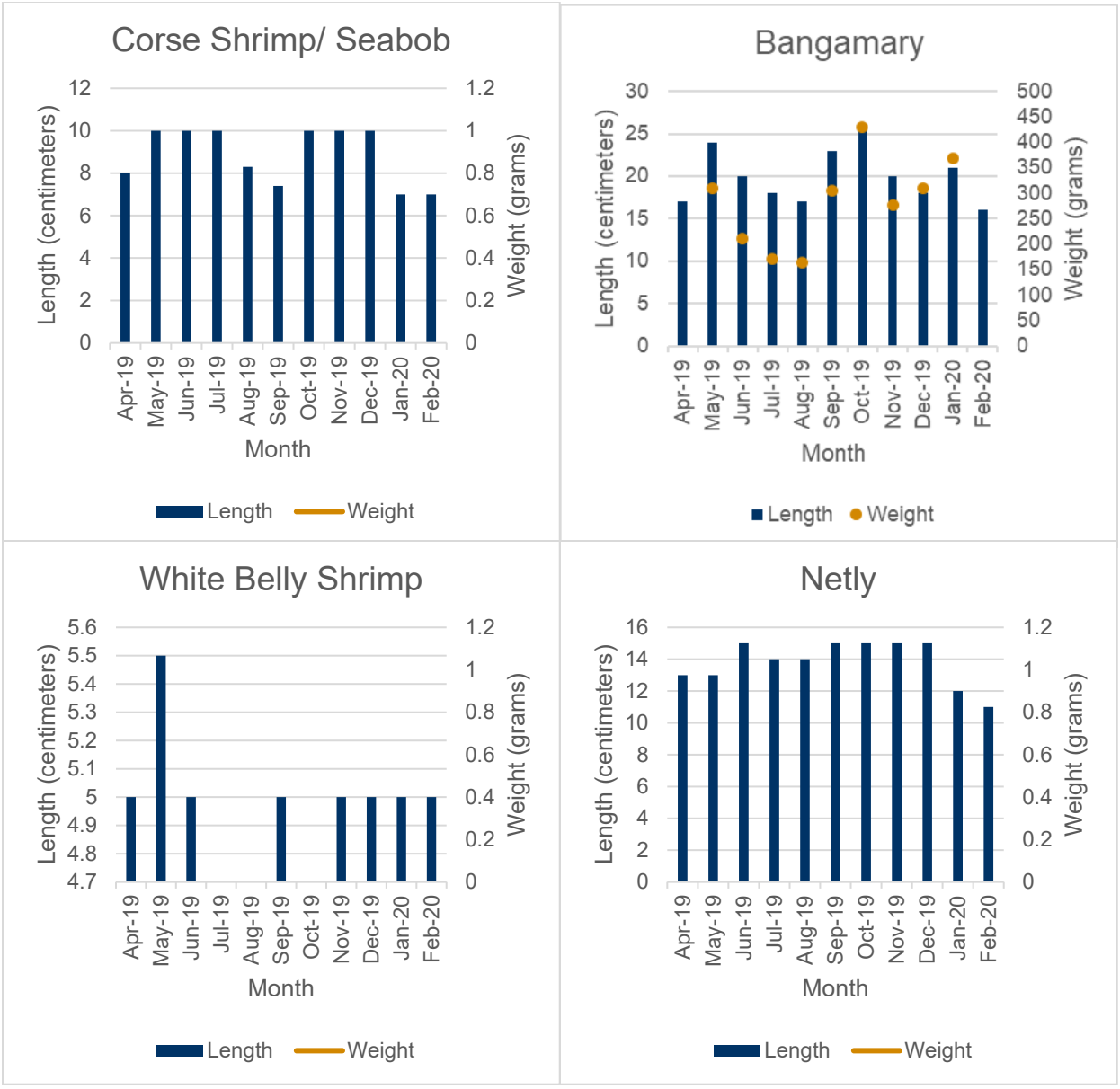


Figure O-7: Average Lengths and Weights of the Most Abundant Species Caught [4]

3 QA/QC DATA

During the QA/QC exercise, a GoPro camera was installed on the vessel belonging to the onboard supervisor from the Ogle landing site. Several key observations were made from the video monitoring conducted on 23 September 2019:

- Bycatch is discarded overboard while the vessel is still at sea. This practice has led to the development of a commensal relationship between the fisherfolk and seabirds such as pelicans, seagulls, and frigate birds that feed on the discarded bycatch. These birds flock to the vessel when the seines are pulled up expecting food. This relationship may exist with other scavenging species

[4] Weights of individual Corse Shrimp/Seabob, White Belly Shrimp, and Netly are too low to be measured with the scales used by the field team.

including marine scavengers. Cranes also flocked to the boat when it came inshore to clean all the scraped shrimp that remained.

- The bycatch was comprised significantly of silver belt and this is consistent with the data collected by the onboard supervisor.
- The onboard supervisor also practices line fishing while the seines are being soaked. This is for recreational purposes and catches are for subsistence use. Hauls from these lines are not reported by the supervisor as a part of the commercial catch per trip.

The onboard supervisor indicated that the trip recorded was not productive as the haul of commercially viable species was smaller than expected. Indeed, the July to September period is considered “slow” for shrimping, the haul from the trip was smaller than other fishing trips conducted by the supervisor over the reporting period and also had less species diversity (see Figure O-8). However, the biometric measurements were consistent with data previously collected and a significant number of fishes were juvenile (see Figure O-9). In addition, as previously discussed for other sites, several different species were caught and categorized as “flat banga” although at this site it was comprised mainly of juvenile bangamary. Overall, the study team was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

The second QA/QC exercise was not conducted in January 2020 due to inactivity at the site during the visit. The team revisited the site in February 2020 and collected data on a haul brought to shore by the supervisor. Average total weight recorded by the supervisor in the month of February was the second lowest during the recorded period at 51 kilograms (112 pounds). The haul assessed during the QA/QC exercise was even lower at 40 kilograms (88 pounds). The majority of the haul was comprised of the corse shrimp/seabob. This corresponded with overall trends recorded by the supervisor. The diversity of the haul also included all the major species recorded by the supervisor.

The biometric data collected during the QA/QC had some small variances. For example, the average length of bangamary measured by the supervisor in February 2020 was 16 centimeters whereas a representative fish in the QA/QC haul was 19 centimeters. Corse shrimp/seabob measured 7 centimeters during the QA/QC exercise and 7.5 centimeters was the average length of measurements taken by the onboard supervisor. Netly measured 13.5 and 11 centimeters while the white belly shrimp measured 3 and 5 centimeters from the data collected during the QA/QC exercise and the average lengths measured by the onboard supervisor, respectively. Overall, the study team was satisfied that the data reported by the onboard supervisor was within an acceptable range of accuracy and following the guidance provided in taking biometric measurements.

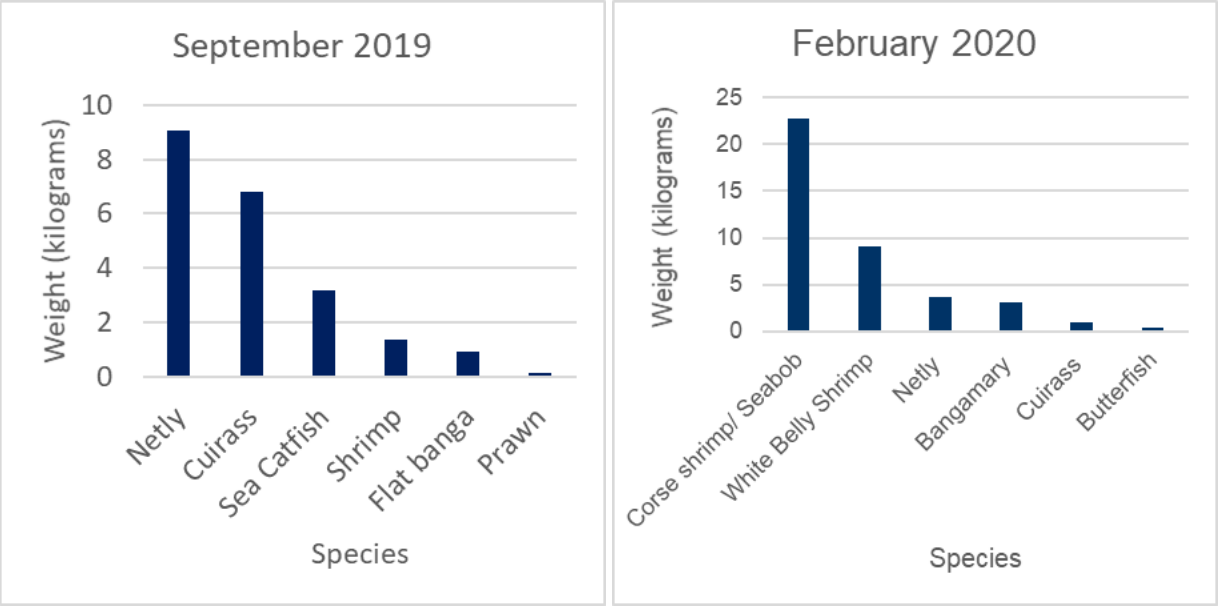


Figure O-8: Catch Composition of Commercially Viable Species during the QA/QC Exercises

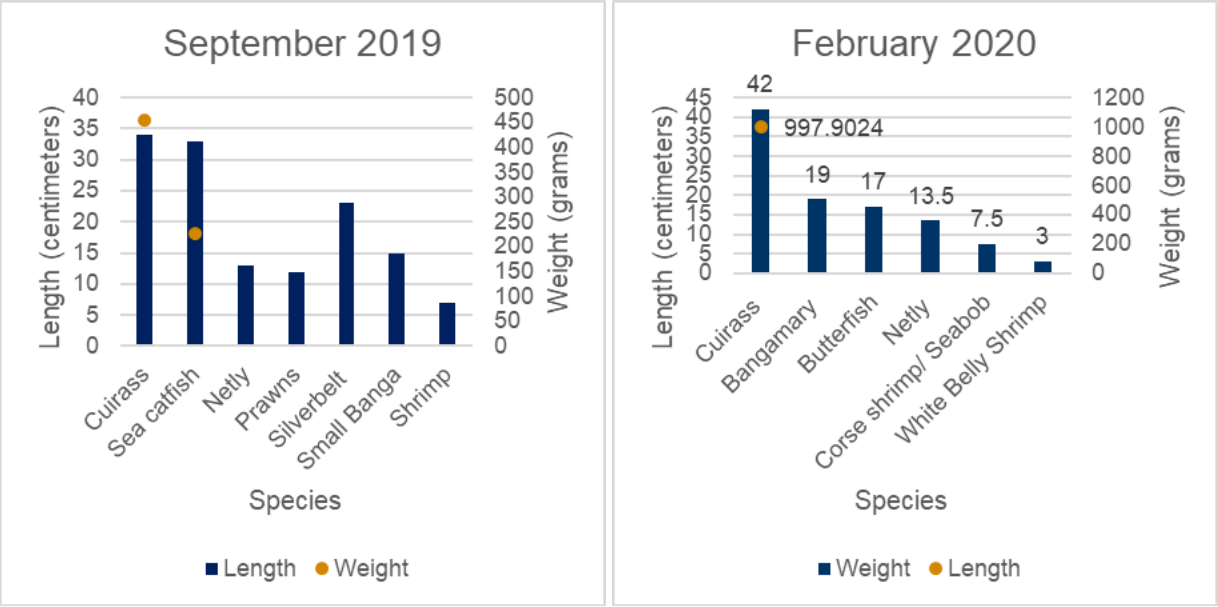


Figure O-9: Lengths and Weights of Fishes Measured during the QA/QC Exercises

APPENDIX P MAHAICONY BRIDGE (REGION 5)

1 LANDING SITE OVERVIEW

The landing site at Mahaicony Bridge is a medium-sized landing site in Region 5. Fisherfolk estimate that approximately 15 outboard cruisers operate at this landing site all of which have engines of 40 hp or greater. Most of the vessels use drift seines with mesh sizes of 6.4 centimeters (2.5 inches) to target bangamary. Bangamary is also the target species of most of the fisherfolk at the Riverview landing site (Region 4), but the mesh sizes of the drift seines are slightly larger at 7 centimeters (2.75 inches). A few vessels at the Mahaicony Bridge landing site also use drift seines with mesh sizes of 10 to 20 centimeters (4 to 8 inches), but data were not collected for these vessels. Given the similarities of fishing practices by fisherfolk at the Mahaicony Bridge and Riverview (Region 4) landing sites, fisherfolk frequently interchange where their vessels are landed for a variety of factors, including that some of the fisherfolk who utilize the Riverview landing site as their primary landing site reside in Mahaicony and vice versa. These fisherfolk have sometimes expressed a preference for landing their vessels closer to their homes. Fisherfolk indicated that the main challenge to their fishing activities are conflicts with trawler vessels while at sea, which would sail over seines causing destruction of the seines, a loss of catch, and expenses for seine mending. Their main expense is fuel.

Vessels at this landing site fish primarily along the coast of Region 5 and many fisherfolk prefer to fish at the mouth of the Mahaicony River. Fishing trips last for 1 to 3 days. Depending on the season, fisherfolk travel to preferred fishing grounds approximately 10 to 29 kilometers offshore at depths of 13 to 22 meters. Seines are soaked for 3 to 10 hours and are typically soaked more than once per fishing trip by all fisherfolk using this landing site. It may be assumed that lower species diversity of landed hauls at this site in comparison to Riverview (Region 4) may be a decision by fisherfolk to optimize the effort expended by ensuring that only fishes for which there are guaranteed markets are stored on board and transported to the landing site.

2 REGIONAL SUPERVIORS RESULTS

One regional supervisor participated in the study and the results contained within this section are provided by him over the course of the study period.

2.1 Effort and Haul

Based on the data collected by the regional supervisor, a total of 20 different species of fishes were caught with a total weight of 118,702 kilograms (261,693 pounds). Bangamary represented 76 percent of the total hauls at the landing site with a total haul of 89,692 kilograms (197,737 pounds) as seen on Figure P-1. The second and third most abundant species caught were butterfish and trout with total weights of 14,752 kilograms and 5,942 kilograms (32,522 pounds and 13,100 pounds), respectively. These represented 12 and 5 percent of the total weight of fishes caught at this landing site. Collectively, these three species accounted for approximately 93 percent of the total haul at this landing site. Hauls comprised of these three species was expected as data were collected only from the “bangamary seine.” In addition, these three species were also observed at the Riverview landing site (Region 4) because that data pool was predominantly representative of hauls from bangamary seines. The fourth most abundant species caught at this landing site was basha. However, with a total haul weight of 2,201 kilograms (4,852 pounds), it was caught in significantly lower quantities than bangamary, butterfish, and trout. Of the 20 species reported, 11 were caught in relatively low quantities of 500 kilograms (1,102.3 pounds) or lower including high-value species like snapper and red snapper.

Over the period April 2019 to February 2020, a fishing trip lasted for 28 hours on average. The following trends were observed (Figure P-2):

- The months with the lowest average effort were April 2019 and February 2020 when fishing trips lasted for 18 hours and 22 hours respectively. These months are typically considered as part of the hard season for artisanal fisherfolk. However, it should be noted that data collection at this landing site started on April 27, 2019 and consequently, the average monthly effort was calculated based on a comparatively small data pool.
- Fishing trips that lasted on average 25 to 30 hours occurred in August to November 2019, and in January 2020.
- Fishing trips lasting for more than 30 hours occurred in May to July and December 2019.

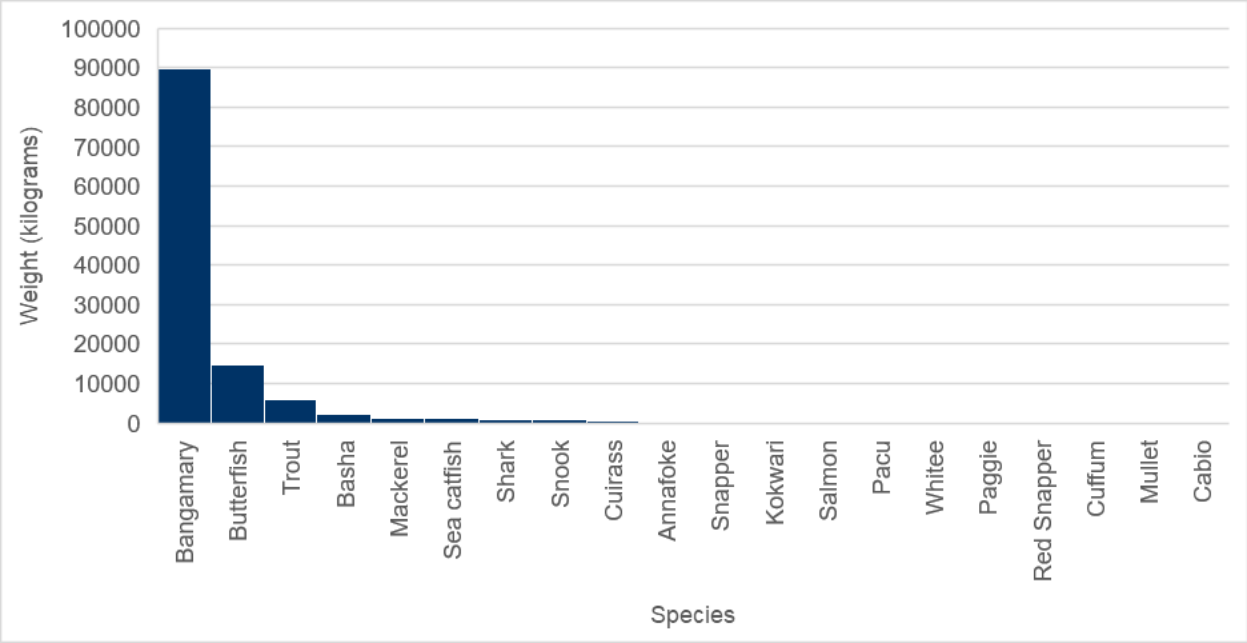


Figure P-1: Total Weight of Species Caught at the Mahaicony Bridge Landing Site

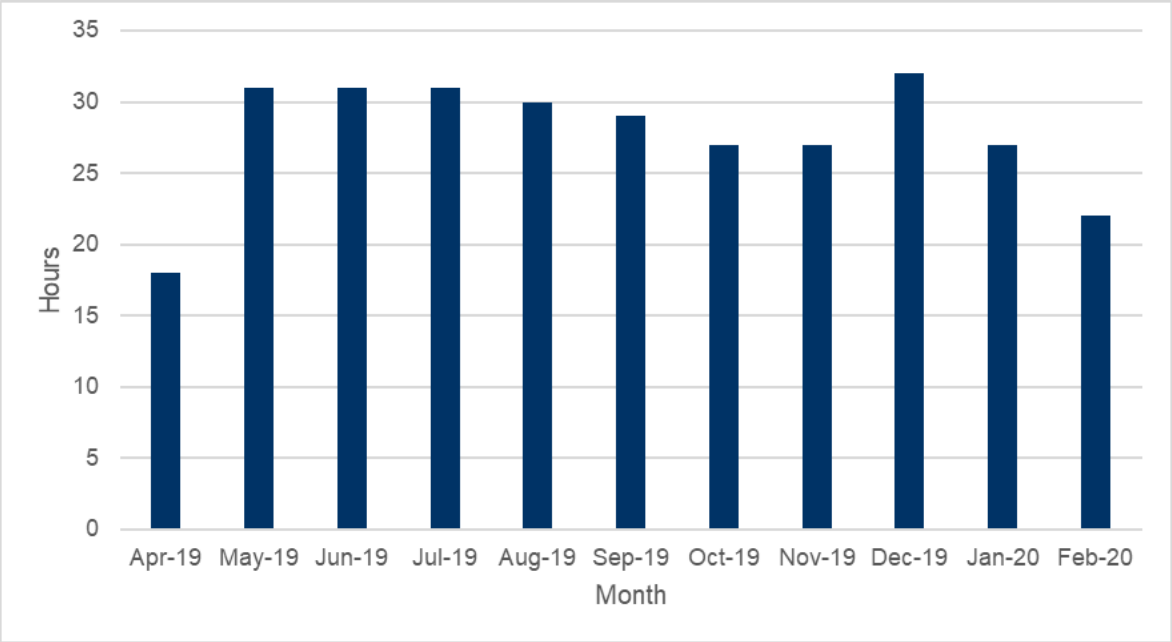


Figure P-2: Average Monthly Fishing Effort at the Mahaicony Bridge Landing Site

2.2 Target Species and Diversity

Species diversity was significantly lower than was reported at the Riverview landing site (Region 4) where 54 different species of fishes were recorded. This stark difference in species diversity may be principally attributed to what fisherfolk deem commercial species based on the markets available at each of these landing sites. The Riverview and Mahaicony Bridge landing sites are relatively proximate and fisherfolk tend to share preferred fishing grounds. As such, more species than were reported are likely caught in the seines by the fisherfolk operating out of the Mahaicony Bridge landing site, but are released or discarded as bycatch at sea. In addition, similar to hauls from landing sites in Smith's Creek and Morahwanna (Region 1), Charity (Region 2), and Riverview (Region 4), shark was also deemed a commercial species, but was not reported by species. Given the similarity of fishing grounds shared by fisherfolk at this landing site and the Riverview landing site, it may be assumed that similar species of shark were caught by the fisherfolk. The shark species reported at the Riverview landing site were green shark, san shark, the hammerhead shark (some species of which are considered vulnerable by the IUCN), and the blacktip shark, which is an endangered, rare, and protected species. Large quantities of bycatch were not reported at this landing site and this may be attributed to the relatively large mesh sizes of the seines used.

Species diversity of hauls was observed to change seasonally (Figure P-3). These changes were related to the wet and dry seasons with more species caught in the May to July 2019 wet season followed by a dip in species diversity in the August to October 2019 dry season. Thereafter, species diversity again increased in the November 2019 to January 2020 wet season before declining once again with the dry season as observed in April 2019 and February 2020. This could be as a result of increased nutrients available at the mouth of the Mahaicony River for feeding during this period. Fishes such as paggie and pacu were caught in higher quantities during this period as the brackish zone is used by fisherfolk at these times. In addition, fisherfolk believe that increased effort is required during the "hard" season. As a result, it is likely that they ventured farther offshore to fish resulting in greater species diversity and hauls comprising fishes found more frequently offshore such as mullet.

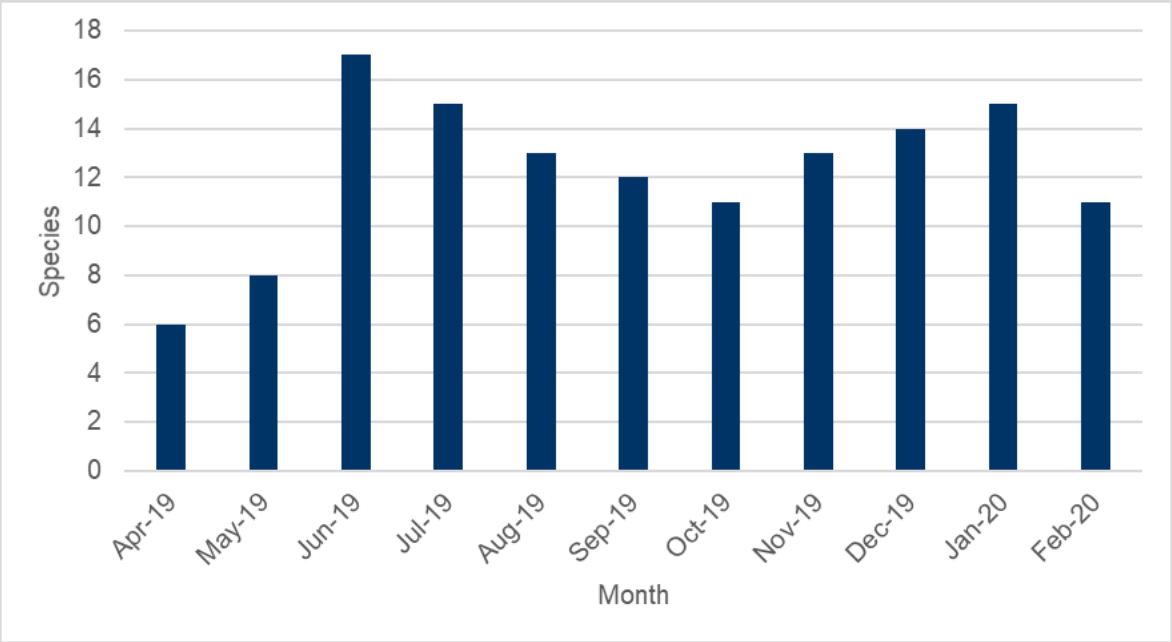


Figure P-3: Species Diversity at the Mahaicony Bridge Landing Site

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip. Figure P-4 presents the average monthly productivity of fishing trips, which was measured as the dividend of total monthly productivity by the number of fishing trips. There were variations in the average monthly productivity of the fishing trips at this lading site. Based on the good and hard seasons identified by fisherfolk, seasonal variations in average monthly productivity are as follows:

- In the April to September 2019 period, the average monthly productivity was 431 kilograms (950 pounds). Neither the most productive or least productive months were observed during this period. However, it must be noted that, like average monthly effort, the calculation of average monthly productivity for April 2019 was based on a smaller data pool.

- In the October 2019 to February 2020 period, average monthly productivity was 315 kilograms (694 pounds). Both the least and most productive months were observed during this period. The former was in January 2020 with 141 kilograms (310 pounds) and the latter in October 2019 with 622 kilograms (1371 pounds). Mahaicony Bridge and Smith’s Creek and Morahwanna (Region 1) were the only two landing sites that target fish species where the highest productivity was observed in October 2019. In addition, during October 2019 fisherfolk expended lower effort than most other months in the good season. However, it is not clear as to whether less effort was expended by design, or whether there was a greater abundance of fishes, which allowed fisherfolk to achieve optimum haul capacities more quickly.

- The most productive consecutive period at this landing site was from July to October 2019 when vessels exceeded 450 kilograms (992 pounds) every month. Average productivity was 534 kilograms

(1,177 pounds) per trip during this period. By comparison, average productivity was 289 kilograms (637 pounds) for the other months namely, April to June 2019 and November 2019 to February 2020.

By comparison, combined average productivity for the wet and dry seasons was as follows:

- In the May to July 2019 period, which is the primary wet season, average monthly haul was 451 kilograms (994 pounds).
- In the August to October 2019 period, which is the primary dry season, average monthly haul was 528 kilograms (1164 pounds).
- In the November 2019 to January 2020 period, which is the secondary wet season, average monthly haul was 259 kilograms (570 pounds).
- In February 2020 and April 2019 period, which is the secondary dry season, average monthly haul was 174 kilograms (383 pounds).

Overall, average productivity per fishing trip was on an upward trend from April to July 2019 after which it declined before peaking in October 2019. For the most part, this is consistent with fisherfolk views that the good season starts in April and continues to September. Like the Charity landing site (Region 2), seasonal productivity is not influenced by the wet and dry seasons because the difference in hauls between the wet and dry seasons is not significant. Finally, based on the data collected for this landing site in 2019, October may also be considered as part of the good season in 2019. October also the month after the end of the July to September spawning season and this may also have contributed to increased hauls during this month. Additional data are needed for this landing site to determine whether the productivity observed in October is representative of this month in other years.

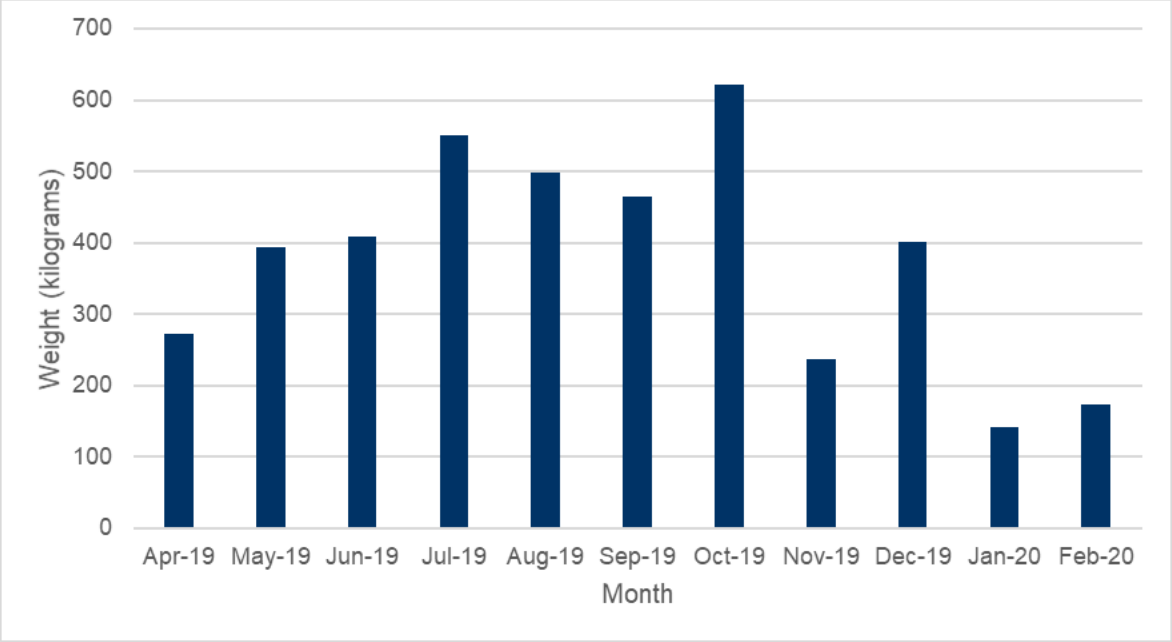


Figure P-4: Average Monthly Productivity of Fishing Trips at the at the Riverview Landing Site

2.4 Prices and Markets

Based on data collected by the regional supervisor, snapper was the highest-value fish at this landing site with annual average price of $973 GYD ($4.6 USD) per kilogram as seen on Figure P-5. Although snapper was also the highest-value fish at Charity (Region 2) and Riverview (Region 4), the annual average prices at the Mahaicony Bridge landing site were significant higher. This may be attributed to the relative scarcity of snapper in comparison to the Charity landing site and to bargaining between fisherfolk and the vendors or consumers to whom the fish is sold. Red snapper, another type of snapper reported at this landing site, was also a high-valued species. However, at prices of $551 GYD ($2.60 USD) per kilogram, it was significantly less expensive than (grey) snapper. Cabio was the second most highly valued species with an annual average price of $661 GYD ($3.20 USD). Cabio is a relatively rare fish, hence the price.

Bangamary, the target species of most fisherfolk at this landing site and the most abundant species caught, was a medium valued species with annual average prices of $225 GYD ($1 USD). The two secondary target species butterfish and trout were more highly valued with annual average prices of $331 GYD ($1.60 USD) and $592 GYD ($2.80 USD) respectively. In fact, trout was the third most expensive fish at this landing site. Although glue from trout and snapper are high-value and high demand, there is no established market for these by-products at this landing site because fishes are typically sold un-gutted. Approximately eight species were low-value at this landing site with annual average prices of less than $100 GYD ($0.48 USD) per kilogram, all of which were also infrequently caught. In total, fishes sold at this landing site were valued at $29,997,072 GYD ($144,216 USD).

Fishes landed at this site are sold to vendors who have refrigerated trucks and visit the landing site on a daily basis and typically buy large quantities of the target species bangamary, butterfish, and trout. Snapper is also sold to trucks or local vendors at the site. Vendors would both export fishes and sell in local marketplaces. Locals from Mahaicony and other neighboring communities also visit the landing site to purchase fishes directly from fisherfolk when the vessels land.

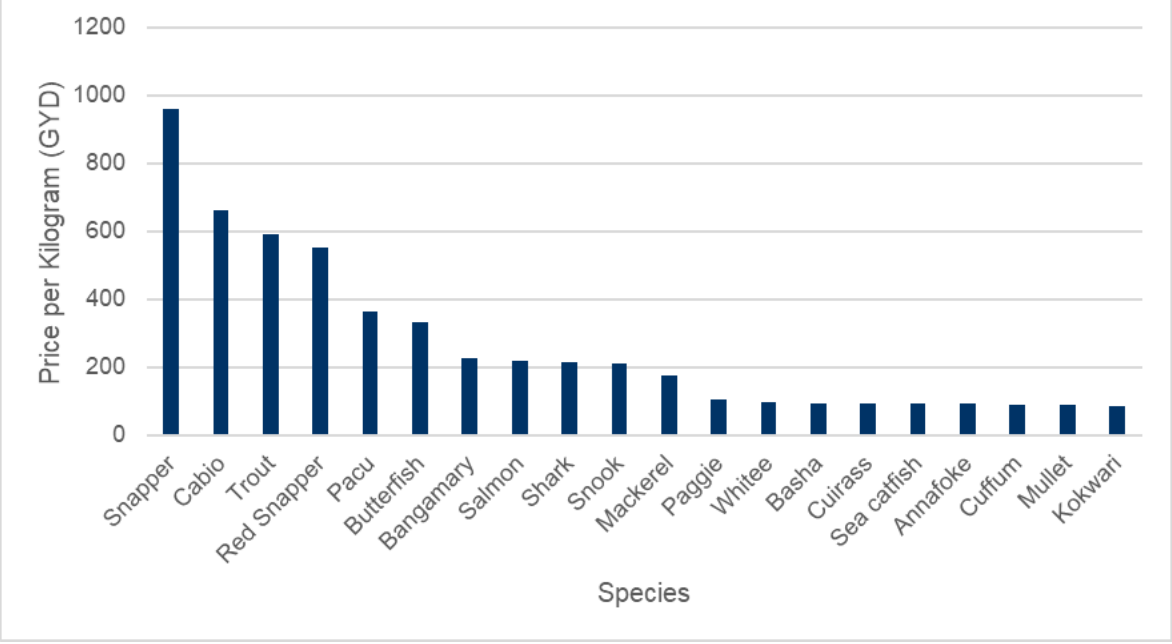


Figure P-5: Annual Average Prices per Kilogram of Fishes at the Mahaicony Bridge Landing Site

The minimum, maximum and average prices for the four most abundant species caught is shown on Figure P-6. Average prices for all four of these species was relatively stable throughout the year. However, there was a noticeable decline in the average prices from July to October 2019. This was the most productive consecutive period at this landing site and this decline could be attributed to the increase of supply. Maximum and average prices for bangamary and trout subsequently increased and peaked in December 2019 to February 2020. However, the price of trout did not increase following the price dip in July 2019 but remained at consistently low levels through to February 2020. It is likely that this was influenced by the high demand for the glue (swim bladders) from trout. Fisherfolk reported that the glue was being sold at a high price and this was an incentive to fisherfolk to increasingly target trout. As a result, there was an oversupply of this fish in the local marketplace that precipitated a decline in the price for the flesh of trout. This trend in pricing for trout was also observed at the Charity landing site (Region 2) and Riverview landing site (Region 4). Fisherfolk at the Charity landing site also indicated that oversupply of the fish as a result of the high prices of glue also contributed to the price decline.

The differences in maximum and minimum prices are attributed mainly to bargaining between fisherfolk and vendors. Some fisherfolk have indicated that they are able to bargain for better prices per kilogram when fishes are larger. This may be a contributing factor to the significant spike in maximum prices of basha in November 2019 (as seen on Figure P-6), given that average lengths and weights were higher in that month.

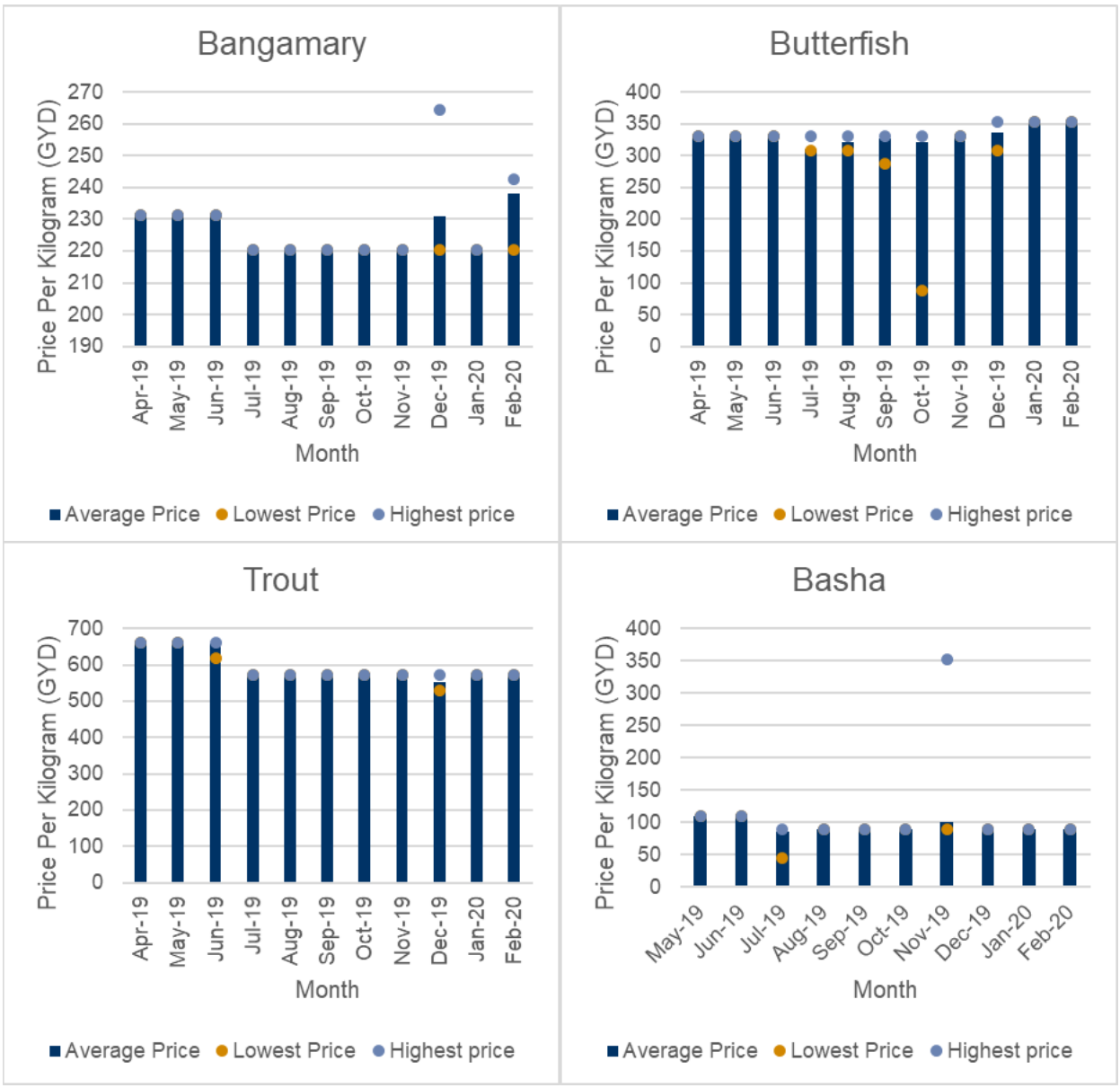


Figure P-6: Monthly Price Variations of the Four Most Abundant Species Caught

2.5 Biometrics

The regional supervisor measured the lengths and weights of fishes that were representative of hauls for which data were collected. The annual average length and weight of these fishes are shown on Figure P-7. The largest fish caught was the cuffum, which had an annual average length of 70 centimeters and annual average weight of 7,257 grams. The smallest species caught was the red snapper, which had an annual average length of 24.5 centimeter and annual average weight of 333 grams and would not be considered mature for the species. Most of the species caught at this landing site had achieved sizes of sexual maturity with the exception of the shark, which were immature.

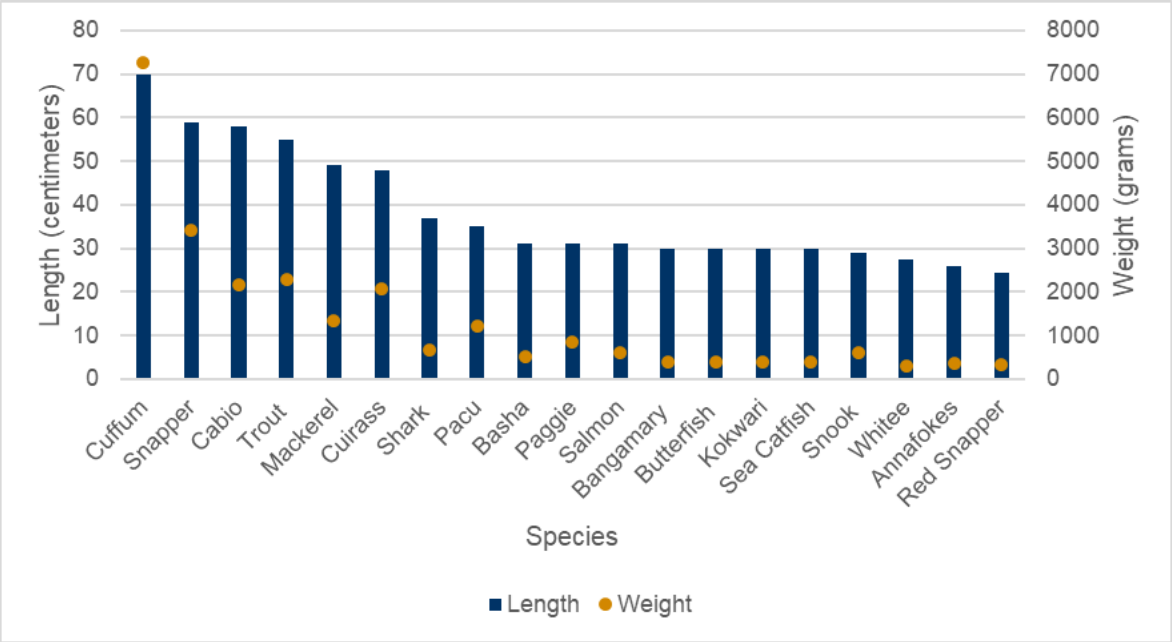


Figure P-7: Annual Average Lengths and Weights for Fishes Measured at the Mahaicony Bridge Landing Site

The supervisor did not measure the lengths and weights of fishes for the months of April, May, June, and October 2019. The monthly variations in the average lengths and weights of the four most abundant species caught for the months in which data were collected is shown on Figure P-8. The sizes of trout and butterfish peaked in August 2019 with average lengths of 60 and 31 centimeters, respectively. This adheres to the expected trends of larger fishes, typically spawning females coming closer to shore to spawn during the July to September period. However, the largest bangamary and basha were caught in December 2019. This is unusual and could be a result of the relatively small pool of data.

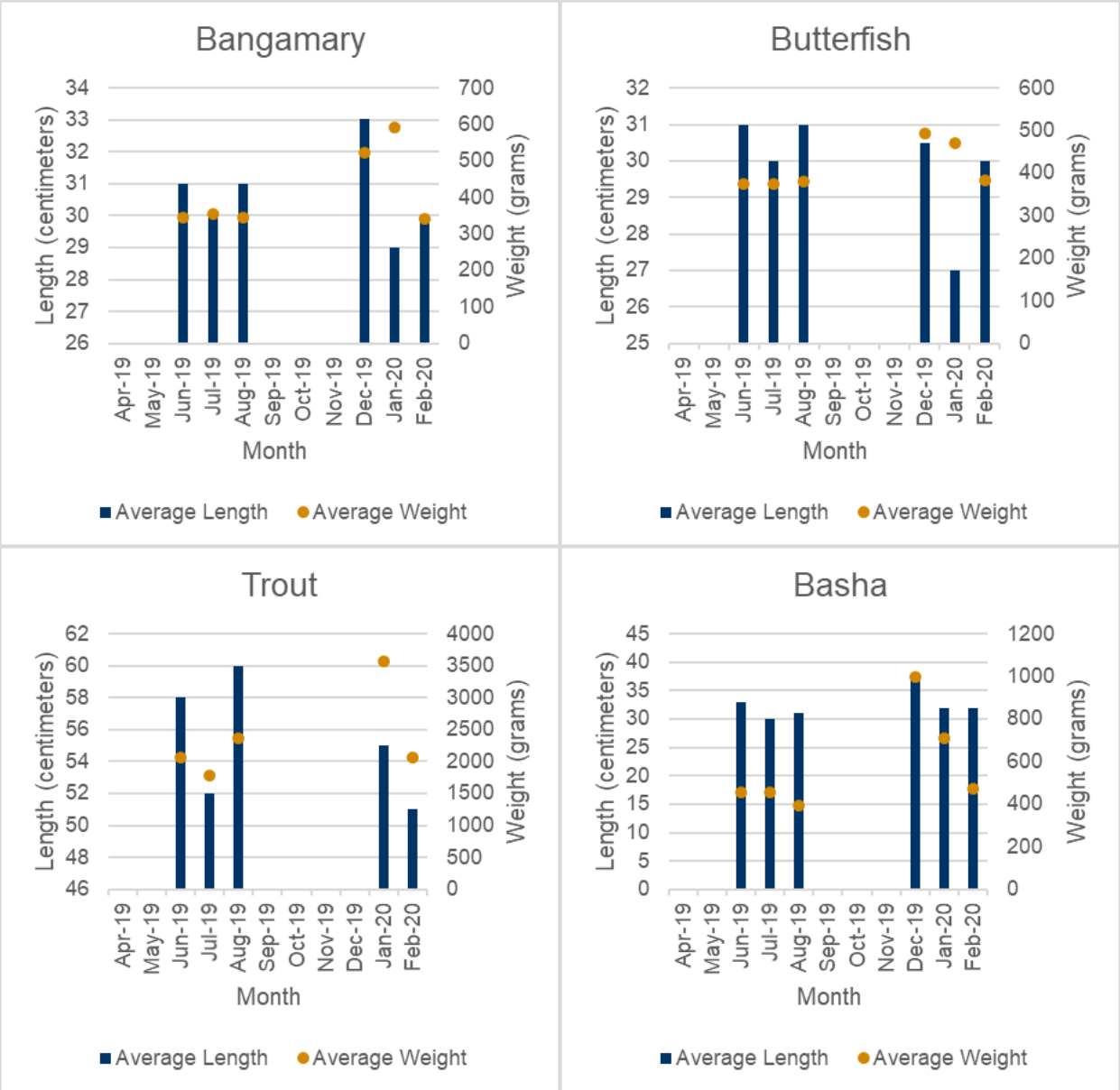


Figure P-8: Monthly Average Lengths and Weights of Most Abundant Species Caught

3 QA/QC DATA

During the first QA/QC exercise conducted in September 2019, one vessel that landed at the site was assessed. The vessel used a bangamary seine, which is typical of most vessels operating at the landing site. The vessel that was assessed had conducted a 2-day fishing trip along the coastline of Mahaicony and Abary during which time the seine was soaked three times.

The data collected from this haul generally matched the trends that were evident in the data collected by the regional supervisor. Bangamary was by far the most abundant species caught (Figure P-9). Trout was the second most abundant species caught by a slight margin, but this is not typical of bangamary vessels. Biometric measurements were also consistent with the trends reported by the regional supervisor and all

species may be considered sexually mature (Figure P-10). No bycatch was observed on the vessel by the study coordinator and likewise.

During the QA/QC exercise in January 2020, another vessel was assessed. The vessel also used a bangamary seine and had spent 2 days at sea. Total haul was 415 kilograms (914 pounds). This deviated significantly from the data recorded by the regional supervisor during January 2020 where vessels had average hauls of 141 kilograms (310 pounds). However, the QA/QC exercise was conducted relatively early in January, and it is likely that the haul was representative of trends from December 2019 when hauls averaged 400 kilograms (881 pounds). Catch composition included the three main target species of bangamary, butterfish, and trout. Bangamary represented 89 percent of the total haul, butterfish 10 percent, and trout 0.6 percent. This is similar to the proportions of these fishes in the data collected by the regional supervisor.

Prices recorded during the QA/QC exercise did not vary significantly from those recorded during this month by the supervisor. Bangamary, snook, and trout had prices of $220, $308, and $485 GYD ($1.00, $1.40, and $2.30 USD) per kilogram, respectively, during the QA/QC exercise. The recorded average prices for the species with data provided by the supervisor were $220, $353, and $573 GYD per kilogram ($1.00, $1.70, and $2.80 USD) for the bangamary, snook, and trout.

Biometric data collected during the QA/QC exercise for 30 centimeters for both bangamary and butterfish and 68 centimeters for trout. The average lengths of these species based on the data collected by the regional supervisor showed small variations during this month as bangamary measured 29 centimeters, butterfish measured 27 centimeters, and trout measured 55 centimeters. Overall, the study coordinator was satisfied that the regional supervisor was accurately recording the commercial species caught and is following the guidance provided in taking biometric measurements.

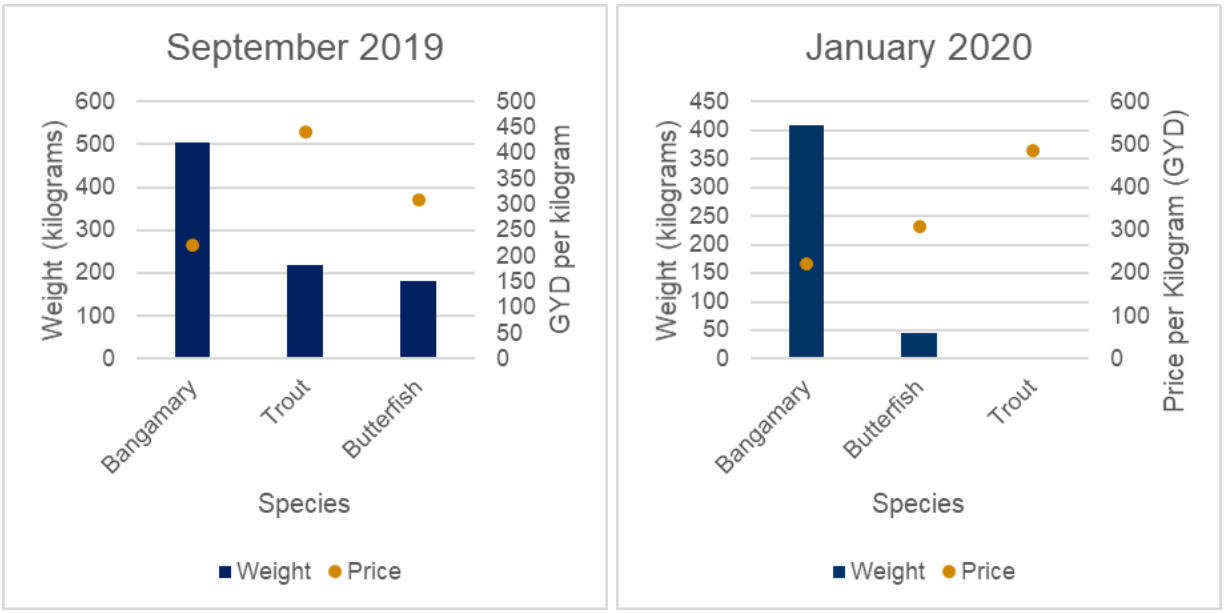


Figure P-9: Catch Composition of Commercially Viable Species during the QA/QC Exercises

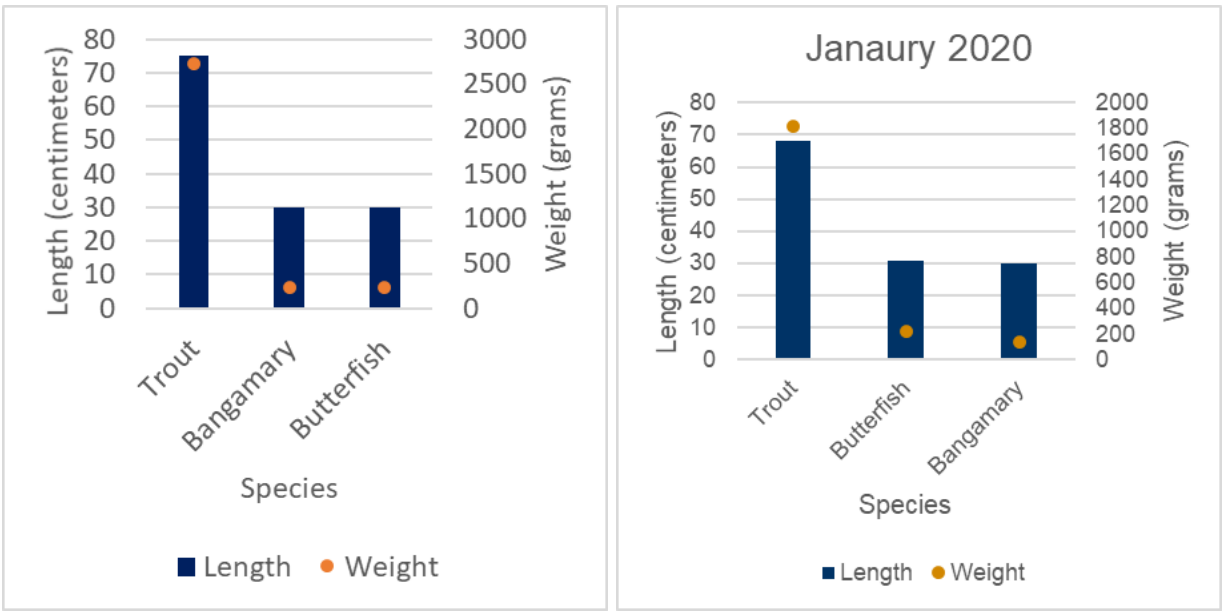


Figure P-10: Lengths and Weights of Fishes Measured during the QA/QC Exercises

APPENDIX Q BUSHLOT (REGION 5)

1 LANDING SITE OVERVIEW

Bushlot is the only landing site in Guyana at which most of the vessels are sail vessels, as fishing with sails is a dying art in the country. Fisherfolk indicated that 20 sail vessels are operational at this landing site year-round, but approximately 40 vessels use the landing site during peak fishing seasons. Although the vessels primarily use sails, some are also fitted with small outboard cruisers of 5 to 15 hp.

Fisherfolk use drift seines of 6.3 to 18 centimeters (2.5 to 7 inches) mesh size. Fisherfolk at this landing site fish about 3 to 4 kilometers off the Bush Lot beach at depths of about 1 to 4 meters. They have soak times ranging between 2 to 6 hours. Fishing trips generally cost $2,000 GYD ($10 USD).

The typical yield from a fishing trip is 27 kilograms (60 pounds). The main species caught at this site are cuffum, cuirass, bangamary, trout, and paggie that are sold as ‘mixed fish’ for $180 GYD ($0.8 USD) per kilogram. Higher valued species like snapper and trout are also caught at this landing site, and prices vary seasonally. Previously, the catch was sold to trucks that came to the site to purchase. However, the access road to the landing site is in a significantly deteriorated state, and fisherfolk now have to transport their catch to the villages for sale. Fisherfolk shared challenges of launching and landing vessels due to an accretion of mud at the landing site and also reported that rough seas were a common challenge that disrupted their fishing activities.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor from Bushlot uses drift seines with mesh sizes of 11 centimeters (4.5 inches), 13 centimeters (5 inches), and 18 centimeters (7 inches) to target larger species of fish such as snapper and trout. The supervisor explained that the choice of gear per fishing trip is determined by recent success using either of the drift seines and hauls from other fisherfolk who land at the site. Sails are used mainly to eliminate fuel expenses; however, this method is not as efficient as using an engine and may be very time consuming. In addition, there are generally no clearly defined routes to the preferred fishing ground as vessels move with winds. As a result, the onboard supervisor also has a 15 hp engine to be used as a backup in the event of an emergency requiring quick return to shore, or if challenged by unfavorable winds. Each fishing trip lasts for approximately 12 hours and each trip has a crew of 2. Hauls from the onboard supervisor are sold to local vendors or transported by the onboard supervisor to the Rosignol landing site for sale.

Due to the accretion of mud on the landing site, the supervisor frequently relies on the high tides to leave and return to the landing site. In September 2019, the spring tides prevented the onboard supervisor from conducting the number of fishing trips that were planned for that month. The onboard supervisor also encountered significant challenges with the proliferation of sargassum during February to May. The supervisor also reported that occasionally significant quantities of seagrass are also caught in his seines.

2.1 Target Species and Diversity

The total weights of combined hauls from the onboard supervisor’s vessel over the period May 2019 to February 2020 was 4,485 kilograms (9,888 pounds), and 1,922 hours of effort was expended. Cuirass and snapper were the most abundant species caught (see Figure Q-1). Cuirass accounted for 28 percent of the total catch with 1,287 kilograms (2,837 pounds) while snapper accounted for 27 percent of the total catch with 1,211 kilograms (2,670 pounds). The third and fourth most abundant species caught were paggie and mullet, which accounted for 12 percent and 10 percent of the total haul, respectively. Overall, 22 commercial species were recorded by the onboard supervisor of which 13 were caught in relatively low quantities of 50 kilograms (110 pounds) or lower. The supervisor reported bycatch comprised of seaweed, sea bats, and stingrays (some of which are endangered, threatened, and protected species).

However, the supervisor indicated that stingrays and sea bats caught in the seines are released because it is recognized that the numbers of these species are declining in Guyana.

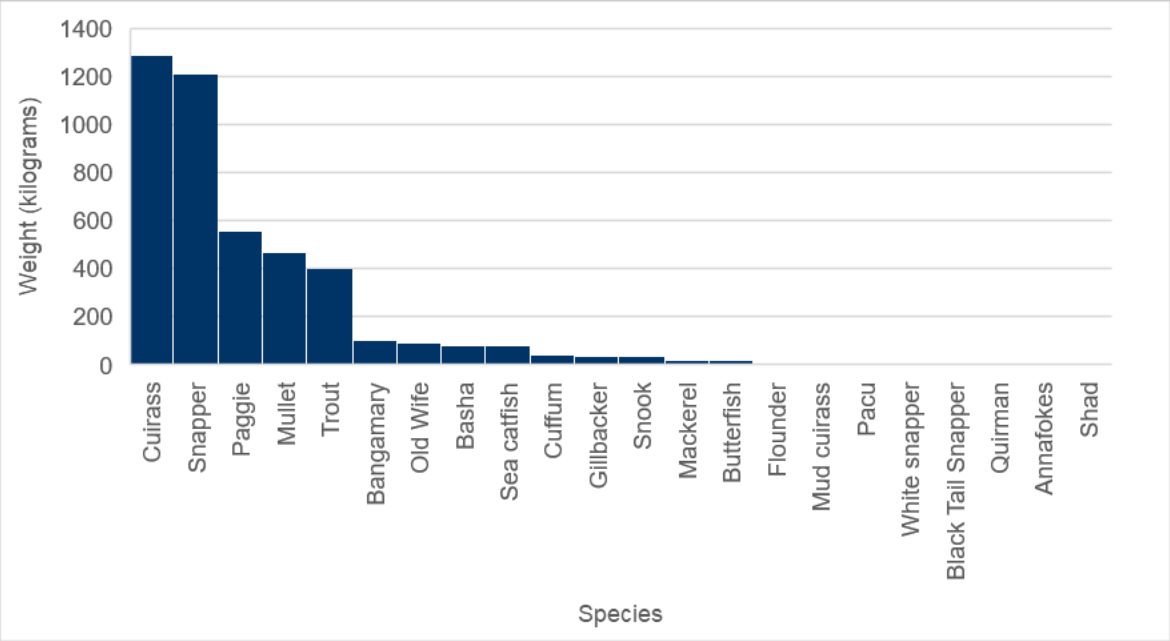


Figure Q-1: Total Weight of Species Recorded by the Bushlot Onboard Supervisor

2.2 Fishing Areas

The main fishing area used by vessels operating from Bushlot is 100 square kilometers. Overall, the onboard supervisor had a traveling range of 255 square kilometers along the west coast of the Berbice River. Figure Q-2 shows the fishing points in the seasons that were considered by the onboard supervisor as the peak/good season (May to September 2019) and off-peak/hard season (October 2019 to February 2020) at the outset of the study program. During the May to September period, the onboard supervisor consistently traveled farther offshore for fishing activities. Moreover, the farthest distance offshore was traveled for fishing in the May to September period. Specifically, the farthest distance traveled in May to September for fishing was 11.5 kilometers offshore while the farthest distance traveled for fishing in October 2019 to February 2020 was 8.5 kilometers. The closest fishing point to the shoreline was observed in September 2019, where the onboard supervisor fished just 0.25 kilometer from shore.

The onboard supervisor expended significantly greater effort in May to September, which was evidently due to fishing activities being conducted farther offshore. Several factors determined where the onboard supervisor decided to soak the seines. These factors include the amount of fishes caught in these locations before, time and distance traveling to and from fishing grounds, and the presence of other fisherfolk or fishing activities in the area. In addition, the calmer seas reported to prevail during the May to September period would have allowed longer distances to be traversed more easily by the supervisor's sailboat.

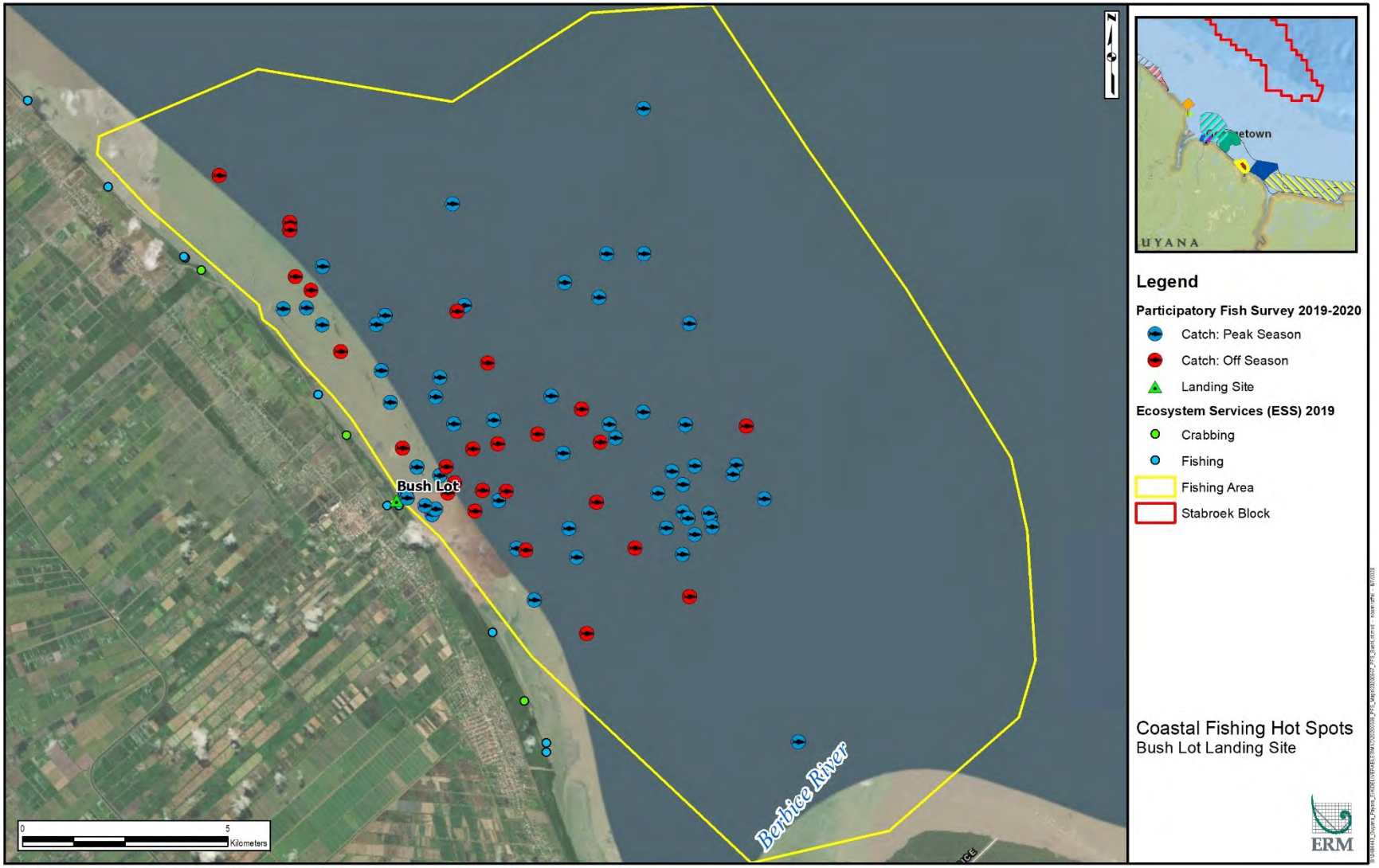


Figure Q-2: Fishing Area and Fishing Points Used by the Bushlot Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

During the study period, the onboard supervisor spent an average at 192 hours per month fishing but there were variations in the effort expended per fishing trip on a monthly basis as seen on Figure Q-3. The onboard supervisor’s monthly effort peaked in July 2019 with 299 hours of fishing activity. The lowest effort was expended in September 2019 when 113.5 hours were spent fishing, but this reduced effort was due to the spring tides that prevented the supervisor from going to sea.

As seen on Figure Q-4, the greatest total hauls were recorded in November 2019 with 750 kilograms (1,653 pounds). The highest average weight of hauls per soaking was recorded in January 2020 with 40 kilograms (88 pounds) as seen on Figure Q-5. This is unusual as both of these months are part of the hard season for fishing. Moreover, the lowest average weight of hauls per soaking was in August 2019, which was expected to have been the peak month for fishing at this landing site, with 14 kilograms (31 pounds). Except for September 2019 when fishing activities were curtailed by the spring tides, the lowest total haul was observed in August 2019 with 270 kilograms (595 pounds).

Seasonal variations in effort and productivity were observed as follows:

- In the May to September 2019 good season, the total weight of hauls was 1,798 kilograms (3,964 pounds) with 1,031 hours spent at sea. On average, soaking of the seine in this period yielded 20 kilograms (44 pounds). Within this period, the average weight of hauls consistently declined over June to August. Moreover, although effort increased in July 2019, the total monthly haul declined due to the lower productivity per soaking. Productivity further declined in August 2019 to the lowest levels recorded at this landing site.

- In the October 2019 to February 2020 hard season, total weight of hauls was 2,687 kilograms (5,923 pounds) with 891 hours spent at sea. On average, soaking of the seine in this period yielded 33 kilograms (73 pounds). In particular, total hauls and average productivity per soaking were consistently high from November 2019 to February 2020. Compared to the May to September 2019 season, total hauls were greater, soakings more productive on average, and overall effort lower.

By comparison, seasonal trends in the wet and dry season were as follows:

- In August to October 2019, the primary dry season, total weight of hauls was 787 kilograms (1,735 pounds) with 551 hours spent at sea. On average, the seine yielded 17 kilograms (37 pounds) per soaking in this period.

- In May to July 2019, the primary wet season, total weight of hauls was 1,376 kilograms (3,034 pounds) with 372 hours spent at sea. On average, the seine in this period yielded 25 kilograms (55 pounds) per soaking in this period.

- In November 2019 to January 2020, the secondary wet season, total weight of hauls was 1,776 kilograms (3,915 pounds) with 524 hours spent at sea. On average, the seine yielded 36 kilograms (79 pounds) per soaking in this period.

- In February 2020, which is considered within the secondary dry season, the total weight of hauls was 546 kilograms (1204 pounds) with 176 hours spent at sea. On average, soaking of the seine in this

period yielded 34 kilograms (75 pounds). In addition, data collection at this site did not commence until May 2019 and therefore, there will be a data gap for April to complete this season.

Based on the trends seen above, there appears to have been a reversal of the good and hard seasons at this landing site. Specifically, the average weight of hauls per fishing trip was lower than 30 kilograms (66 pounds) from May to October 2019. However, productivity was consistently higher over the November 2019 to February 2020 period. The supervisor indicated that this reversal in seasonality has occurred previously and that this is the second consecutive year in which this was observed. However, the supervisor was unable to offer any reasons as to why this would have been observed. Data collected from onboard supervisors at the Albion (Region 6) and Complex 66 (Region 6) landing sites also show unseasonably high productivity over the October 2019 to February 2020 period. Additional data are needed from this landing site to determine what factors could have contributed to this reversal.

Based on the differences observed in the good and hard seasons, productivity based on climatic seasonality also changed relative to the other seasons. As a result, the average weight of hauls during the primary wet and dry seasons were significantly lower than in the secondary wet season and February 2020 (the only month of the secondary dry season for which data are available). In addition, total hauls in the primary wet and dry seasons were lower than the total hauls in the secondary wet season.

The trends in seasonal productivity may also explain why effort peaked in July 2019. Several other onboard supervisors expended peak effort in November and December 2019, the hard season, including at landing sites in Lima (Region 2), Windsor Forest (Region 3), La Grange (Region 3), Riverview (Region 4), Ogle (Region 4), Rosignol (Region 5), and Albion (Region 6). Only the onboard supervisor from the Complex 66 landing site also expended the greatest effort in July 2019. Given that productivity was declining, the onboard supervisor may have decided to expend greater effort on fishing to increase the total monthly haul and this may have been accomplished with relative ease because waters are generally calmer and more conducive to fishing. Overall, the trends observed at this landing site highlight that conventionally held beliefs about seasonality are not necessarily applicable at all times and places in Guyana.

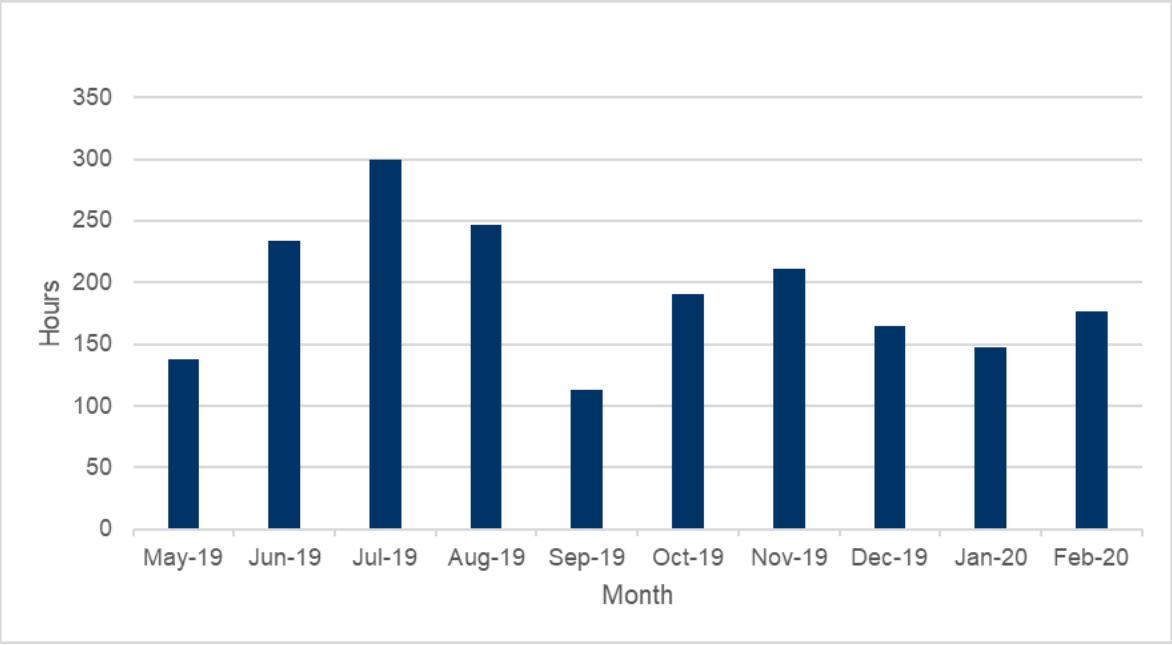


Figure Q-3: Total Monthly Fishing Effort Recorded by the Bushlot Onboard Supervisor

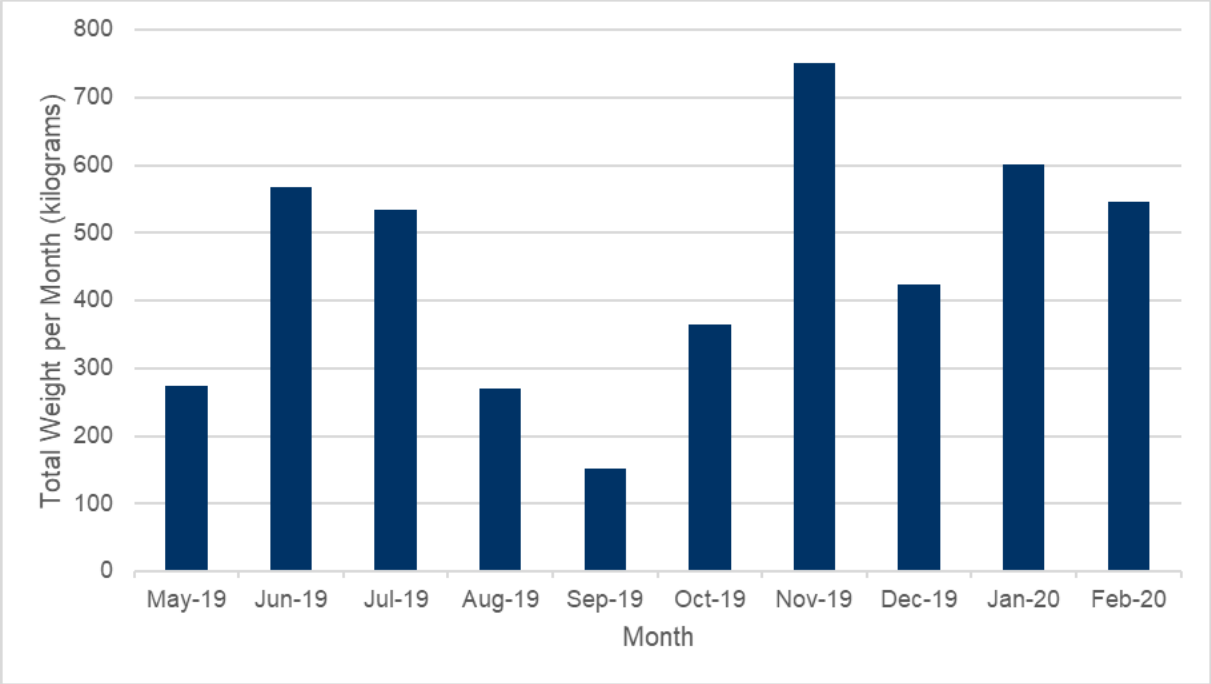


Figure Q-4: Total Monthly Weight Recorded by the Bushlot Onboard Supervisor

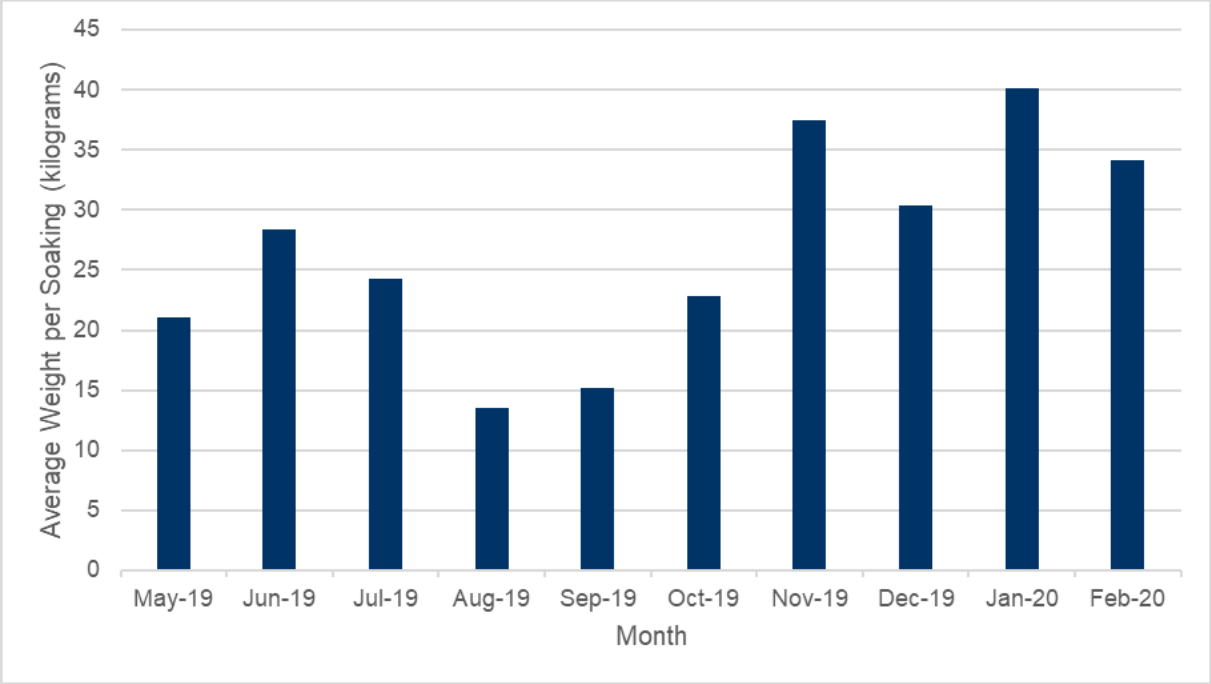


Figure Q-5: Average Weight per Soaking Recorded by the Bushlot Onboard Supervisor

2.4 Biometrics

The onboard supervisor measured the lengths and weights of representative fishes per each haul and the annual average lengths and weights of these fishes are shown on Figure Q-6. Based on the measurements taken by the onboard supervisor, most of the fishes caught were sexually mature. The two most abundant species caught were also mature with snapper reaching annual average lengths of 67 centimeters and cuirass 58 centimeters. These larger fishes were caught because the onboard supervisor used the drift seine with mesh sizes of 18 centimeters (7 inches) most frequently. However, the annual average length of bangamary was 23 centimeters indicating that hauls of this fish were mainly juveniles. This was unexpected given that the mesh sizes of the seines used by the supervisor is larger than those on the bangamary seines from which hauls typically comprise mature fish. Additional data collection by this supervisor will allow for a better understanding of how often juvenile bangamary is typically caught at Bushlot.

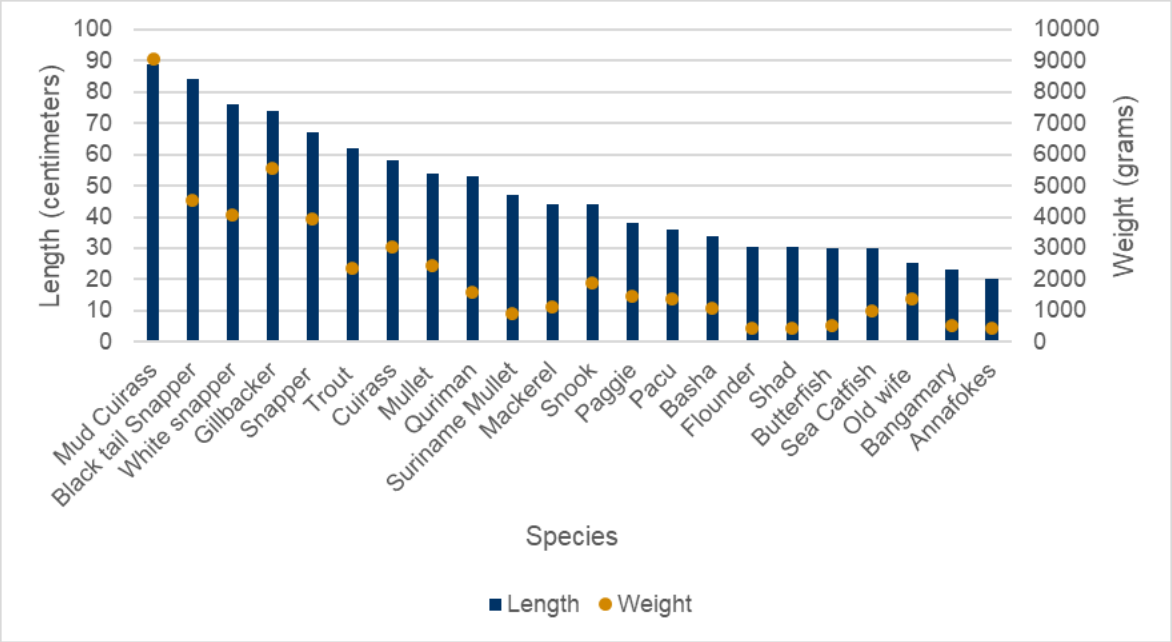


Figure Q-6: Average Length and Weight of Fishes Caught by the Bushlot Onboard Supervisor

The monthly average lengths and weights of the four most abundant species caught are presented on Figure Q-7. All the fishes measured had reached maturity. The largest sea catfish, cuirass, and gillbacker were caught in June and July 2019, after which there was a decline in sizes. This may have been due to more mature females with eggs coming closer to the shoreline to spawn in lagoons, estuaries, and mangroves during June and July. This trend is also seen in the data recorded at several other landing sites, like Smith's Creek (Region 1) and Charity (Region 2) where smaller fishes are caught when the spawning season ends. Mullet was only caught during September 2019 to February 2020. This may be related either to the fishing grounds preferred by the supervisor during this period or an interception of migratory mullet.

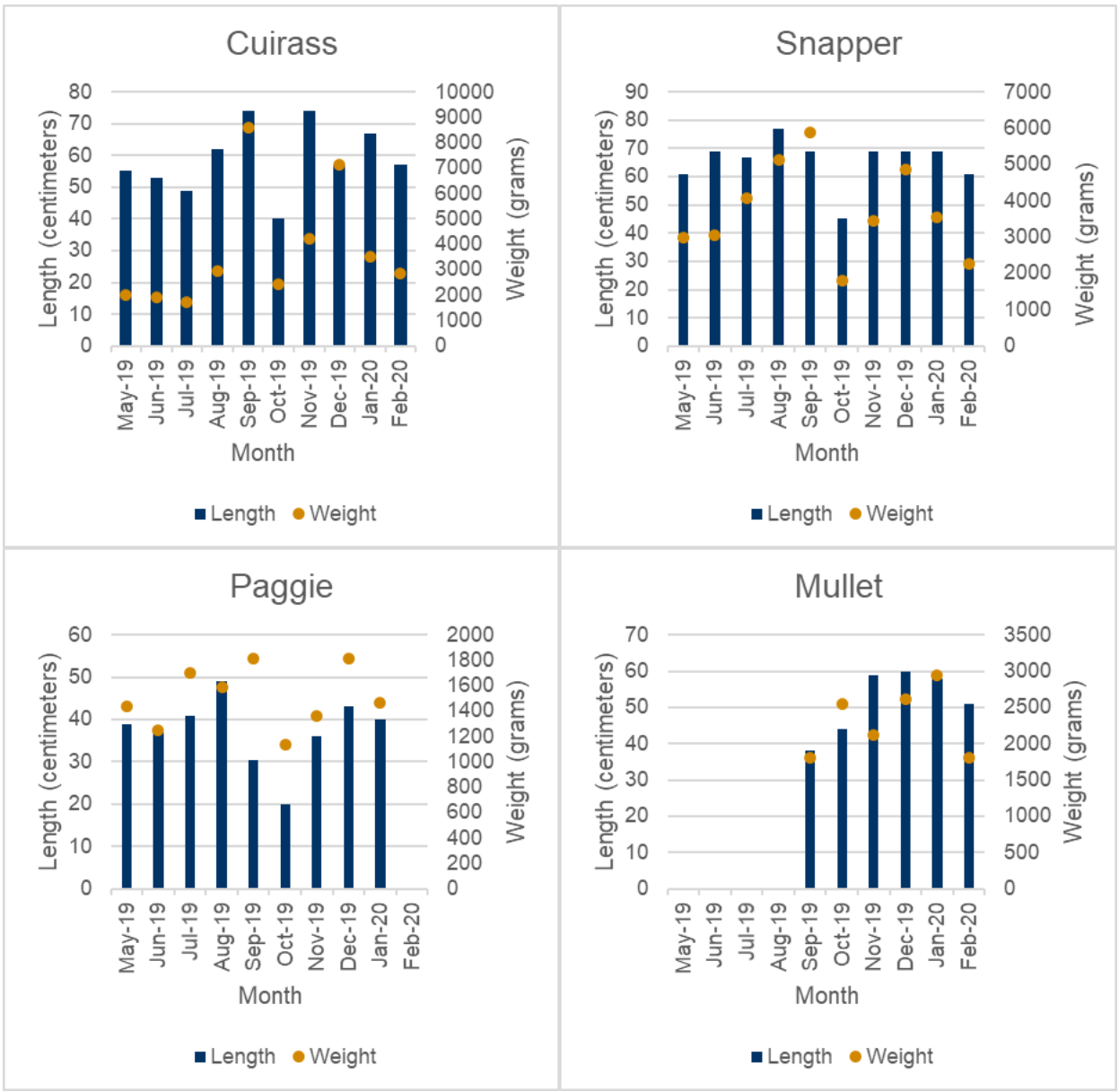


Figure Q-7: Total Weight of Species Recorded by the Bushlot Onboard Supervisor

3 QA/QC DATA

The first QA/QC exercise was conducted in October 2019 for one of the fishing trips conducted by the onboard supervisor. During this trip, the supervisor spent 14 hours at sea and fished along the Bush Lot coastline using a drift seine with mesh sizes of 12.7 centimeters (5 inches). The most abundant species caught during this fishing trip were cuirass and paggie (see Figure Q-8).

During the second QA/QC exercise in January 2020, a GoPro camera was installed on the vessel belonging to the onboard supervisor from the Bushlot landing site (see Figure Q-9). Several key observations were made from the video monitoring:

- The supervisor used drift seines with mesh sizes of 11 centimeters (4.5 inches). This seine had smaller mesh sizes than the most frequently used, which was 18 centimeters (7 inches), or the seine

used during the first QA/QC exercise that had mesh sizes of 12.7 centimeters (5 inches). The onboard supervisor did not use other methods to fish.

- The supervisor using the sail boat traveled to the fishing site in 30 minutes. The site was noticeably close to shore as the shoreline was still clearly visible in the video.
- The seine was soaked twice. The first was made at 1330 hours and left for 4 hours. During this soaking, the supervisor actually swam to shore to recover floats. Upon return to the vessel, the sea level was so shallow that the supervisor waded back to the vessel. The seine was soaked for a second time at 1830 hours and was left overnight while the onboard supervisor slept on the vessel.
- The catch from the first haul of the seine was stored on ice overnight in the vessel.
- The entire trip lasted for 18 hours.
- No bycatch were observed.

During the QA/QC exercise, the supervisor recorded a total haul of 40 kilograms (88 pounds) during the two soakings. This showed a deviation from the average recorded in the month of January 2020 by the supervisor, which was 40 kilograms (88 pounds) for only one soaking. However, this may have been a less productive fishing trip. The average haul per soaking in December 2019 was 30 kilograms (66 pounds). The differences in the haul may also be due to the distance at which the fishing was conducted relative to the shore and to the mesh sizes of the seines used. In addition, there were no significant deviations in catch composition or species diversity. However, the use of seines with smaller mesh sizes allowed the capture of smaller species such as the Suriname mullet.

During both of the QA/QC exercises, the study coordinator also took biometric measurements of the same fishes that were measured by the onboard supervisor and no data deviations were observed (Figure Q-10). Overall, the study coordinator was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

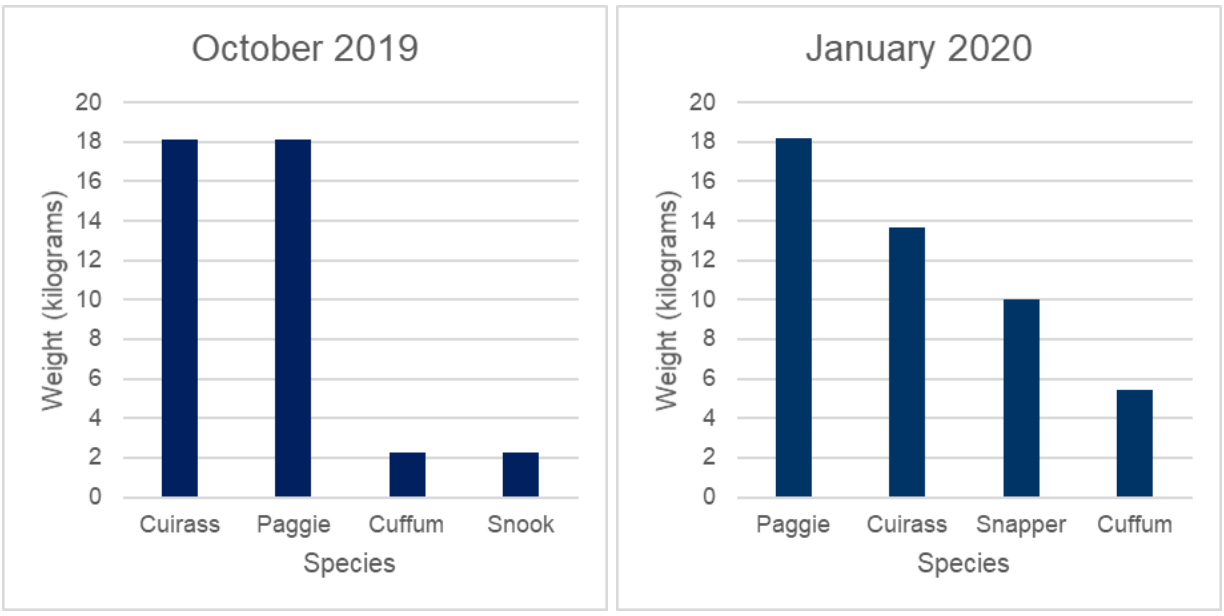


Figure Q-8: Catch Composition of Commercially Viable Species during the QA/QC Exercises

Figure Q-9: The Study Coordinator Mounting the GoPro Camera at the Bushlot Landing Site

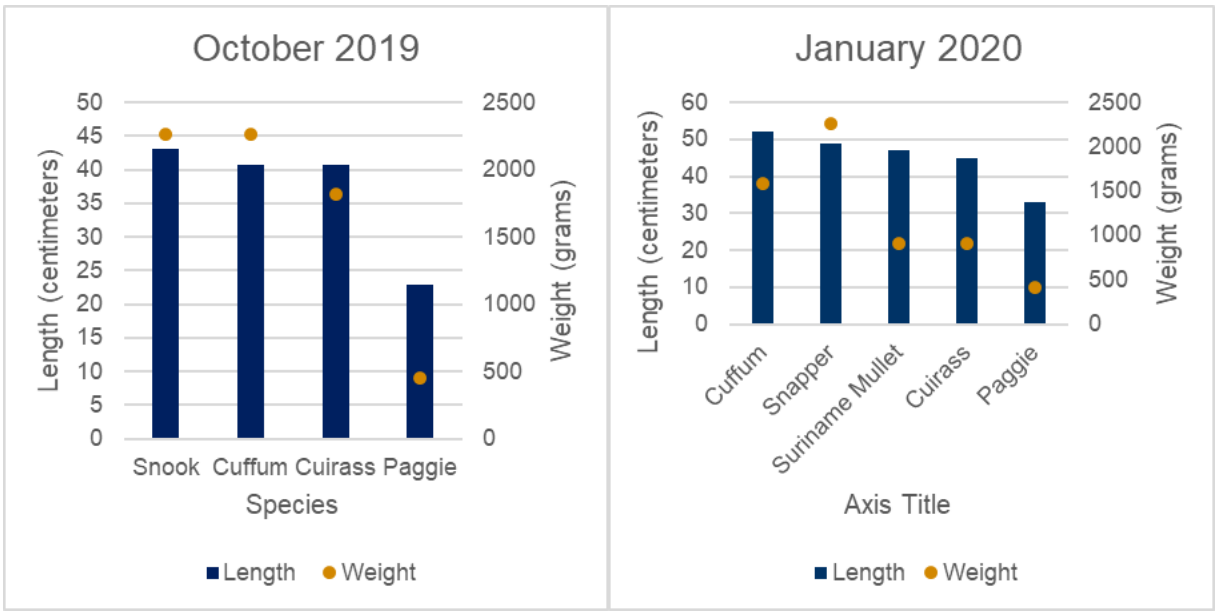


Figure Q-10: Lengths and Weights of Fishes Measured during the QA/QC Exercises

APPENDIX R ROSIGNOL (REGION 5)

1 LANDING SITE OVERVIEW

Rosignol is the largest landing site in Region 5, and a cooperative called the Rosignol Fishermen's Cooperative Society (RFCS) manages the site. According to the RFCS, more than 40 vessels use this landing site, use a range of fishing gear, and are outfitted with outboard engines of 25 to 60 hp. Fishing trips by large vessels with 60 hp engines are at a distance of about 24 kilometers (14.9 miles) from the coastline and 27 meters (88.6 feet) of depth. These larger vessels may spend up to 2 weeks at sea. Smaller vessels usually fish up to 5 kilometers (3.1 miles) from the coastline and up to 5 meters (16.4 feet) of depth, and generally return to port daily. Fisherfolk reported soak times of 2 to 6 hours.

Species caught at this site are characterized as "mixed fish" including bangamary, trout, basher, gillbacker, snapper, shark, etc. Larger vessels have a yield of up to 454 kilograms (1,000 pounds) per trip that is sold at the landing site for $600 to $1,600 GYD ($2.9 to 7.7 USD) per kilogram depending upon the season. The main expense is fuel with fishing trips costing about $5,000 GYD ($24 USD) for smaller vessels and $240,000 GYD ($1,148 USD) for the larger vessels that spend extended periods at sea.

Fisherfolk at this landing site indicated that one of the main challenges they encounter is conflicts with trawlers and the risks of pirate attacks while at sea. Fisherfolk also contended that overfishing is prevalent and has depleted fish stocks. As a result, greater effort is required by fisherfolk to achieve hauls that make their fishing practice economically feasible.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor at this landing site who participated in the study targeted snapper during the study period. The onboard supervisor at this landing site used drift seines of 4.5, 5, and 7.5 inches (10, 13, and 19 centimeters, respectively) mesh sizes on an alternating basis. The selection of gear type is based largely on the supervisor's experience of which fishes are typically more abundant at certain time periods and also by recent success using particular gear types. During the study period of June 2019 to February 2020, the drift seines with mesh sizes of 19 centimeters (7.5 inches) was most frequently used with the target species of snapper and trout. The vessel has a haul capacity of 450 kilograms (992 pounds) and is powered by a 60 hp engine. Each fishing trip lasts for approximately 10 days and has a five-member crew.

The onboard supervisor uses a variety of fishing grounds extending up to the Demerara River to the west and eastward into Surinamese waters. The main expenses per fishing trip are for rations for the crew, fuel, and ice for the preservation of the haul. Hauls from the onboard supervisor are sold to vendors who visit the landing site to purchase fishes for export and local sale. The supervisor did not encounter any challenges that significantly affected fishing practices during the study period.

2.1 Target Species and Diversity

The total weights of combined hauls from the onboard supervisor's vessel over the period April 2019 to February 2020 was 3,949 kilograms (8,706 pounds) from 2,208 hours of effort during the study period. The most abundant species caught was snapper, with a total weight of 1,963 kilograms (4,328 pounds) representing 50 percent of the supervisor's haul (see Figure R-1). The second and third most abundant species caught were trout and cuirass, respectively. Trout had a total weight of 586 kilograms (1,291 pounds), which accounted for 14 percent of the total haul, while cuirass had a total weight of 548 kilograms (1,208 pounds) accounting for 13 percent of the total haul. Snapper and trout were the two most abundant species caught at landing sites in Charity (Region 2) and Complex 66 (Region 6) as well, where drift seines with mesh sizes of 18 centimeters (7 inches) was used. Similarly, cuirass was the most abundant species caught at the Bushlot landing site (Region 5) where the main type of gear used by the

onboard supervisor was drift seines with mesh sizes of 18 centimeters (7 inches). Overall, 13 species were caught, six of which were caught in low quantities of 100 kilograms (220 pounds or lower). Among these six least-caught species were bonito fish, a species of small tuna that was not recorded by any of the other regional or onboard supervisors.

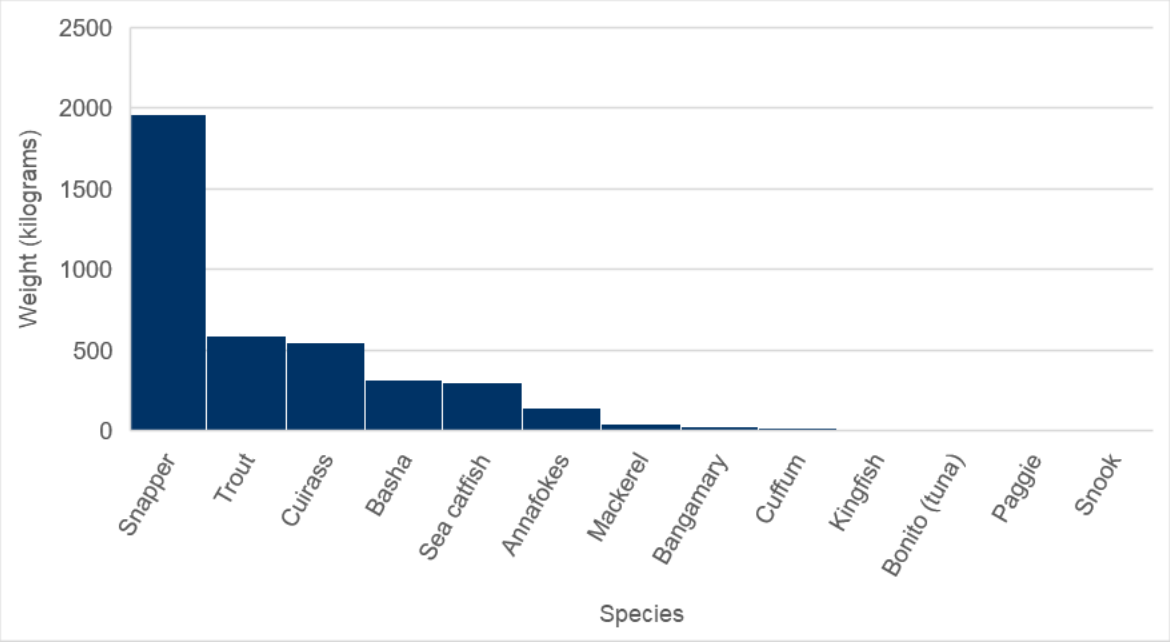


Figure R-1: Total Weight of Species Recorded by the Rosignol Onboard Supervisor

2.2 Fishing Areas

The onboard supervisor covers the second largest traveling range within the study participants with 6,076 square kilometers. Due to the expanse of the traveling range, fishing points were observed around main clusters, all of which were located around the mouths of rivers:

- The largest cluster covered an area of 1,743 square kilometers with fishing points at the mouths of the Mahaica and Berbice rivers, and also along the Region 5 coastline between these two rivers. Most of the fishing points in the hard season were located in this cluster particularly around the mouth of the Mahaica River.
- The second largest cluster covered an area of 1,015 square kilometers with fishing points around the mouth of the Corentyne River.
- The smallest cluster covers an area of 546 square kilometers with fishing points around the Coppename River in Suriname. These fishing grounds were approximately 191 kilometers from the landing site, the farthest the onboard supervisor traveled to access the fishing grounds. Fishing was only conducted at these fishing points during the good/peak season.

Based on the spread of the fishing points, there are clear seasonal patterns in the onboard supervisor's fishing activities as seen on Figure R-2. In particular, the onboard supervisor fished farther offshore and farther away from the landing site during the peak season. Waters are reportedly calmer during this period and therefore, more conducive to traversing greater distances. However, greater effort was expended by the supervisor during the off-peak season indicating that there were longer fishing trips likely

due to more effort and also rough seas that would have hampered normal traveling for the supervisor. Additionally, the onboard supervisor indicated that initial soakings of the seine did not yield economically viable hauls and as a result, more time was spent at sea looking for alternative fishing grounds in which the seine could soaked again.

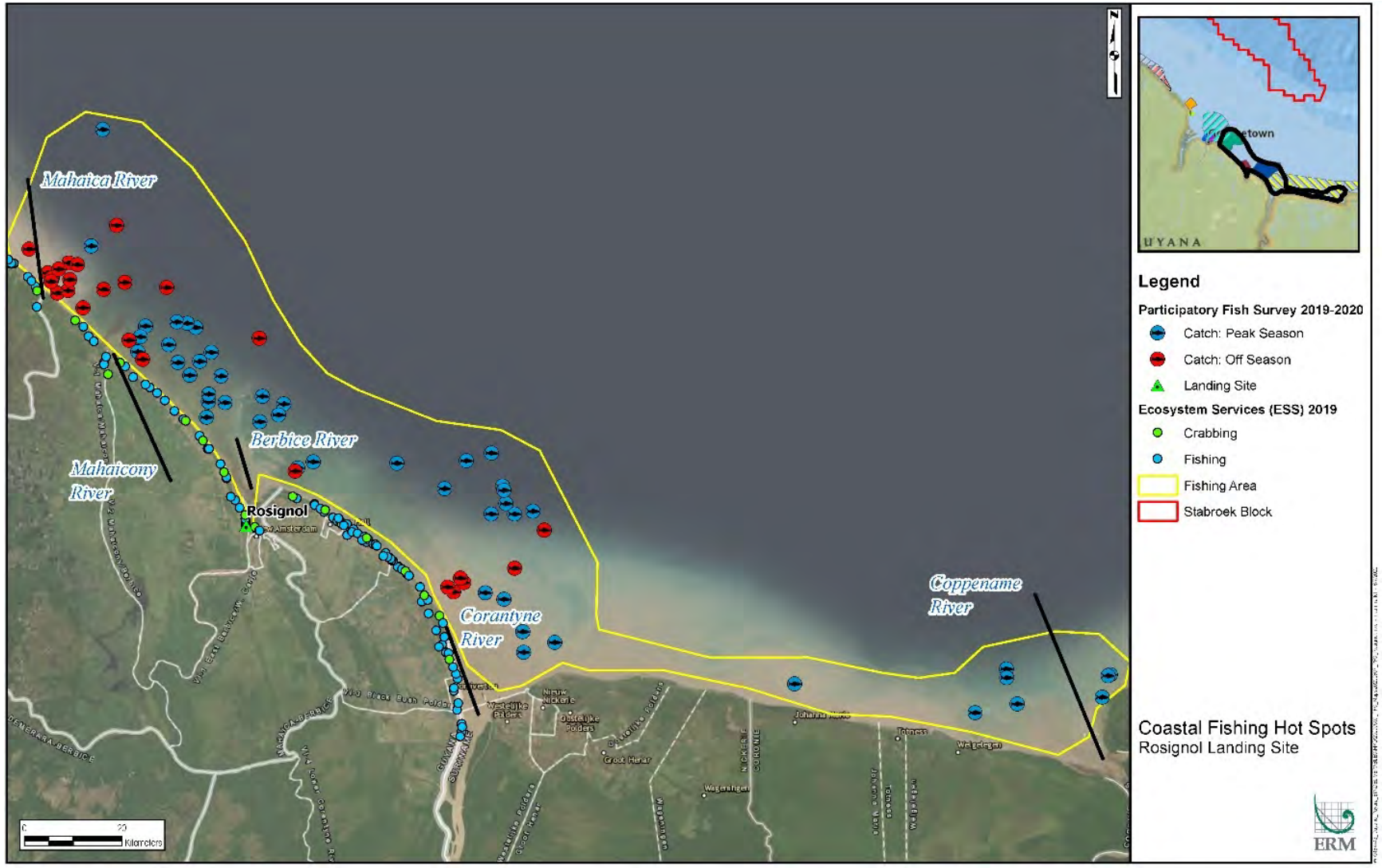


Figure R-2: Fishing Area and Fishing Points Used by the Rosignol Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

During the study period, the onboard supervisor spent an average of 245 hours per month fishing, but there were variations in the effort expended per fishing trip on a monthly basis as seen on Figure R-3. The onboard supervisor’s monthly effort peaked in December 2019 with 384 hours of fishing activity. The lowest effort was expended in June 2019 and February 2020 with 120 hours of fishing activity for both. As seen on Figure R-4, the greatest total hauls were recorded in August 2019 with 903 kilograms (1,991 pounds). The highest average weight of hauls per soaking was recorded in June 2019 with 172 kilograms (379 pounds) as seen on Figure R-5.

Seasonal variations in effort and productivity were observed as follows:

- In the June to September 2019 good season, the total weight of hauls was 2,793 kilograms (6,158 pounds) with 1,008 hours spent at sea. On average, soaking of the seine in this period yielded 79 kilograms (174 pounds). June to August was the most consistently productive period. June 2019 was particularly notable because it was the month in which the highest average weight per soaking was recorded, the month with lowest effort, and one of the months with the greatest total hauls.

- In the October 2019 to February 2020 hard season, total weight of hauls was 1,156 kilograms (2,548 pounds) with 1,200 hours spent at sea. On average, soaking of the seine in this period yielded 24 kilograms (53 pounds). Hauls were consistently lower throughout this season than in the good season. During this period, December 2019 had the greatest total haul, but it was also the month in which the onboard supervisor expended the greatest effort.

By comparison, seasonal trends in the wet and dry season were as follows:

- In August to October 2019, the primary dry season, total weight of hauls was 1,247 kilograms (2,749 pounds) with 696 hours spent at sea. On average, soaking of the seine in this period yielded 37 kilograms (82 pounds).

- In June to July 2019, the primary wet season, total weight of hauls was 1,704 kilograms (3,757 pounds) with 456 hours spent at sea. On average, soaking of the seine in this period yielded 116 kilograms (256 pounds).

- In February 2020, which is considered within the secondary dry season, the total weight of hauls was 109 kilograms (240 pounds) with 120 hours spent at sea. On average, soaking of the seine in this month yielded 21 kilograms (46 pounds). Data collection at this site did not commence until June 2019 and therefore, there will be a data gap for April to complete this season.

- In November 2019 to January 2020, the secondary wet season, total weight of hauls was 888 kilograms (1,958 pounds) with 936 hours spent at sea. On average, soaking of the seine in this period yielded 23 kilograms (51 pounds).

Based on the trends discussed above, productivity of fishing activities adhered to the belief of fisherfolk pertaining to the good and hard seasons. Average haul per soakings was also greater during the good

season as compared to the hard season. The trends also demonstrated that the relationship between effort expended and total haul is also ultimately determined by the seasons. In particular, in the hard seasons, greater effort is not an indicator of greater productivity, and in the good seasons, greater productivity required a disproportionate level of effort. For example, similar levels of effort were expended in June 2019 and February 2020, but the greater average weight of hauls per soaking in June 2019 resulted in significantly higher total hauls. On the other hand, while the greatest effort was expended in December 2019, it was not the month with the highest haul. Total hauls are expected to be greatest when high levels of total effort are expended when the average weight of hauls per soaking are the highest.

As a result of the higher productivity of the good season, productivity was also higher in the primary wet and dry seasons. These trends are evident although additional data are needed to complete the seasonal data sets for the primary wet season and the secondary dry season. Within the timeframes of the good and hard seasons, productivity of hauls was highest in the wet seasons. As such, it may be concluded that the hauls per soaking of the seine are most productive during the wet seasons because fishing is done primarily around the river mouths. According to Lowe-McConnel (1962), nutrient flows are increased during the wet season and fishes are expected to be more abundant at river mouths during this season.

However, as previously indicated, given the sharp decline in productivity in September 2019, the onboard supervisor has asserted that the good season may be shorter than is currently believed. Sharp reductions in productivity were also observed at other landing sites during the good season. For example, productivity sharply declined in August 2019 based on data collected from onboard supervisors at landing sites in Windsor Forest (Region 3) and Riverview (Region 4). The onboard supervisor asserted that the changes in productivity at the landing site, especially the shortening of the good season, coincided with the commencement of oil drilling activities offshore. It is believed that the noise, vibrations, and lights associated with drilling activities attract fishes to the vicinity of the drill sites thereby reducing the abundance in the fishing grounds preferred by artisanal fisherfolk. Additional data have to be collected to determine whether the reasons for these declines are localized to the landing site and whether there is indeed a varied periodicity of the good season at different landing sites.

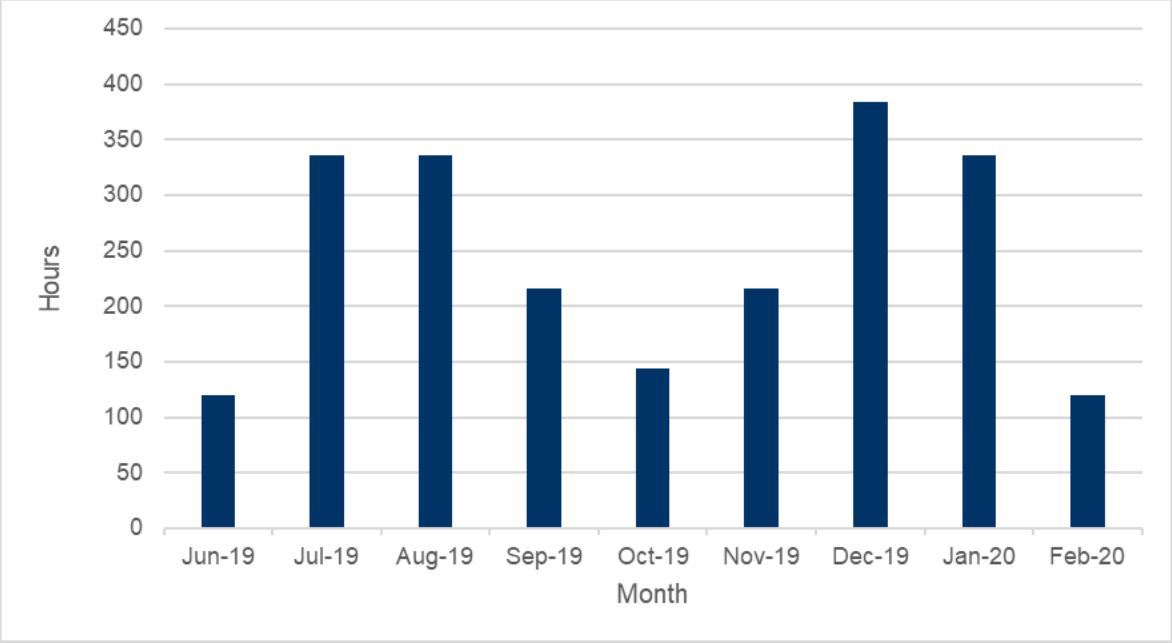


Figure R-3: Total Monthly Fishing Effort Recorded by the Rosignol Onboard Supervisor

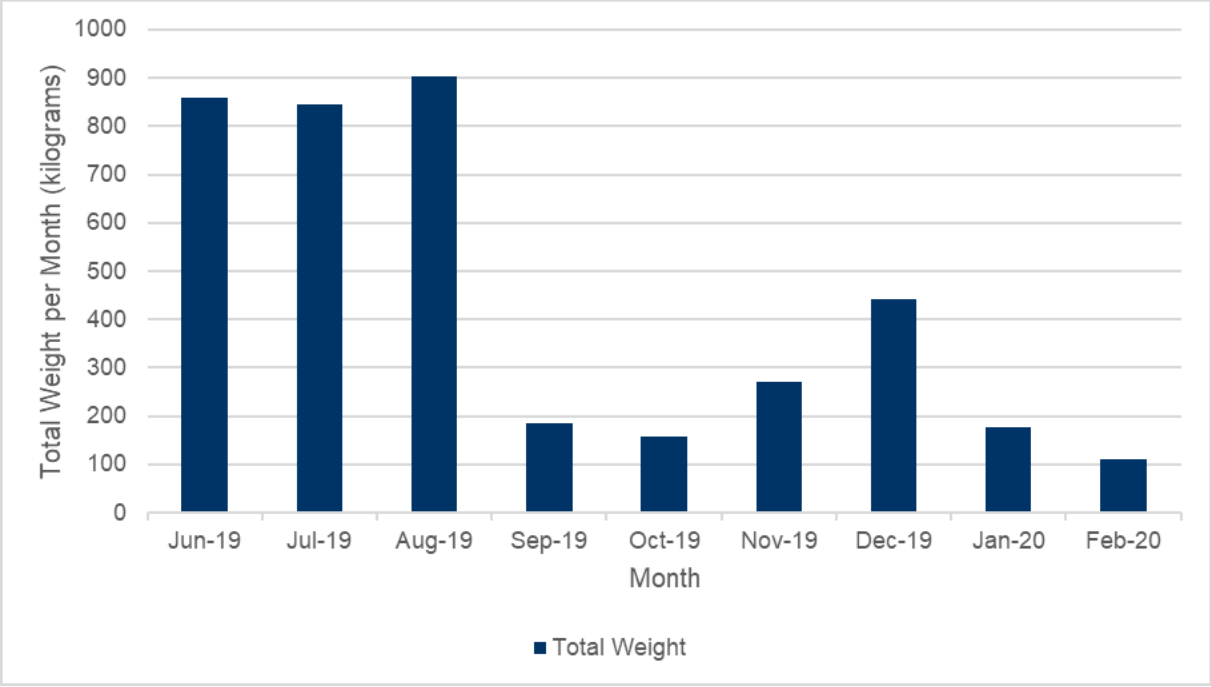


Figure R-4: Total Monthly Weight Recorded by the Rosignol Onboard Supervisor

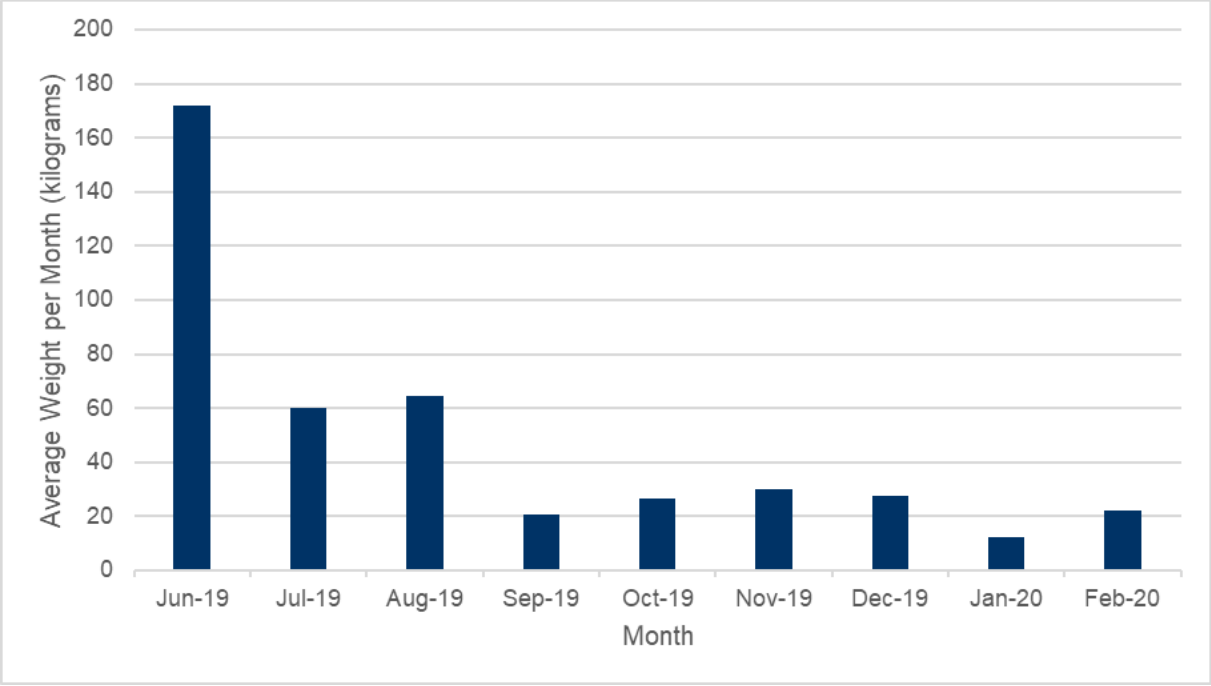


Figure R-5: Average Weight per Soaking Recorded by the Rosignol Onboard Supervisor

2.4 Biometrics

The onboard supervisor measured the lengths and weights of representative fishes per each haul and the annual average lengths and weights of these fishes are shown on Figure R-6. Based on the

measurements taken by the onboard supervisor, all the fishes caught were sexually mature. The annual average lengths of some of the fishes caught at this landing site are among the largest reported by the study. For example, the target species, snapper and trout, had annual average lengths of 86 and 71 centimeters, respectively. This is larger than the annual average lengths of these fishes caught at Charity (Region 2), Bushlot (Region 5), and Complex 66 (Region 6) where drift seines with mesh sizes of 18 or 19 centimeters (7 or 7.5 inches) were used. However, the onboard supervisor at Hampton Court (Region 2) used a drift seine with mesh sizes of 20 centimeters (8 inches) and caught snapper, which were larger (annual average length of 94 centimeters). A relatively small pool of biometric data was recorded by the onboard supervisor on a monthly basis and as such, a comparison of the monthly trends in sizes of the most abundant species caught cannot be done for this landing site.

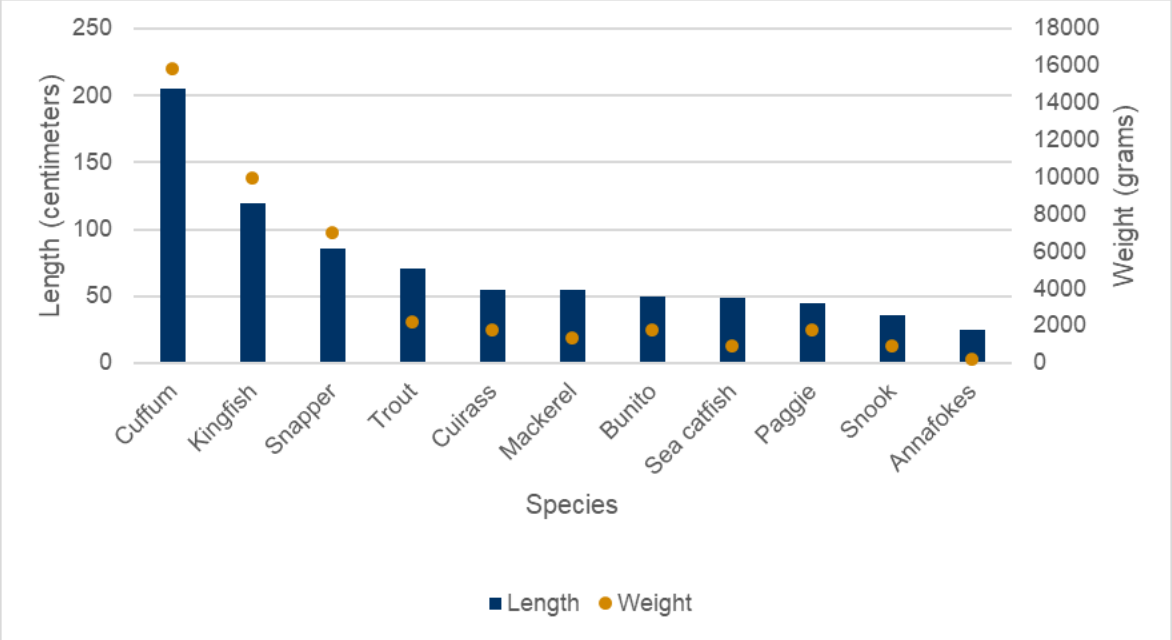


Figure R-6: Average Length and Weight of Fishes Caught by the Rosignol Onboard Supervisor

3 QA/QC DATA

In October 2019, the study team intended to meet with the onboard supervisor's vessel when it landed to assess the haul, take biometric measurements, and compare these results to the data collected by the onboard supervisor. This could not be accomplished due to changes in the supervisor's expected return date. As a result, the team could not conduct QA/QC assessment of the data collected by the onboard supervisor. However, the study coordinator assessed the haul from a vessel at the Rosignol landing site that also used drift seines with mesh sizes of 18 centimeters (7 inches). The vessel had returned from an 8-day fishing trip where seines were soaked multiple times. The vessel used a 60 hp outboard engine. The data collected by the study team from this vessel were consistent with the data collected by the onboard supervisor. The target species, snapper, was the most abundant species caught (Figure R-7). The haul also had relatively low species diversity that is typical of this type of fishing. The biometric data collected are similar to that observed by the supervisor at this site. Snapper is normally the largest of the fishes caught using this fishing method and this is consistent with biometric measurements taken by the onboard supervisor (see Figure R-8).

In January and February, 2020, the team tried to conduct QA/QC exercises at the landing site. The study team made arrangements to meet the onboard supervisor when the vessel landed. However, the vessel landed earlier than scheduled, and the haul was sold out before the team's arrival on both occasions. In addition, there were no landed vessels that could be assessed during visits to the landing site.

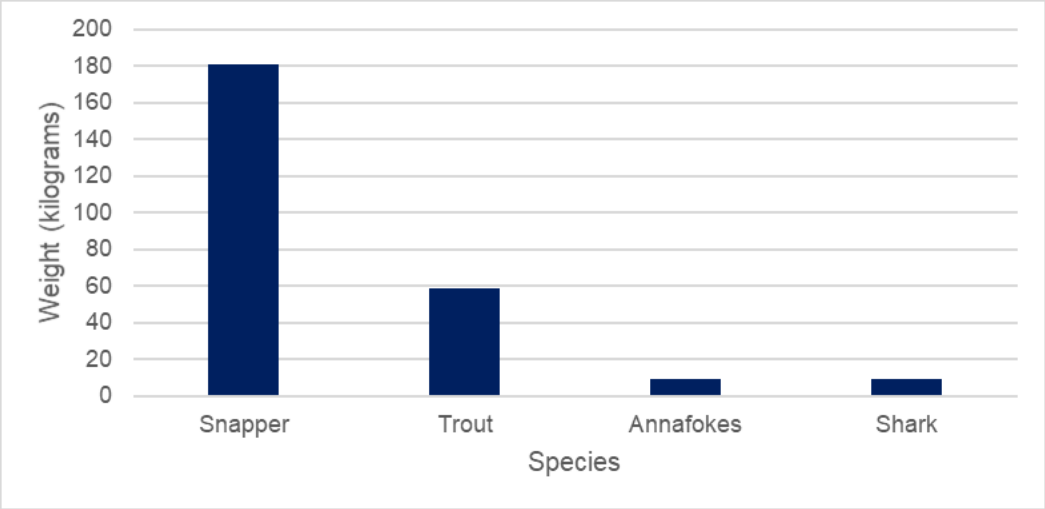


Figure R-7: Catch Composition of Commercially Viable Species during the QA/QC Exercises

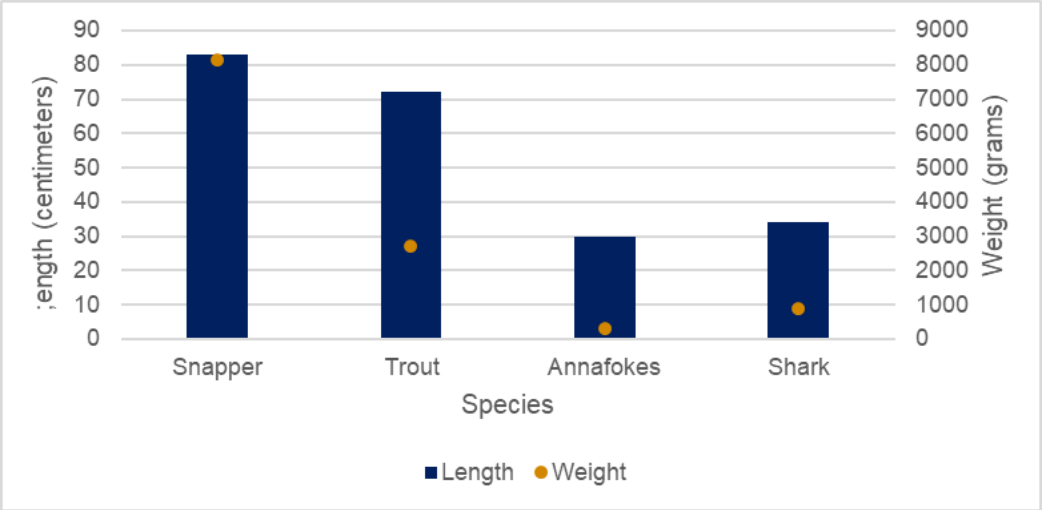


Figure R-8: Biometric Measurements Collected for the Rosignol Landing Site

APPENDIX S ROSE HALL (REGION 6)

1 LANDING SITE OVERVIEW

Rose Hall is the only landing site in the study where fisherfolk exclusively use pin seines for nearshore fishing. During the baseline data collection in February 2019, four fisherfolk were actively using the landing site. However, the number of fisherfolk operating at the landing site declined due to migration and by February 2020, only two fisherfolk continued to use the landing site. Both of these fisherfolk use pin seines with mesh sizes of 2.5 to 3.8 centimeters (1 to 1.5 inches) and target shrimp.

During the April 2019 to February 2020 period, the fisherfolk at this landing site experienced several challenges that significantly curtailed and temporarily stopped their fishing activity. In the aftermath of the spring tides in September 2019, significant quantities of mud and "caddy," a hard black sand and seashell mixture, were deposited on the seashore. Under these conditions, fisherfolk reported difficulties in accessing the landing site and setting up their seines. In addition, in January and February 2020, fisherfolk reported that the seas became too rough to continue fishing. Rough waters caused the seines to break down causing losses of catch. Fisherfolk also incurred costs to repair the seines that were damaged. As a result, all activities at this landing site ceased in January and February, and for most of March 2020. By the end of March 2020, fisherfolk indicated that waters were once again calm enough to allow the resumption of fishing activities.

Fisherfolk also indicated that lack of available markets to sell their produce was also a challenge.

2 REGIONAL SUPERVISOR RESULTS

One regional supervisor participated in the study and the results in this section were provided by him over the course of the study period.

2.1 Effort and Haul

Based on the data collected by the regional supervisor, shrimp was the most abundant species caught by weight with 4,156 kilograms (9,162 pounds), accounting for 78 percent of the total weight caught (Figure S-1). It should be noted that both white belly shrimp and corse shrimp were caught by the fisherfolk but were not reported separately by the regional supervisor. Bangamary was the second most abundant species caught with a total weight of 633 kilograms (1,396 pounds). Similarly, at the landing site in Zeeburg (Region 3) where Chinese seines are used to target white belly shrimp, the most abundant species caught was the white belly shrimp that accounted for 85 percent of the total haul, while the second most abundant species caught was bangamary. Long head cuirass and butterfish were the third and fourth most abundant species caught at the Rose Hall landing site, but at significantly lower quantities than shrimp and bangamary. In addition, small quantities of high-value species like snapper, prawns, and trout were also reported. In fact, prawns were only reported at this landing site and by the regional supervisor at the Riverview landing site in Region 4. In addition, due to the close proximity of the pin seine sites to the coast, small quantities of crabs were also reported. In total, recorded hauls at this landing site had a total weight of 5,325 kilograms (11,805 pounds).

Pin seine fishing requires significantly lower effort than other types of fishing, and in favorable conditions can be conducted on a daily basis. Generally, effort expended on fishing using pin seines is constant throughout the year. Fisherfolk set pin seines less than 1 kilometer offshore of the Rose Hall beach. Fisherfolk set the pin seines during low tide and leave them to soak for 12 hours. When low tides return, fisherfolk return to their seines using catamarangs or flat-bottom boats to recover the catch. This activity generally occurs once daily. However, if the first tide cycle occurs early in the day, fisherfolk may fish twice in one day.

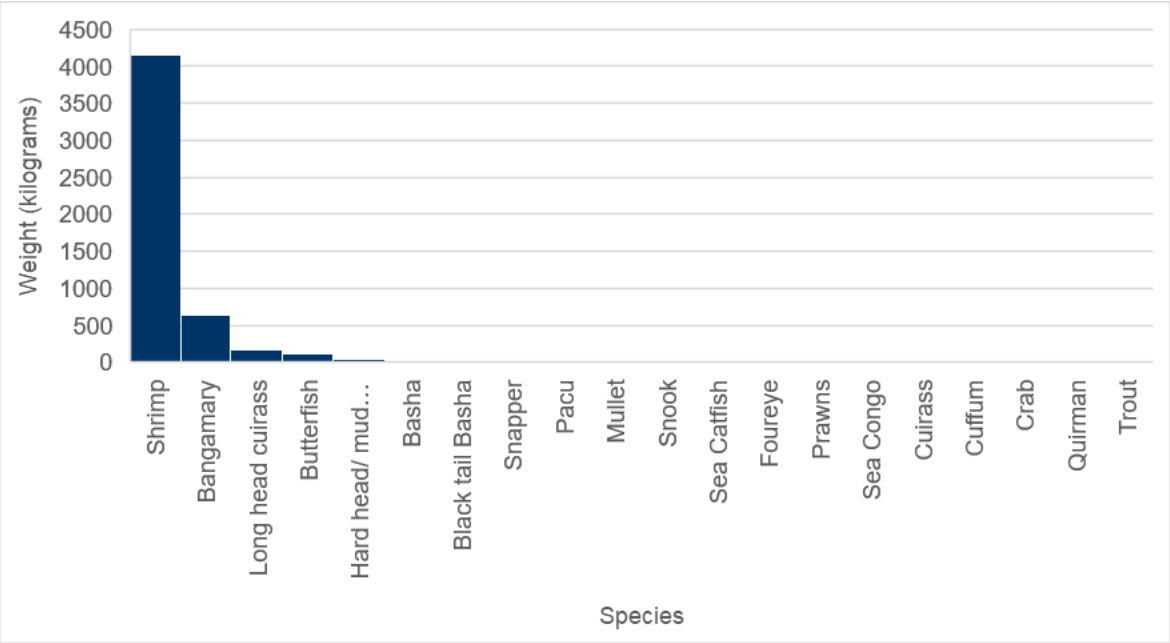


Figure S-1: Total Weight of Species Caught at the Rose Hall Landing Site

2.2 Target Species and Diversity

A total of 21 commercially viable species were caught at this landing site (Figure S-2). Species diversity peaked in July and was consistently high from May to August 2019. This may be attributed to more fish species coming closer to shore to feed during the raining season of May to July and to spawn from July to September. The diversity of species caught sharply declined in September 2019 as fishing activities were curtailed due to the spring tides and their aftermath. Bycatch is not recorded by the regional supervisor at this landing site as fishes not considered commercially viable are discarded at sea around the seines. This attracts birds to the area to feed on the discarded catch. In addition, it is likely that this also attracts more shrimps and fishes to this area to feed, which may then be caught in the pin seines.

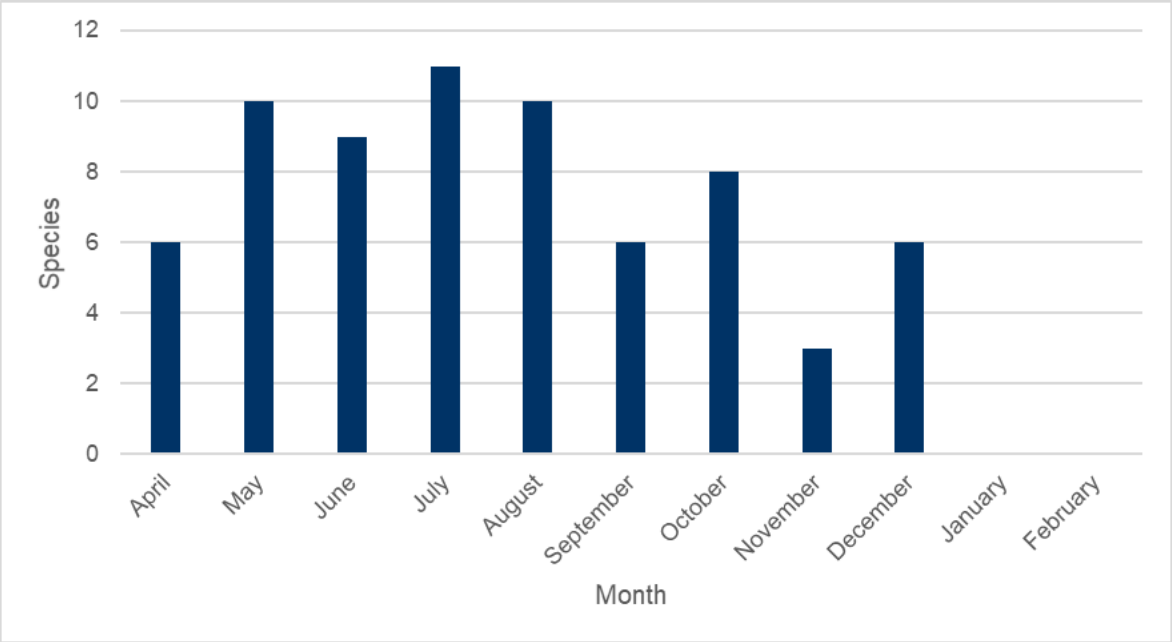


Figure S-2: Species Diversity

2.3 Seasonal Productivity

Artisanal fisherfolk believe that the peak and off-peak seasons for fishing occur from April to September and October to March, respectively. On the other hand, some fisherfolk have asserted that there are no seasonal variations for pin seine fishing because hauls are dependent on what species are closest to shore when the seines are set. However, this is not considered applicable to this landing site because the majority of the hauls comprise shrimp. There are varying beliefs on the most productive months for shrimping. Some fisherfolk indicated that shrimp catch generally increases during the closed trawl season, which occurs from August 16 to October 05 annually, and others indicated that productivity increases during the dry seasons of February to April and August to September. Spawning seasons of white belly shrimps runs from January to April and June to July and may also contribute to increased productivity as white belly shrimp and corse shrimp/seabob may travel closer to shore to spawn in the mangroves.

Figure S-3 shows the average productivity of fishing trips on a monthly basis that is measured as the dividend of total monthly productivity and the total number of hauls per month. The most productive months were October and November 2019 when average productivity per haul was 48 kilograms (106 pounds) and 38 kilograms (84 pounds), respectively. Relatively high productivity was also observed in April and July 2019 with 31 kilograms (68 pounds) in each month. Lowest productivity was recorded in May, June, and December 2019 when average hauls were 20 kilograms (44.1 pounds) or lower. Given the temporary cessation of activities at the landing site in January and February 2020, no productivity was recorded during that period.

Disruptions to fishing activities in September 2019 and January to March 2020, in addition to challenges in collecting data from the regional supervisor in March 2020, have hindered the emergence of any clear trends for productivity in the dry seasons (August to October and February to March), the closed trawl season, and the January to April spawning season. Additional data are required to better understand seasonal productivity of shrimping using pin seines at this landing site. Moreover, it may also be useful to collect data for another landing site that uses pin seines exclusively to better understand whether the catch composition observed at Rose Hall is representative of pin seine fishing.

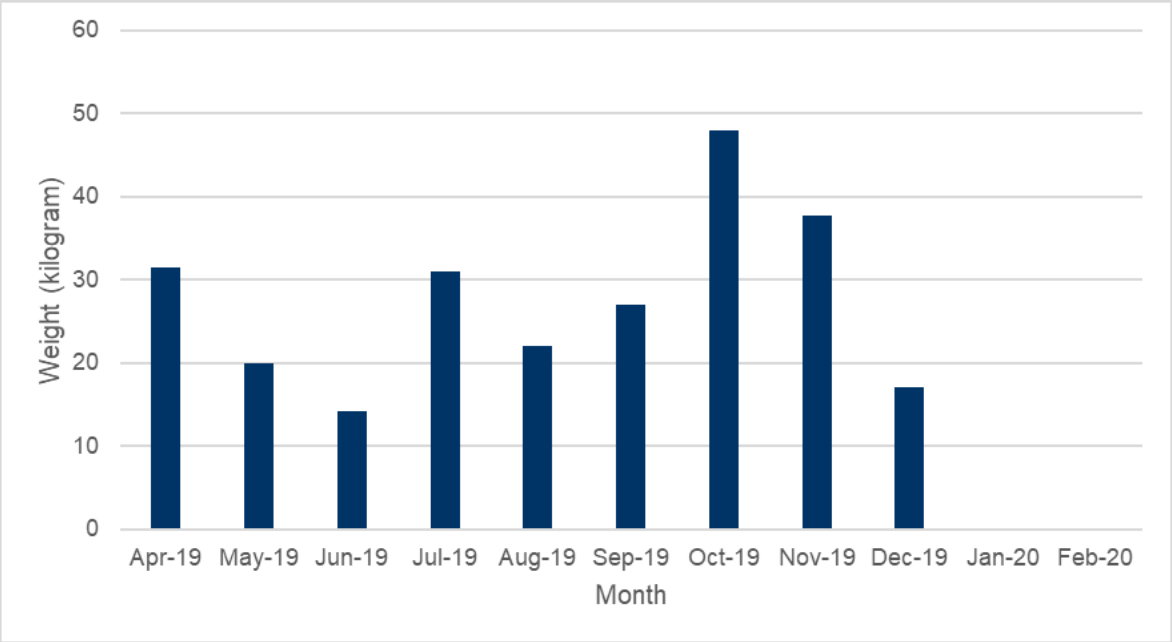


Figure S-3: Average Monthly Productivity of Hauls Recorded at the Rose Hall Landing Site

2.4 Prices and Markets

During the reporting period, snook and prawns were the highest-value species with annual average prices per kilogram of $1,261 GYD ($6 USD) and $1,220 GYD ($5.90 USD) as seen on Figure S-4. These prices, and prices for most other species caught at the landing site were significantly different than those reported by other regional supervisors, for example:

- The annual average price per kilogram of snook at Smith's Creek and Morahwanna (Region 1), where it was one of the most abundant species caught, was $405 GYD ($1.90 USD). At landing sites in Charity (Region 2) and Riverview (Region 4), annual average prices per kilogram for snook were $140 GYD ($0.70 USD) and $198 GYD ($0.90 USD) respectively.

- The annual average price per kilogram of snapper at Charity (Region 2), where it is the primary target species and the most abundant species caught, was $719 GYD ($3.40 USD). In fact, the annual average price per kilogram for snapper at Rose Hall of $905 GYD ($4.40 USD) is second only to the price obtained at the Mahaicony Bridge landing site of $959 GYD ($4.60 USD) where snapper is more expensive largely because of its scarcity at the landing site.

- The annual average price per kilogram of bangamary at Riverview (Region 4) and Mahaicony Bridge (Region 5), where it is the primary target species, were $223 GYD ($1 USD) and $225 GYD ($1 USD). In fact, the annual average price per kilogram for bangamary at Rose Hall of $479 GYD ($2.30 USD) is similar to the price of $415 GYD ($1.90 USD) obtained at Smith's Creek and Morahwanna (Region 1) where bangamary is more highly valued.

- The annual average price per kilogram of white belly shrimp was $261 GYD ($1.30 USD) at the Zeeburg landing site (Region 3), where it is the primary target species, compared with $448 GYD ($2.20 USD) per kilogram of 'mixed shrimp' at Rose Hall, where this is also the most abundant species caught.

- The annual average price per kilogram of trout at Charity (Region 2), Riverview (Region 4), and Mahaicony Bridge (Region 5) were $339 GYD ($1.60 USD), $620 GYD ($2.90 USD), and $592 GYD ($2.80 USD), respectively.

The reasons for these price differences compared to other landing sites may also be the primary factor influencing the considerable variations in minimum, maximum, and average prices of the four most abundant species caught shown on Figure S-5. Unlike the other landing sites where hauls are sold primarily to vendors for resale, the fisherfolk at Rose Hall take their catch to the Rose Hall Municipal Market for sale directly to consumers. In addition, fishes are not sold per kilogram but as single, whole fishes. In this way, fisherfolk set prices based on quantities caught per haul thereby ensuring that higher prices are reflective of scarcity. For example, the highest monthly average and maximum prices for the four most abundant species caught were observed in May, June, and December 2019, which were also the months when average productivity per haul was lowest. In addition, lower prices during the peak season may have arisen as a result of greater supply, and therefore greater competition, at the market place. There were also several months in which hauls did not include some species of fishes, and this may have further amplified perceived scarcity of these fishes. As seen on Figure S-5, butterfish was caught in September 2019 and not again until December 2019, at which time the price significantly increased. In January and February 2020 when the supervisors did not conduct any fishing activity, fisherfolk from the Rose Hall landing site sourced fishes and shrimps from New Amsterdam and Canje, approximately 10 kilometers away, to be sold in the Rose Hall Municipal Market.

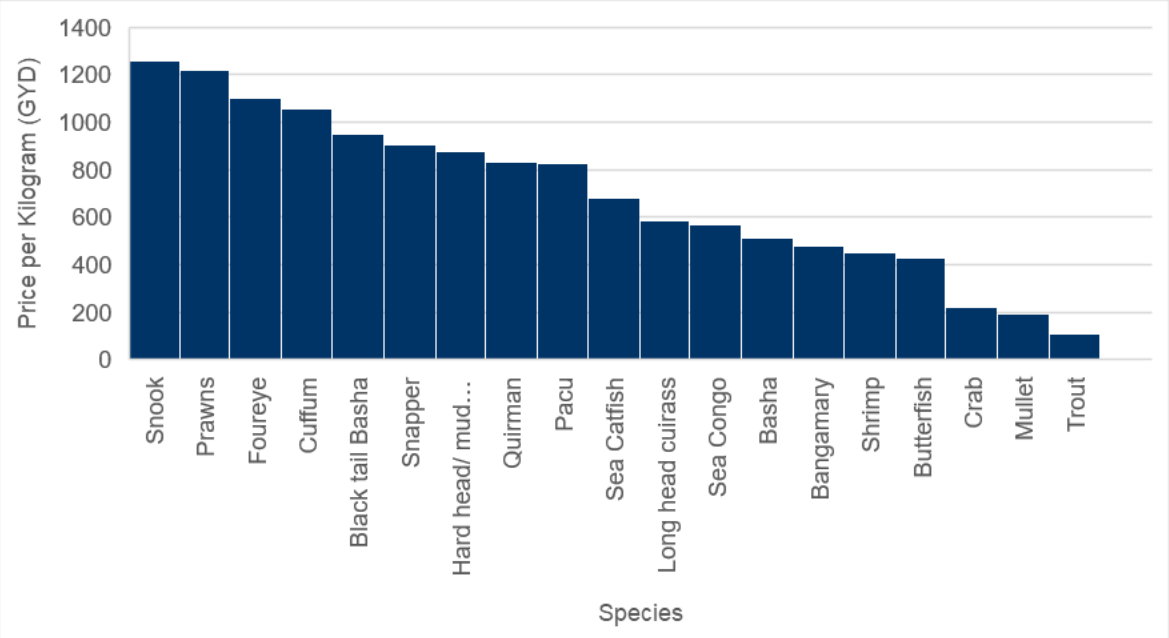


Figure S-4: Average price of Fishes Recorded at the Rose Hall Landing Site

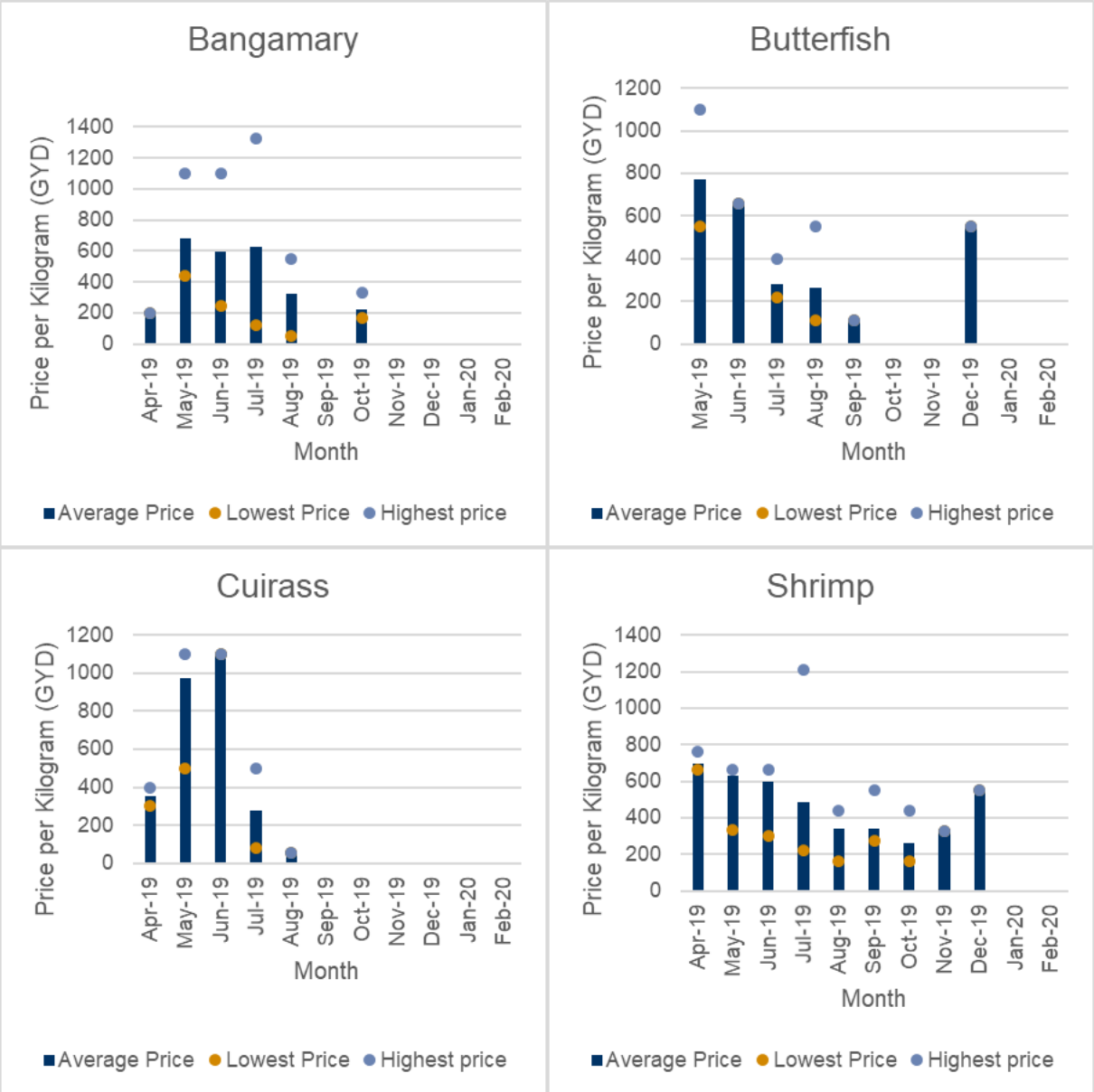


Figure S-5: Monthly Price Variations of the Four Most Abundant Species Caught

2.5 Biometrics

The biometric data collected from the landing site are reflective of the size inconsistencies typical for this type of fishing. Some species were sexually mature including cuffum, quirman, sea congo, long head cuirass, and hardhead/flat head cuirass. However, these species were caught in low quantities. Based on the annual average lengths, the main fish species caught, bangamary and butterfish, were not sexually mature (see Figure S-6).

Due to the inconsistencies with which the four most abundant fishes caught comprise hauls at the landing site in combination with measurements having not been taken for the shrimps, no trends are evident in the analysis of monthly variations in biometric data.

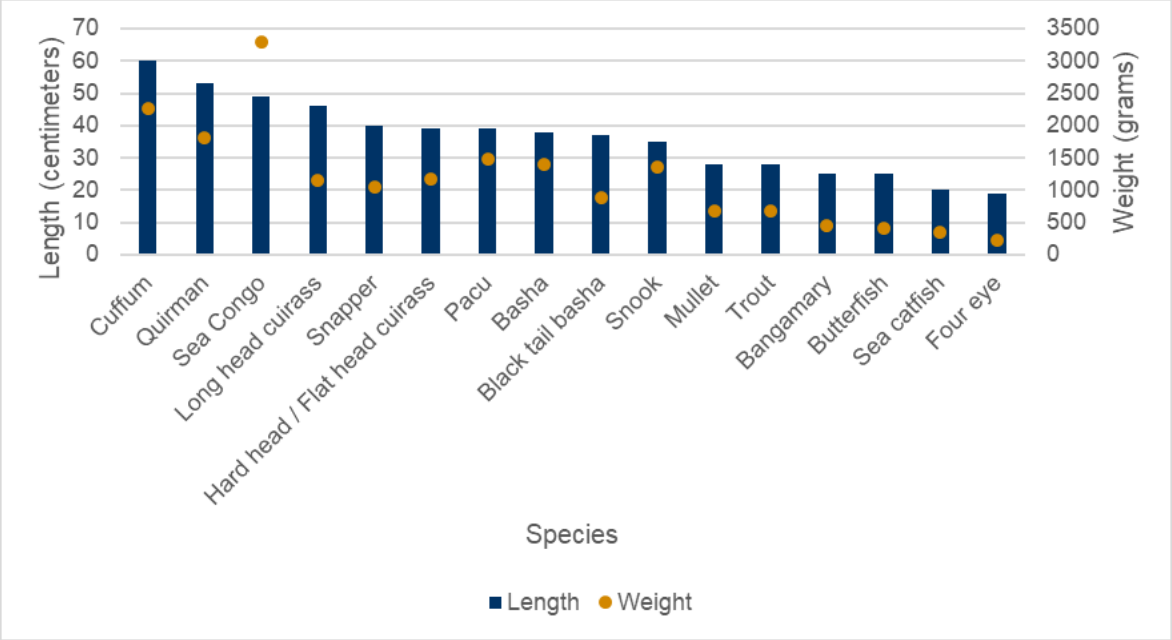


Figure S-6: Annual Average Lengths and Weights for Fishes Measured at the Rose Hall Landing Site

3 QA/QC DATA

The study coordinator assessed a haul from the regional supervisor's pin seine during the October 2019 QA/QC exercise. During the trip, the supervisor caught 5 kilograms (11 pounds) of corse shrimp/seabob (Figure S-7). This is typical of fishing at the site using the pin seine method and corresponded with the data collected by the regional supervisor during the July to September period. The study coordinator could not observe how the catch was sorted in the seine and see what species were determined to be commercially viable versus bycatch. In 2020, there was no fishing activity at the landing site and therefore, the QA/QC exercise could not be conducted.

Figure S-7: Catch Recorded from the Pin Seine Supervisor at Rose Hall

APPENDIX T ALBION (REGION 6)

1 LANDING SITE OVERVIEW

Albion is one of the largest landing sites in Region 6, and fisherfolk have indicated that 60 vessels use this landing site. All vessels are outboard cruisers fitted with engine sizes ranging from 15 to 50 hp. Most vessels are characterized as bangamary vessels because they use drift seines with mesh sizes of 7 centimeters (2.75 inches) and target bangamary. Other vessels are characterized as trout vessels that use drift seines of 4.5 inches and 7 inches (11 and 18 centimeters).

Fisherfolk from this landing site make daily trips along the Region 6 coastline typically traveling between the mouth of the Berbice River to the west, and Whim village to the east. Fishing occurs approximately 25 kilometers offshore at depths of 10 to 33 meters. Seines are soaked for 1 to 4 hours. According to fisherfolk, the main species caught at this site are bangamary, butterfish, trout, and sea catfish. A typical haul is approximately 300 kilograms (660 pounds) of fishes depending upon the season. Hauls are sold to vendors who visit the landing site with refrigerated trucks, who in turn sell the fish at markets in surrounding villages. Prices range from $160 to 300 GYD ($0.76 to 1.43 USD) per kilogram depending on the species and the season. The main expense is fuel with trips costing $6,000 GYD ($29 USD) for the bangamary vessels.

All fisherfolk interviewed at this location indicated that trawler vessels are a challenge because they frequently pass over and damage seines, causing the fisherfolk to lose catch and requiring seine repairs.

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor at this landing site who participated in the study uses a drift seine with mesh sizes of 7 centimeters (2.75 inches), referred to as a “bangamary seine” to target bangamary. Typically, fishing trips last for 12 hours at sea. The vessel has a haul capacity of 1,000 kilograms (2,200 pounds) and is powered by a 15 hp engine. Each fishing trip required a two-member crew inclusive of the onboard supervisor. Similar to the other fisherfolk at this landing site, the onboard supervisor fishes along the Region 6 coastline. Fuel is the most significant expense per fishing trip for the onboard supervisor and generally, fishes are not iced before returning to shore. Most of the haul is sold to vendors while the glue and trout are sold to exporters who visit the landing site with trucks. These fishing practices are similar to those described by the onboard supervisor at the Riverview landing site (Region 4), with the key difference being that the onboard supervisor at Riverview used a 40 hp engine.

2.1 Target Species and Diversity

The total weights of combined hauls from the onboard supervisor’s vessel over the period April 2019 to February 2020 was 11,472 kilograms (25,291 pounds) from 1,673 hours of effort. Bangamary, the target species at this landing site, was the most abundant species caught by a significant margin (Figure T-1). The onboard supervisor caught a total of 8,569 kilograms (18,891 pounds) of bangamary representing 75 percent of the total haul. In addition, trout and butterfish were the second and third most abundant species caught with 1,093 kilograms (2,409 pounds) and 870 kilograms (1,918 pounds) caught, respectively. Bangamary, butterfish, and trout were also the three most abundant species caught at all landing sites where the bangamary seines were the predominant gear type including the landing sites in Riverview (Region 4) and Mahaicony Bridge (Region 5). The fourth most abundant species caught was sea catfish and this was also the fourth most abundant species caught at the Riverview landing site.

Overall, 31 species were deemed commercially viable by the onboard supervisor of which 26 species caught were in low quantities of 100 kilograms (220 pounds) or less. Among these were high-value species like snapper and prawns as well as jewfish (an endangered, threatened, and protected species). This is one of only three landing sites where jewfish was reported as part of the hauls. Hauls including

jewfish were reported in October when the onboard supervisor was fishing in the normal fishing grounds along the Region 6 coastline. In total, only 0.45 kilogram (1 pound) of jewfish was caught as fisherfolk do not target this species. It is not known whether jewfish is typically caught in these waters during these months, and further research is needed to determine whether this may be linked to any particular behaviors, such as spawning or feeding behaviors, of this fish. Shark was caught in greater abundance than jewfish but were not identified by species and as such, it cannot be determined whether any of the fishes caught are endangered or vulnerable species. The onboard supervisor also recorded bycatch comprised mainly of rockhead and annafokes. Annafokes are considered a commercial catch by all of the other landing sites and some landing sites such as Ogle (Region 4) also had commercial markets for rockhead.

Despite the similarity of fishing methods between this onboard supervisor and the onboard supervisor at the Riverview landing site (Region 4), the total haul from the onboard supervisor at Riverview was significantly higher. This may be attributed to a variety of factors, foremost of which would likely be the abundance of fishes in the fishing grounds, along with sizes of vessels and respective surface areas of the seines.

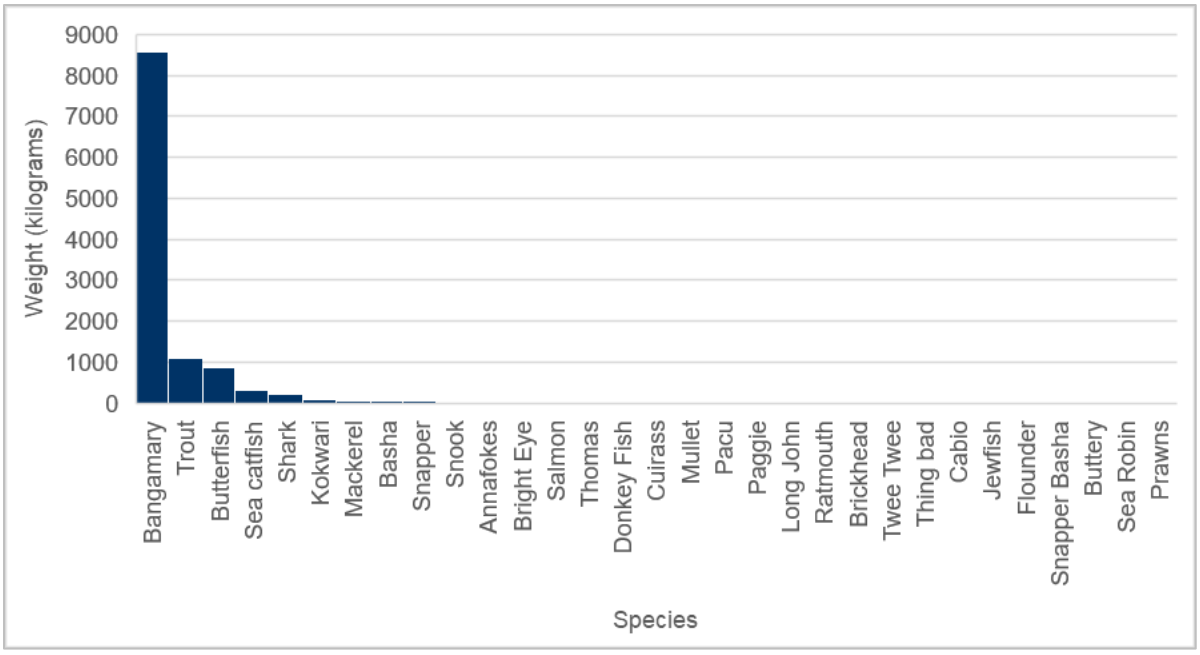


Figure T-1: Total Weight of Species Recorded by the Albion Onboard Supervisor

2.2 Fishing Areas

The main fishing area used by the onboard supervisor is 101 square kilometers. Overall, the onboard supervisor traveled within 142 square kilometers along the coast east of the Berbice River. Figure T-2 shows the fishing points in the seasons which were considered by the onboard supervisor as the peak/good season (May to September 2019) and off-peak/hard season (October 2019 to February 2020) at the outset of the study program. During the October to February period, the onboard supervisor consistently traveled farther offshore to fish than during the May to September period. The farthest distance traveled during the October to February period for fishing was 32.6 kilometers offshore. Overall, 2 kilometers was the nearest fishing point relative to the shoreline.

The fishing points underscore the changed fishing practices that were undertaken by the onboard supervisor. Specifically, greater effort was expended during the hard season, in the form of longer return

commutes between the landing site and the fishing grounds and longer soakings of the seine. These behaviors support the views held by fisherfolk that larger species like trout require more effort to catch and thus, fishing trips are generally conducted farther offshore.

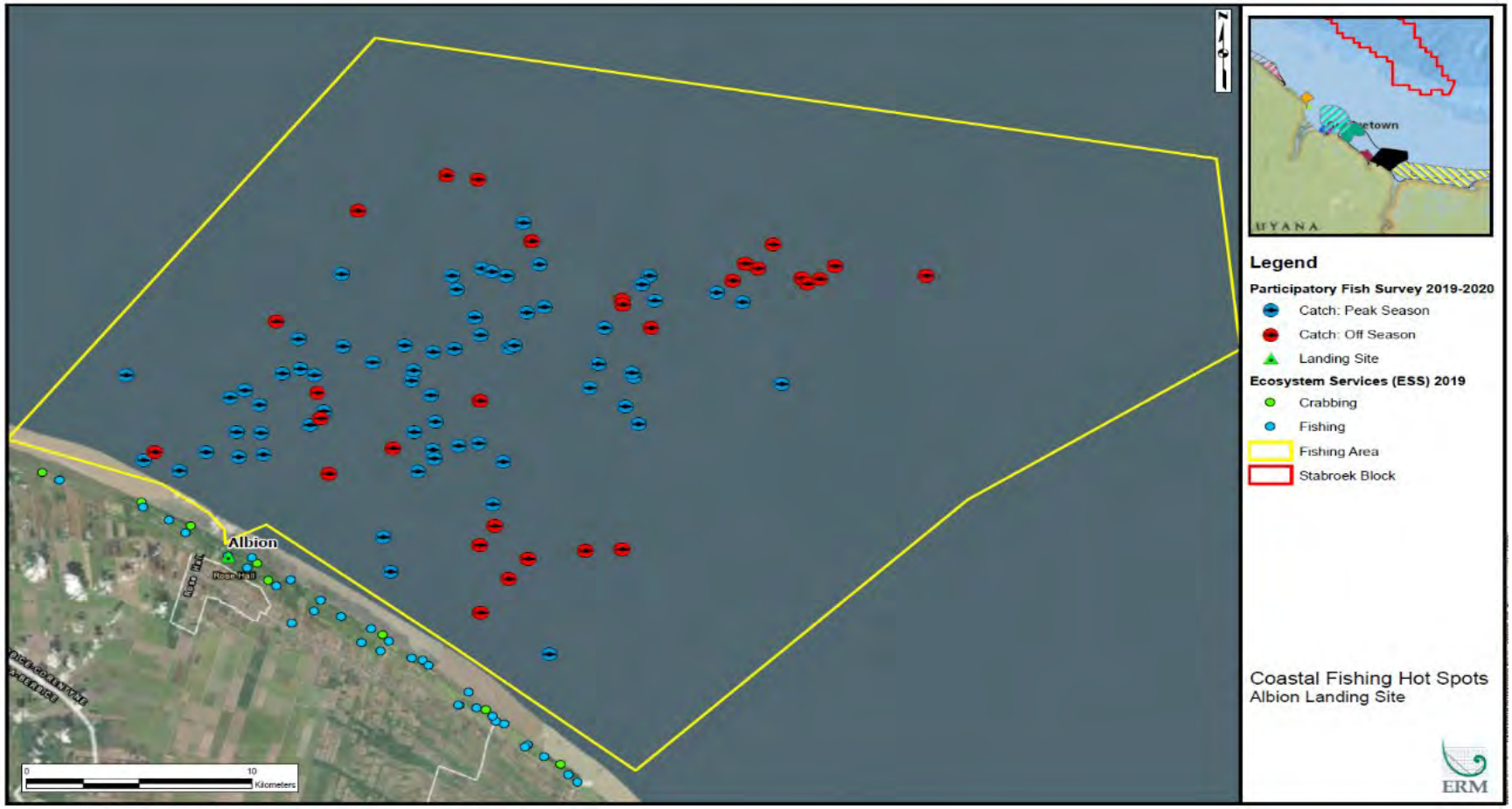


Figure T-2: Fishing Area and Fishing Points used by the Albion Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

During the study, the onboard supervisor spent an average at 167 hours per month fishing but there were variations in the effort expended per fishing trip on a monthly basis as seen on Figure T-3. The onboard supervisor’s monthly effort peaked in December 2019 with 233 hours of fishing activity. The lowest effort was expended in May 2019 when 110 hours were spent fishing. As seen on Figure T-4, the greatest total hauls were recorded in October 2019 with 1,638 kilograms (3,611 pounds). The highest average weight of hauls per soaking on Figure T-5 was recorded November 2019 and February 2020 with 105 kilograms (231 pounds) in both months. This is unusual as both of these months are part of the hard season for fishing. In addition, this follows the trend reported by the onboard supervisor at the Bushlot landing site (Region 5) where the most productive months were also part of the hard season. Moreover, the lowest average weight of hauls per soaking was in June 2019, which was expected to have been one of the months with peak productivity for fishing at this landing site, with an average of 48 kilograms (106 pounds) per soak.

Seasonal variations in effort and productivity were observed as follows:

- In the May to September 2019 good season, the total weight of hauls was 5,007 kilograms (11,038 pounds) with 744 hours spent at sea. On average, soaking of the seine in this period yielded 76 kilograms (167 pounds). Within this period, the average weight of hauls declined in June from a relatively high level in May. In fact, as noted above, the average weight of hauls per soaking were the lowest in June. However, from June to September the average weight of hauls continued to rise but did not achieve the peak until the hard season. A similar trend was observed for total hauls during this season.

- In the October 2019 to February 2020 hard season, the total weight of hauls was 6,466 kilograms (14,255 pounds) with 929 hours spent at sea. On average, soaking of the seine in this period yielded 89 kilograms (196 pounds). In particular, total hauls and average productivity per soaking were consistently high in October to November after which there was a sharp decline in December, ultimately ending with an uptick in January to February. Compared to the May to September 2019 season, the October to February 2020 period had greater total hauls and more productive soakings of the seine. However, the total effort expended for fishing was higher than in the good season.

By comparison, seasonal trends in the wet and dry season were as follows:

- In August to October 2019, the primary dry season, the total weight of hauls was 4,063 kilograms (8,957 pounds) with 519 hours spent at sea. On average, soaking of the seine during this period yielded 92 kilograms (203 pounds).

- In May to July 2019, the primary wet season, the total weight of hauls was 2,582 kilograms (5,692 pounds) with 423 hours spent at sea. On average, soaking of the seine during this period yielded 67 kilograms (148 pounds).

- In February 2020, one of the months of the secondary dry season, the total weight of hauls was 1,365 kilograms (3,009 pounds) with 166 hours spent at sea. On average, soaking of the seine in this

period yielded 105 kilograms (231 pounds). Data collection at this site did not commence until May 2019 and therefore, there will be a data gap for March 2020 and April 2019 to complete this season.

- In November 2019 to January 2020, the secondary wet season, the total weight of hauls was 3,462 kilograms (7,632 pounds) with 566 hours spent at sea. On average, soaking of the seine during this period yielded 82 kilograms (181 pounds).

Based on the data seen above, the October 2019 to February 2020 period was more productive as both the average weight of hauls per soaking and total hauls increased from May to September. However, the total effort expended also increased. In fact, the increases of total haul and total effort were proportionate, with each increasing by 12 percent. This is unusual as greater total effort typically occurred and peaked during the season with the lowest productivity at other landing sites such as Windsor Forest and La Grange (Region 3), Ogle and Riverview (Region 4), and Bushlot and Rosignol (Region 5). In fact, at these sites, greater total haul is associated with lower effort because during the good season, the average weight of hauls per soaking is higher and fisherfolk achieve the target weight of hauls more quickly.

In response to this unusual trend, the onboard supervisor indicated that since the October 2019 to February 2020 period is considered the hard season, the crew was traveling to fishing grounds farther offshore and thereby expended greater effort to access fishing grounds. Accessing fishing grounds farther offshore was also part of a deliberate change in practice to target greater hauls of trout from which income could be earned both for the flesh of the fish and the glue (swim bladders), which are sold separately. Finally, the onboard supervisor indicated that demand for fish is higher during the Christmas and New Year holiday season and this directly influenced the decision to expend greater effort fishing in December 2019 and January 2020.

However, at the Albion landing site, similar to other landing sites in the study, greater effort is not a reliable indicator of greater total haul. As seen from November to December 2019, the onboard supervisor significantly increased effort, but total hauls remained relatively unchanged because the average weight of hauls per soaking also declined. More specifically, when soakings are not as productive, a disproportionate level of effort is required to achieve total hauls comparable to months or seasons when soakings of the seine are more productive. The onboard supervisor indicated that over the last 2 years, trends with hauls during the peak and off-peak season have been inconsistent and did not follow the anticipated seasonal productivity. Additional data are required to ascertain this trend of productivity for this onboard supervisor, particularly given the deliberate change in fishing practices and target species during the hard season. Additional data would also further determine whether the experience is similar for other fisherfolk at the Albion landing site.

Based on the supervisor's experience and the total-haul to total-effort ratio in October 2019 to February 2010, it can be concluded that there is no clearly defined good and hard season for the onboard supervisor's fishing practice. As a result, there are also no clear trends in productivity based on climatic seasonality. For example, the most productive hauls occurred in the dry seasons (August to October 2019 and February 2020) but the greatest total productivity was observed in the secondary wet and dry seasons.

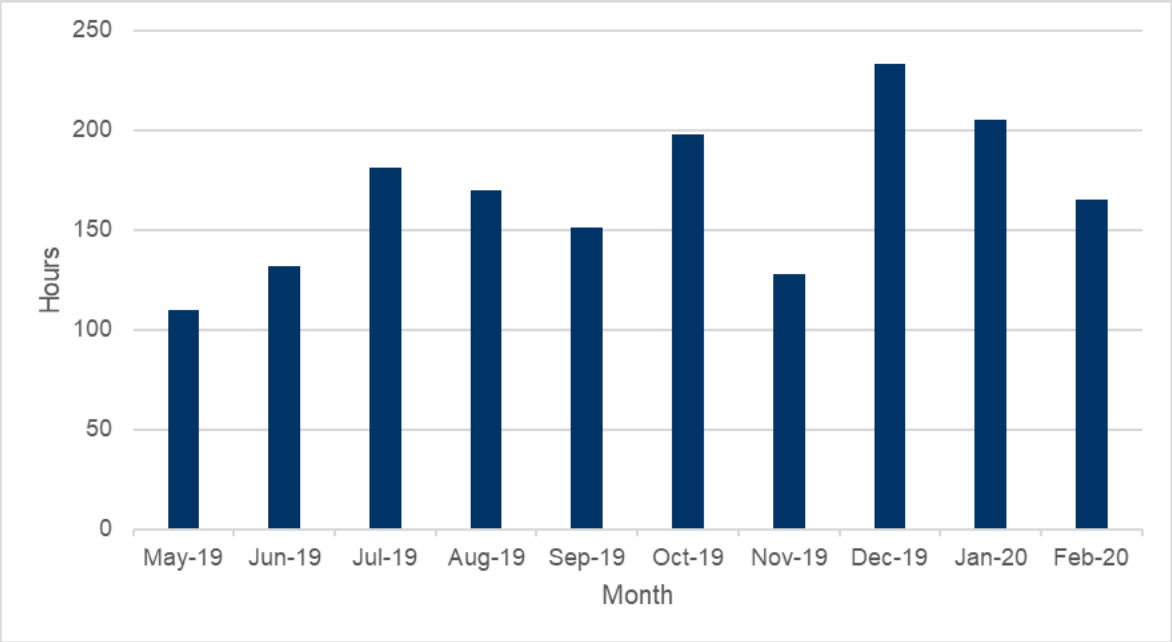


Figure T-3: Total Monthly Fishing Effort Recorded by the Albion Onboard Supervisor

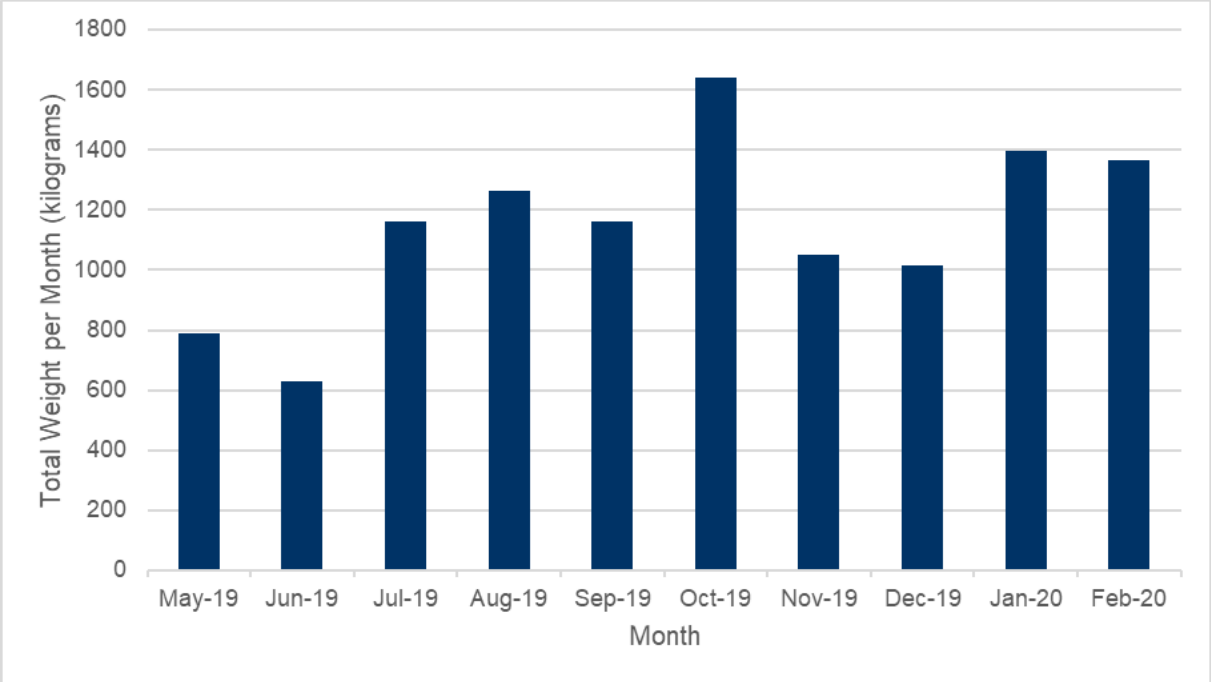


Figure T-4: Total Monthly Weight Recorded by the Albion Onboard Supervisor

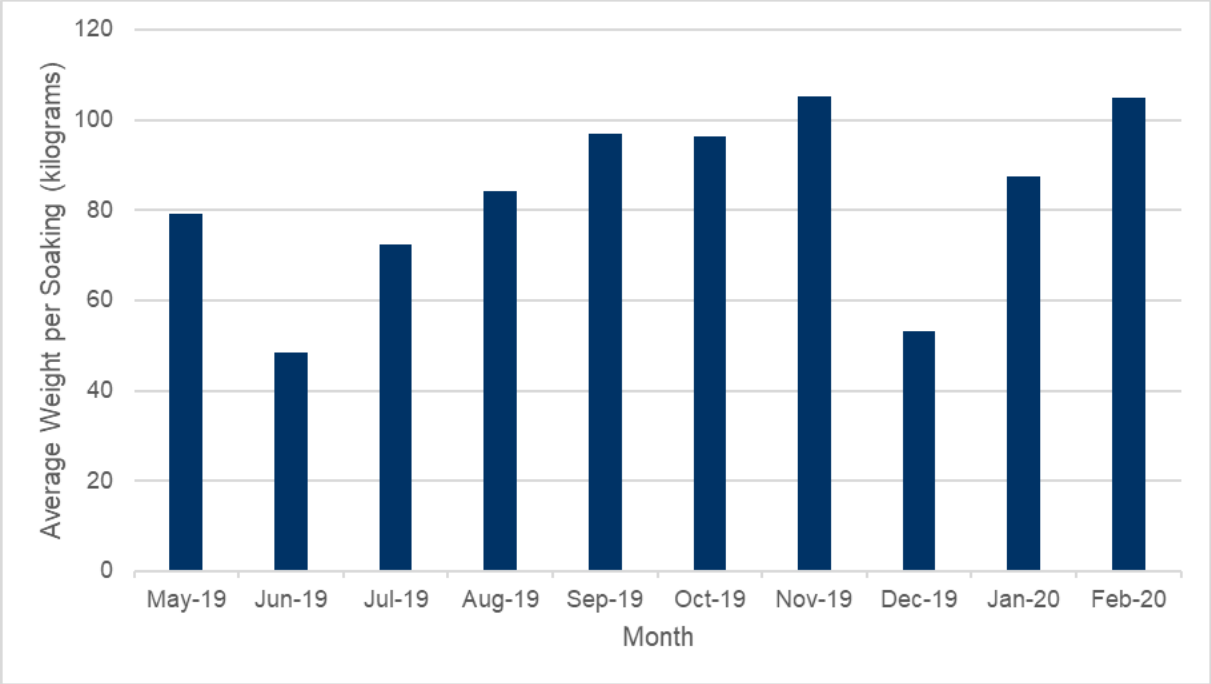


Figure T-5: Average Weight per Soaking Recorded by the Albion Onboard Supervisor

2.4 Biometrics

The onboard supervisor measured the lengths and weights of representatives of 28 species and the annual average lengths and weights of these fishes are shown on Figure T-6. Based on the measurements taken by the onboard supervisor, most of the fishes caught were sexually mature. In addition, target species such as bangamary, butterfish, and trout generally had achieved maturity with annual average lengths 31, 30, and 69 centimeters, respectively. However, the jewfish and sharks were juveniles.

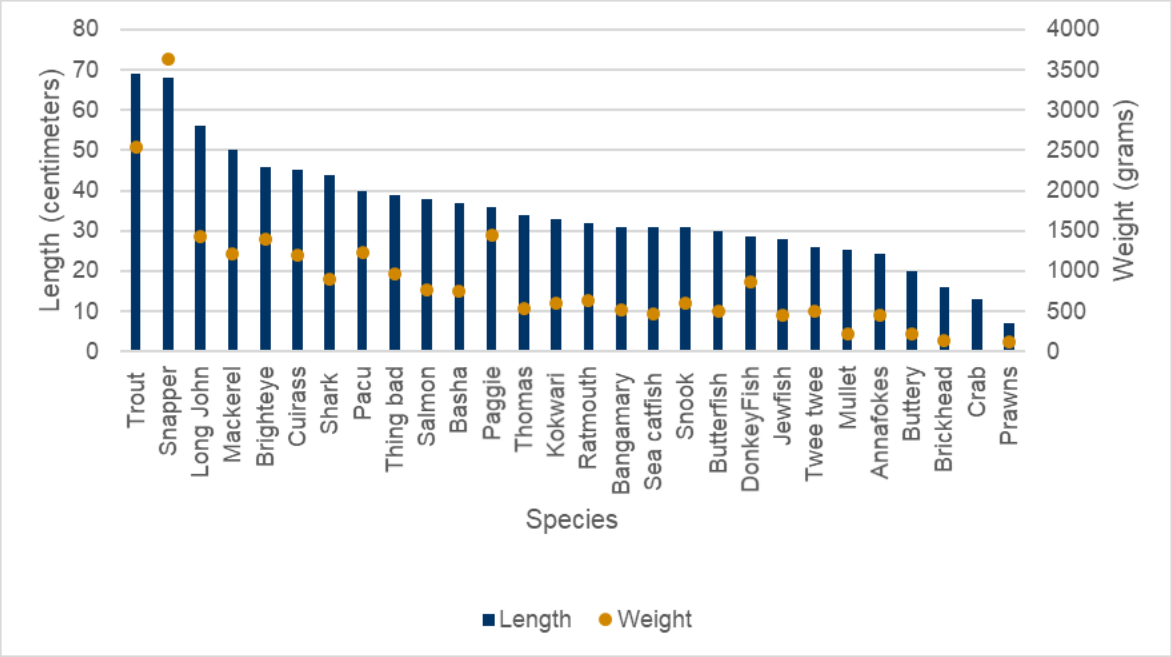


Figure T-6: Average Length and Weight of Fishes Caught by the Albion Onboard Supervisor

The monthly average lengths and weights of the four most abundant species caught are presented on Figure T-7. The average annual lengths of the most abundant species caught was greater than 30 centimeters indicating that these species have matured, similar to the trends observed at the Riverview landing site (Region 4) where the onboard supervisor also uses the bangamary seine for fishing.

Bangamary achieved peak sizes in October 2019 while the largest trout, butterfish, and sea catfish were caught in September, June, and July 2019. This may be related to large fishes coming closer to shore for both feeding and spawning. At the Riverview landing site, peak sizes of these four fishes were recorded in May to June 2019 and peak productivity occurred in July. At the Albion landing site, the largest fishes of the two most abundant species caught were in September to October which immediately preceded the most productive month of November 2019. Additional data would be needed to further examine this relationship.

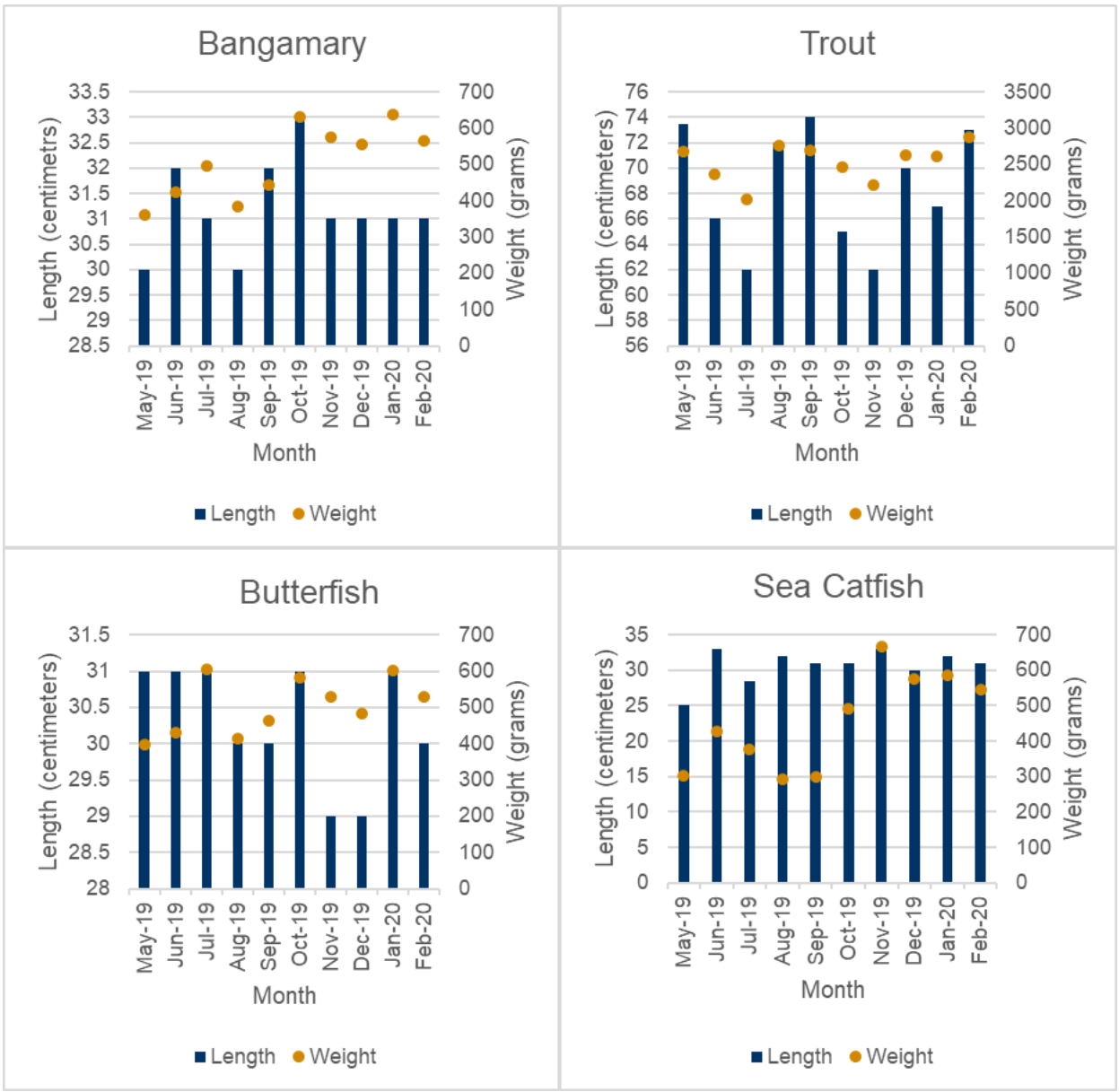


Figure T-7: Average Lengths and Weights of the Most Abundant Species Caught

3 QA/QC DATA

As part of the QA/QC exercise from 7 to 11 October 2019, a GoPro camera was mounted on the onboard supervisor's vessel. Several key observations were made from the video monitoring of the 12-hour fishing trip:

- The seas were noticeably rough. Due to the size of the swells, this indicated that they were at relatively deeper waters than seen during the other videos on fishing activity.
- The vessel uses a bangamary seine and, as expected, bangamary is the primary target species, constituting the main percentage of the total haul. However, prior to the videoed trip, the onboard supervisor and other fisherfolk at the landing site indicated that butterfish was being caught in greater

abundance. This trend in catch composition was observed in the trip that was assessed (Figure T-8) and is supported by video evidence.

- The seines were soaked for 3 hours. During this period, the crew tried to sleep, but were unable due to rough sea conditions.

During the January 2020 QA/QC, a haul from the onboard supervisor's vessel was assessed. The haul from this trip was 191 kilograms (421 pounds) and this was significantly higher than the 87 kilograms (192 pounds) average hauls during this month. However, the supervisor acknowledged that the haul was uncharacteristically large. The supervisor also said that although bangamary seines were still being used, the fishing practices had been changed to target trout because of potential additional earnings from the sale of the glue (swim bladders). As a result, fishing trips were occurring even farther offshore. In addition, trout accounted for 94 percent of the haul, which is not a common catch composition from bangamary seines.

The study coordinator also took biometric measurements of the same fishes that were measured by the onboard supervisor, and no significant data deviations were observed. For example, trout measured during the QA/QC exercise averaged 59 centimeters compared to average monthly lengths of 67 centimeters based on the data collected by the onboard supervisor (see Figure T-9). Similarly, bangamary average length measured during the QA/QC exercise was 31 centimeters compared to average monthly lengths of 29 centimeters based on the data collected by the onboard supervisor. Overall, the study coordinator was satisfied that the onboard supervisor was accurately recording the commercial species caught and following guidance in taking biometric measurements.

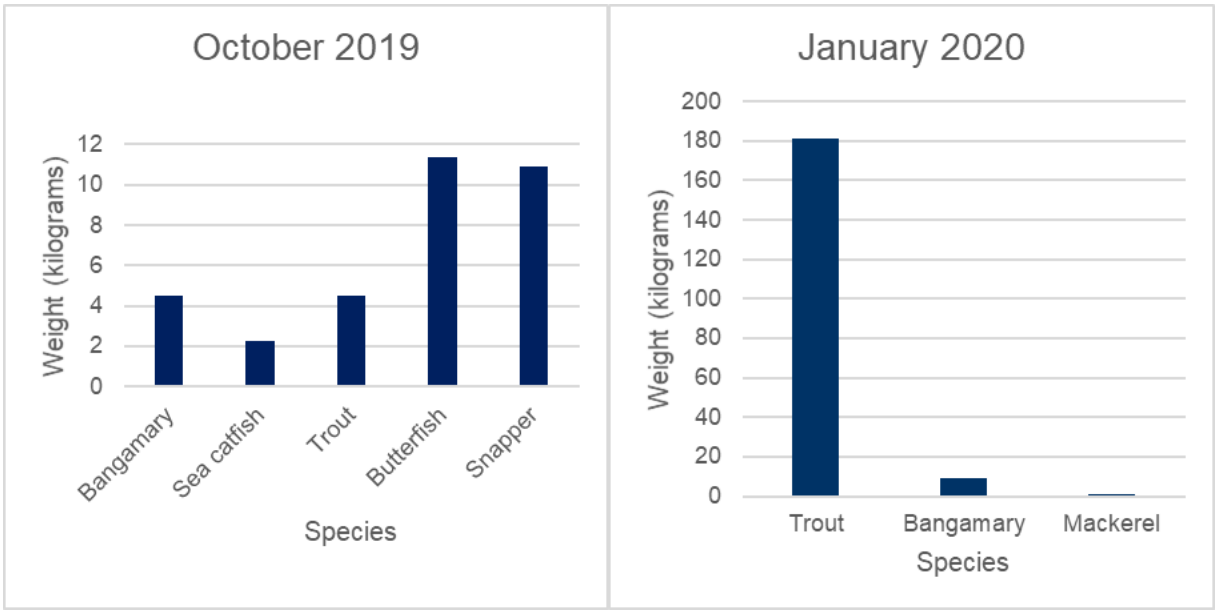


Figure T-8: Catch Composition of Commercially Viable Species during the QA/QC Exercises

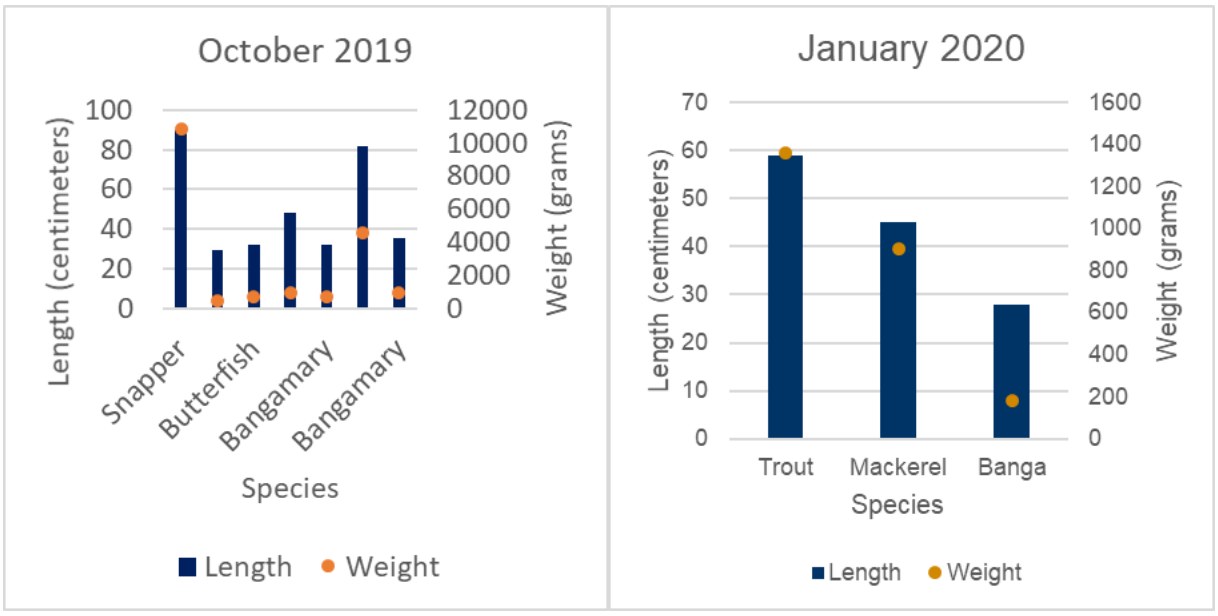


Figure T-9: Lengths and Weights of Fishes Measured during the QA/QC Exercises

APPENDIX U COMPLEX 66 (REGION 6)

1 LANDING SITE OVERVIEW

Complex 66 is the largest landing site for artisanal fishing vessels in Region 6 and one of the largest landing sites in Guyana. The site is also managed by a cooperative called the Upper Corentyne Fishermen Coop Society. Approximately 140 vessels routinely operate at this landing site and more than 200 vessels during the peak fishing seasons. Vessels are fitted with outboard cruisers of 40 to 60 hp. The main gear used are drift seines with mesh sizes of 13 to 20 centimeters (5 to 8 inches). Vessels at this landing site fish along the Suriname and Guyana coast at 30 meters of depth and 34 kilometers offshore. These vessels spend 10 to 16 days at sea per trip with soak times of 6 to 12 hours.

Fisherfolk indicated that obtaining licenses for fishing in Surinamese waters is one of the main challenges they encounter. Fisherfolk also shared the concerns they have for their safety because of alleged pirate attacks while at sea. In addition, fisherfolk indicated that improper disposal of cat-gut seines are contributing to the reduction of fish stocks. These seines are made of plastics and do not degrade in water. Improper disposal of these seines at sea continuously entangle fishes, which would subsequently die in them. The main species targeted at this site are snapper, trout, and gillbacker.

Total haul varies from 100 to 1,000 kilograms (220 to 2,200 pounds), depending on the duration of the trip and season. Prices range from $500 to 800 GYD ($2.4 to 3.8 USD) per kilogram depending on the species being sold. A daily pre-dawn bustling market is at this landing site where fishes are auctioned to vendors and local customers visiting the landing site. The main expense is fuel with extended fishing trips costing approximately $240,000 GYD ($1,148 USD).

2 ONBOARD SUPERVISOR RESULTS

The onboard supervisor who participated in this study uses drift seines with mesh sizes of 19 centimeters (7.5 inches) to target snapper. This is likely the target species because this landing site is one of the major supply sites for the glue (swim bladders) of snapper and trout. The onboard supervisor typically has fishing trips lasting 10 to 15 days. The vessel has a haul capacity of 4,545 kilograms (10,020 pounds) and is powered by a 60 hp engine. Each fishing trip required a three-member crew. The main expenses per fishing trip are for rations for the crew, fuel, and ice for the preservation of the haul. Due to the prolonged periods spent at sea, the supervisor also guts the fishes before icing them during the fishing trip. When gutting fish, the supervisor harvests the glue from the snapper and trout, as well as any eggs from female fishes in particularly gillbacker, snapper, and trout. These are iced and sold separately from the flesh of the fishes upon return to the landing site. Like most other vessels at this landing site, the supervisor also fishes in Surinamese waters but hauls are sold at the market at the Complex 66 landing site when the vessel returns to shore.

During the reporting period, the onboard supervisor did not experience any challenges that significantly affected fishing activities. However, data were not collected in December 2019 because the onboard supervisor decided to stay onshore to spend time with family.

2.1 Target Species and Diversity

The total weights of combined hauls from the onboard supervisor’s vessel over the period April 2019 to February 2020 was 5,588 kilograms (12,319 kilograms) using a total effort of 3,168 hours. Snapper was the most abundant species caught by a significant margin (see Figure U-1). In total, 3,621 kilograms (7,983 pounds) of snapper were caught representing 65 percent of the total haul. Trout was the second most abundant species caught with a total weight of 1,197 kilograms (2,638 pounds) accounting for 21 percent of the total catch. Cuirass and bangamary were the third and fourth most abundant species

caught representing 7 percent and 2 percent of the total haul respectively. A catch composition with snapper, trout, and cuirass as the three most abundant species caught were observed at the Rosignol landing site (Region 5) where drift seines with mesh sizes of 19 centimeters (7.5 inches) were the main type of gear used. Similarly, snapper and trout as the two most abundant species caught were also observed at the Charity landing site (Region 2) where drift seines with mesh sizes of 18 centimeters (7 inches) were used. Cuirass was the most abundant species caught at the Bushlot landing site (Region 5) where the main type of gear used by the onboard supervisor was drift seines with mesh sizes of 18 centimeters (7 inches).

Overall, 15 species were caught, 10 of which were caught in low quantities of 100 kilograms (220 pounds) or lower. Due to the relatively large mesh sizes of the seine, bycatch is limited. The bycatch recorded by the onboard supervisor primarily comprises sea catfish and bangamary, and these are commercially viable if brought back to shore. However, discarding commercially viable and generally mature fishes as bycatch is a deliberate action intended to increase the capacity of the vessel to haul high-value target species like snapper and trout.

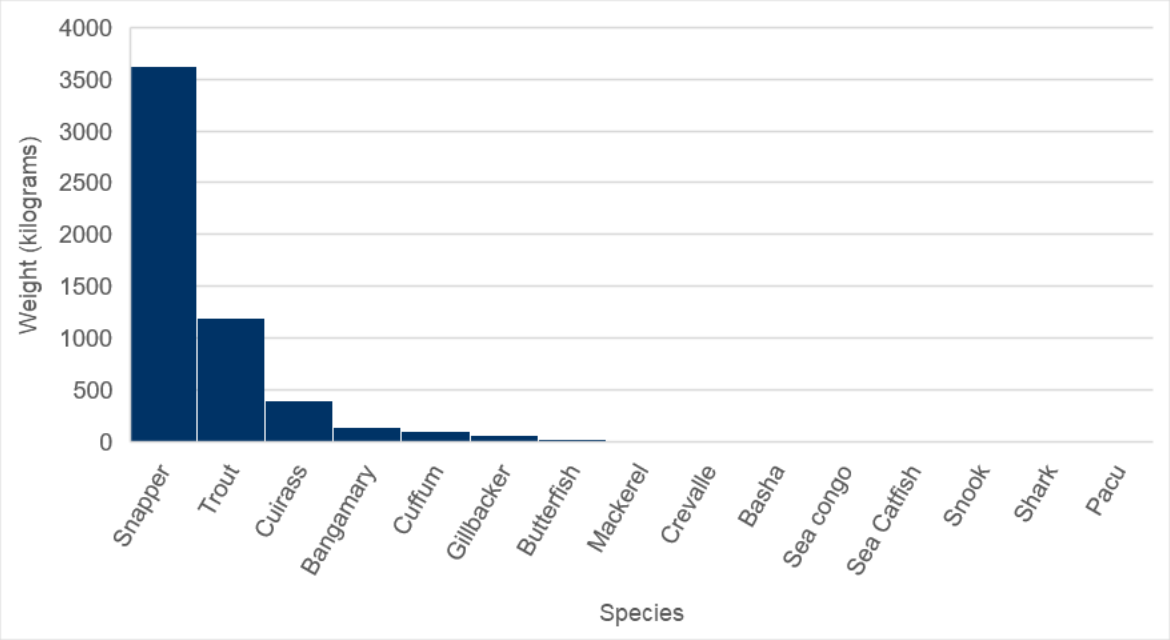


Figure U-1: Total Weight of Species Recorded by the Complex 66 Onboard Supervisor

2.2 Fishing Areas

The onboard supervisor at the Complex 66 landing site had the largest traveling range of any of the onboard supervisors with 7,003 square kilometers (see Figure U-2). Due to the expanse of the traveling range, fishing points were observed around main clusters, all of which were located around the mouths of rivers:

1. The largest cluster covered an area of 1,132 square kilometers with fishing points at the mouth of the Corentyne River. Most of the fishing in this cluster occurred during the peak season. The fishing grounds in this cluster were also used by the onboard supervisor from the Rosignol landing site (Region 5).

2. The second largest cluster covered an area of 603 square kilometers with fishing points around the mouth of the Coppename River in Suriname. Most of the fishing in this cluster occurred during the hard season. The fishing grounds in this cluster were also used by the onboard supervisor from the Rosignol landing site (Region 5) but only during the good seasons.

3. The smallest cluster covers an area of 149 square kilometers with only a few fishing points being marked outside the Suriname River. These fishing grounds were located approximately 209 kilometers from the landing site, the farthest the onboard supervisor traveled to access the fishing grounds. Fishing was only conducted at these fishing points during the good/peak season. The onboard supervisor explained that these fishing grounds are only rarely used and were part of exploratory fishing activities of a single fishing trip.

Generally, the onboard supervisor's vessel remained relatively close to the shore in both the good and hard seasons. The main seasonal difference between the peak and hard seasons in terms of vessel movements was use of the Suriname River, which only occurred during the peak season. Waters are reportedly calmer during the good season and therefore, more conducive to traversing greater distances. However, greater effort was expended by the supervisor during the off-peak season indicating that there were longer fishing trips, likely due to less productivity per haul, along with the rough seas which made travel to and from the landing more difficult.

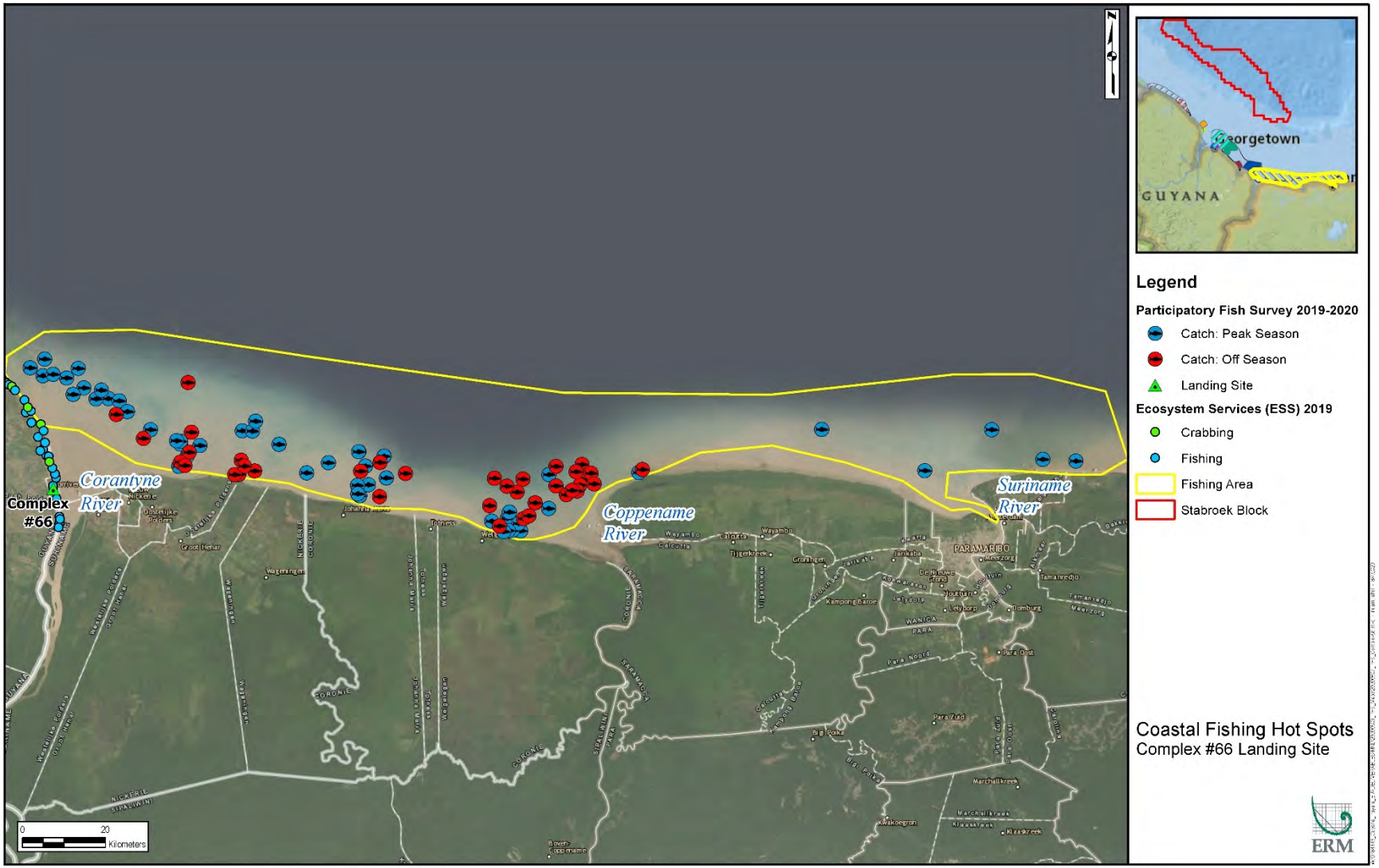


Figure U-2: Fishing Area and Fishing Points used by the Complex 66 Onboard Supervisor

2.3 Seasonal Productivity

The onboard supervisor subscribes to the commonly-held view that fishing is most productive from May to September (the so-called “good season” that peaks in July to September) and less productive from October to March (the so-called “hard season”). It is widely believed that waters are warmer and calmer during the good season, and these conditions are more conducive to fishing. These seasons are believed to influence effort expended by fisherfolk as well as hauls per soaking of the seine and per fishing trip.

During the data collection period, the onboard supervisor spent an average of 310 hours per month fishing, but there were variations in the effort expended per fishing trip on a monthly basis as seen on Figure U-3. The greatest effort was observed in July 2019 when 456 hours were spent fishing. Although 72 hours were expended in April 2019, data collection did not begin until April 27 and as such, there is no comparable full monthly data pool for this month. In July, the onboard supervisor indicated that conditions were favorable and allowed fishing trips to last for longer periods. High levels of effort were also observed during the hard season months of October 2019 and January or February 2020. Increasing effort during the hard season is a common practice among fisherfolk to increase total hauls when hauls per soaking are relatively low. As seen on Figure U-4, the greatest total hauls were recorded in October 2019 with 873 kilograms (1,925 pounds). As seen on Figure U-5, the highest average weight of hauls per soaking was recorded in May 2019 with 73 kilograms (160 pounds).

Seasonal variations in effort and productivity were observed as follows:

- In the May to September 2019 good season, the total weight of hauls was 3,034 kilograms (6,689 pounds) with 1,656 hours spent at sea. On average, soaking of the seine during this period yielded 46 kilograms (101 pounds). This season saw the highest average weight of hauls per soaking and greatest effort over the data collection period. The most productive hauls were recorded in May 2019 and the greatest effort was expended in July 2019.

- In the October 2019 to February 2020 hard season, the total weight of hauls was 2,442 kilograms (5,384 pounds) with 1,368 hours spent at sea. On average, soaking of the seine during this period yielded 44 kilograms (97 pounds). During this season, the greatest total haul of the data collection period was recorded in October 2019 with 873 kilograms (1,925 pounds). In addition, October 2019 also saw the second highest average weight of hauls per soaking and the second greatest total effort expended. Data are not considered for April 2019 in this season because the data pool is too small.

By comparison, seasonal trends in the wet and dry season were as follows:

- In August to October 2019, which falls within the primary dry season, the total weight of hauls was 1,869 kilograms (4,120 pounds) with 1,104 hours spent at sea. On average, soaking of the seine during this period yielded 40 kilograms (88 pounds).

- In May to July 2019, which falls within the primary wet season, the total weight of hauls was 2,039 kilograms (4,495 pounds) with 960 hours spent at sea. On average, soaking of the seine in this period yielded 53 kilograms (117 pounds).

- In February 2020 and April 2019, two months of the secondary dry season, the total weight of hauls was 685 kilograms (1,510 pounds) with 504 hours spent at sea. On average, soaking of the seine during this period yielded 34 kilograms (75 pounds). Data were not retrieved for March 2020 to complete this season.

- In November 2019 and January 2020, two months of the secondary wet season, the total weight of hauls was 995 kilograms (2,194 pounds) with 528 hours spent at sea. On average, soaking of the

seine in this period yielded 46 kilograms (101 pounds). The onboard supervisor did not participate in the fishing trips in December 2019 so no data were collected.

Overall, greater productivity was observed in the May to September 2019 season. Similar to the Albion (Region 6) landing site, greater productivity was also accompanied by an increase in effort, but this may have been partially attributed to using fishing grounds located farther from the landing site thereby requiring additional travel time. Indeed, at Complex 66, total effort and total haul were both approximately 20 percent greater in May to September 2019 as compared with October 2019 to February 2020. This is similar to fishing practices at the Albion landing site where greater effort was also observed in the season with the greatest productivity. Despite higher total productivity in the May to September good season, productivity on a monthly basis was highly varied. The onboard supervisor indicated that there is typically a large variation in hauls over the good season. The owner of the vessel on which the onboard supervisor operates has suggested that downturns in other economic sectors, particularly in agriculture, has led to more persons becoming involved in fishing. Increased competition for the same shared fishing resources has caused many fisherfolk to use larger seines (seines with greater surface areas) with the intention of increasing total hauls. This fisherfolk believes that these practices have changed seasonal dynamics of productivity leading to significant seasonal variability in particular during the peak seasons when more persons are engaged in fishing activity.

Productivity was higher in the primary wet and dry seasons than during the short wet and dry seasons, with the largest hauls occurring in the wet season when fishing effort is concentrated primarily around the mouths of rivers. According to Lowe-McConnel (1962), nutrient flows are increased during the wet season and fishes are expected to be more abundant at river mouths during this season.

Based on the supervisor’s experience and the total-haul to total-effort ratio in October 2019 to February 2020, it can be concluded that there is no clearly defined good and hard season for the onboard supervisor’s fishing practice. This may signal yet another shortened peak season similar to that experienced by fisherfolk in Rosignol. Additional data are required to ascertain if this trend of productivity is typical for this onboard supervisor and to determine whether the experience is similar for other fisherfolk at this landing site.

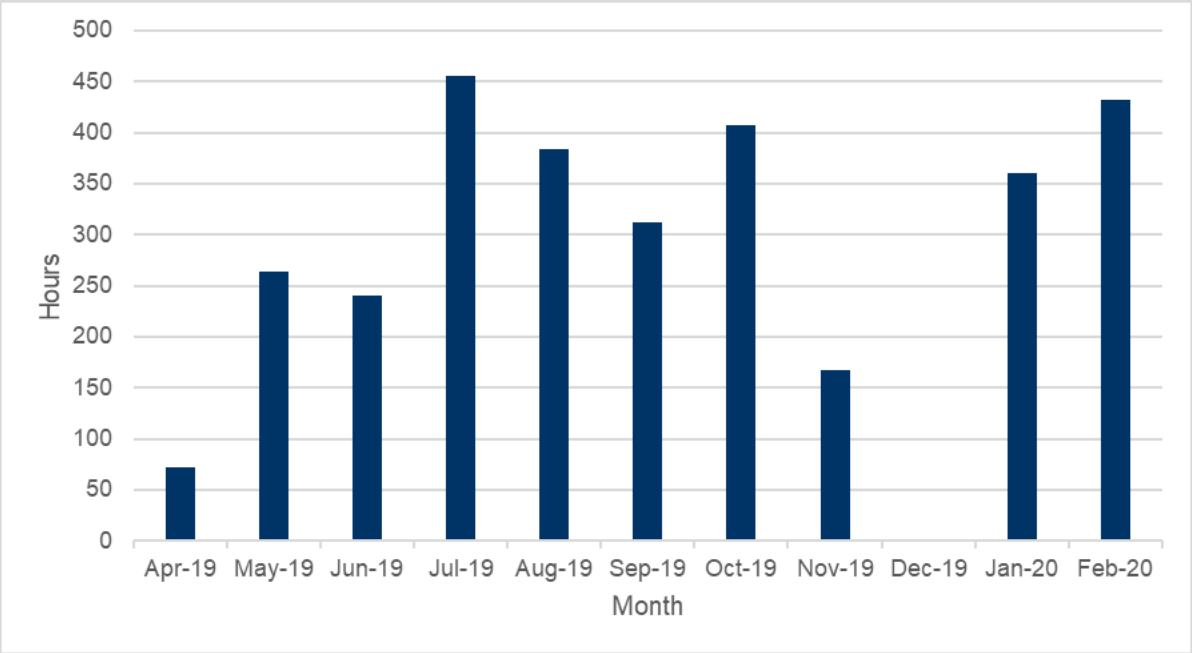


Figure U-3: Total Monthly Fishing Effort Recorded by the Complex 66 Onboard Supervisor

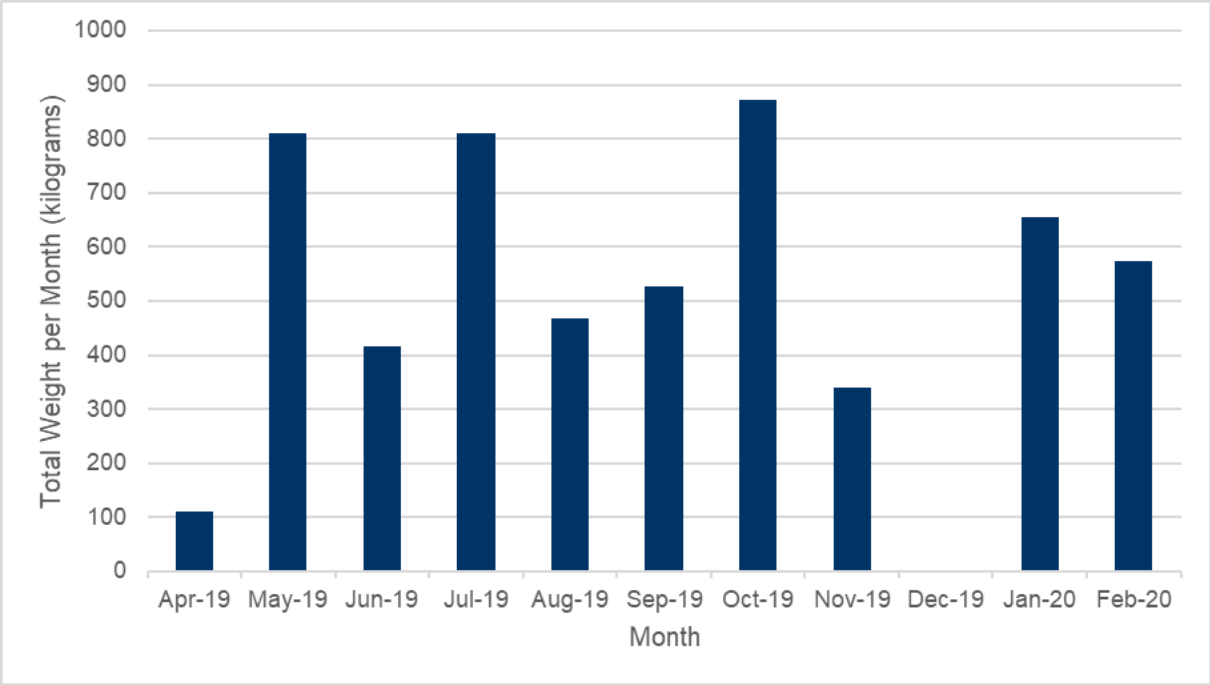


Figure U-4: Total Monthly Weight Recorded by the Complex 66 Onboard Supervisor

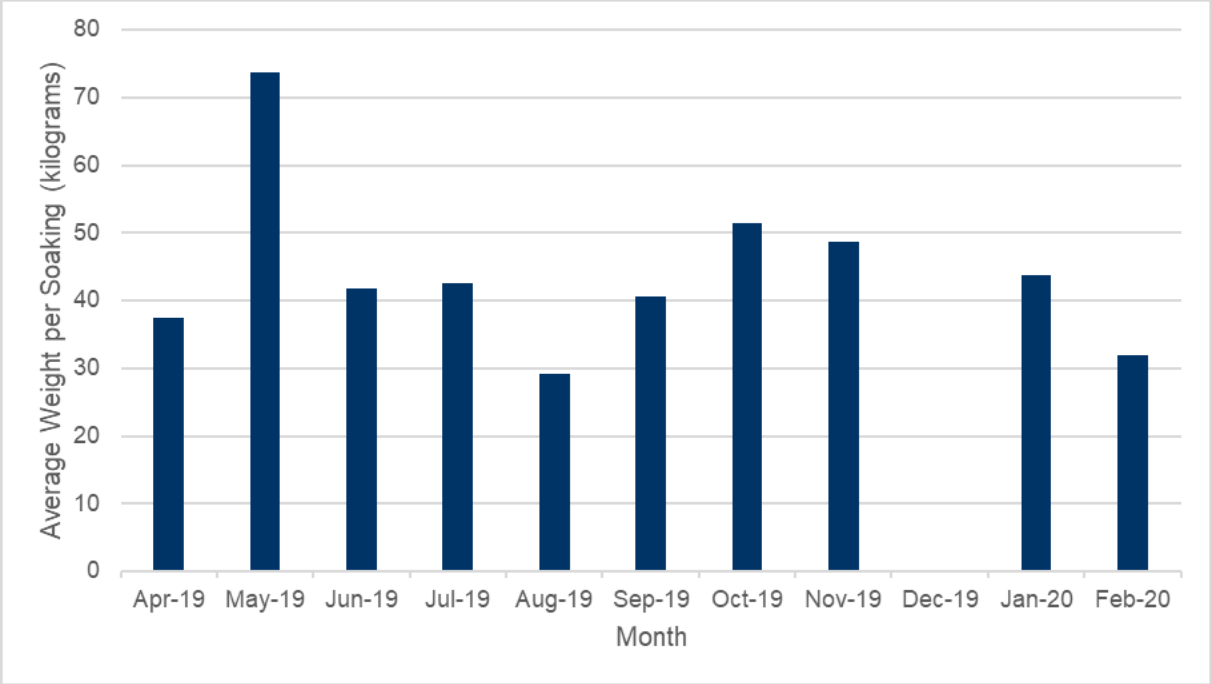


Figure U-5: Average Weight per Soaking Recorded by the Complex 66 Onboard Supervisor

2.4 Biometrics

The onboard supervisor measured the lengths and weights of representative fishes for each haul; the annual average lengths and weights of these fishes are shown on Figure U-6. Based on the measurements taken by the onboard supervisor, most of the fishes caught were sexually mature. The target species of snapper and trout had reached annual average lengths of 69 and 61 centimeters, respectively, and would be considered mature. Snook was the only species caught that did not achieve sexual maturity.

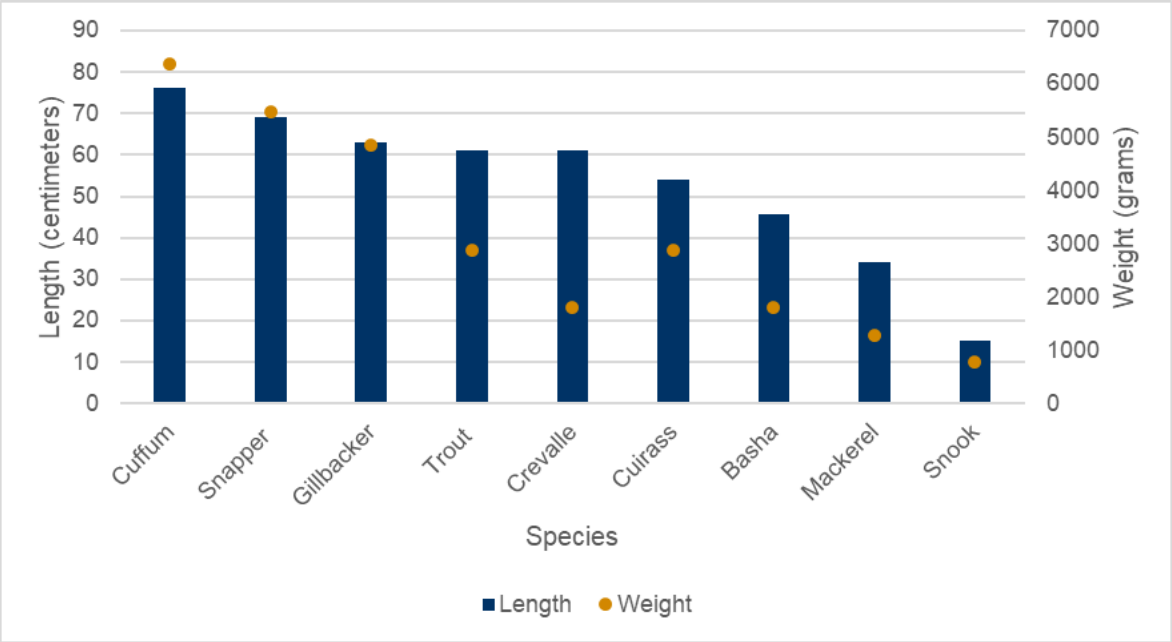


Figure U-6: Total Monthly Weight and Average Weight per Soaking of Hauls Recorded by the Complex 66 Onboard Supervisor

The monthly average lengths and weights of the two most abundant species caught are presented on Figure U-7. All of the fishes measured have reached maturity. The largest snapper and trout were caught in June and July 2019, respectively, after which there was a decline in sizes. This may have been due to more mature females with eggs coming closer to the shoreline to spawn in lagoons, estuaries, and mangroves. This trend is also seen in the data recorded at several other landing sites, like Smith's Creek, Charity, etc., where smaller fishes are caught when the spawning season ends.

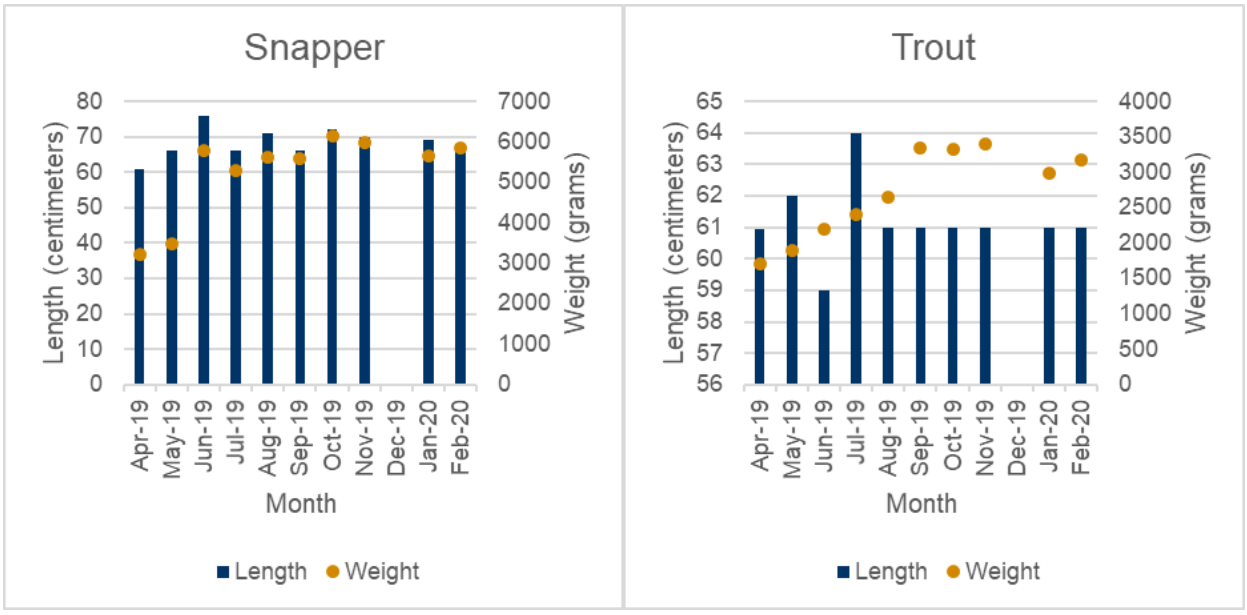


Figure U-7: Average Lengths and Weights of the Most Abundant Species Caught

3 QA/QC DATA

In October 2019, the team conducted the QA/QC exercise for one of the fishing trips conducted by the onboard supervisor. During this trip, the onboard supervisor used a drift seine with mesh sizes of 18 centimeters (7 inches). The trip lasted for 11 days and the seine was soaked 12 times. Fishing activity occurred along the Surinamese coast and the vessel was powered by a 60 hp outboard engine. The supervisor reported that the waters were rough during the fishing trip. The data collected by the study team matched the trends observed during the July to September period in terms of species diversity and composition. As expected, based on the mesh sizes of the seines used, snapper was the most abundant species caught (see Figure U-8). Species diversity was also similar to the trends reported by the onboard supervisor during the reporting period. The biometric data collected showed similar trends to those observed by the supervisor (see Figure U-8). The study coordinator also took biometric measurements of the same fishes that were measured by the onboard supervisor, and no data deviations were observed. Overall, the study coordinator was satisfied that the onboard supervisor was accurately recording the commercial species caught and following the guidance provided in taking biometric measurements.

During the QA/QC exercise in January 2020, the onboard supervisor's vessel had not landed at the site. Another vessel was assessed that also used drift seines with mesh sizes of 19 centimeters (7.5 inches) that conducted its fishing activities in 6 days with 12 soakings of the seine. The vessel, however, stayed in relatively shallow waters of 5 fathoms (9 meters/29.5 feet). This resulted in a large percentage of cuirass being caught by the fisherfolk. Due to this, it is difficult to compare hauls from these two vessels. For example, the size of a representative cuirass from the QA/QC vessel was 55 centimeters, but average monthly length based on data collected by the onboard supervisor was 61 centimeters. Similarly, the size of a representative snapper from the QA/QC vessel was 75 centimeters, but the average monthly length based on data collected by the onboard supervisor was 69 centimeters.

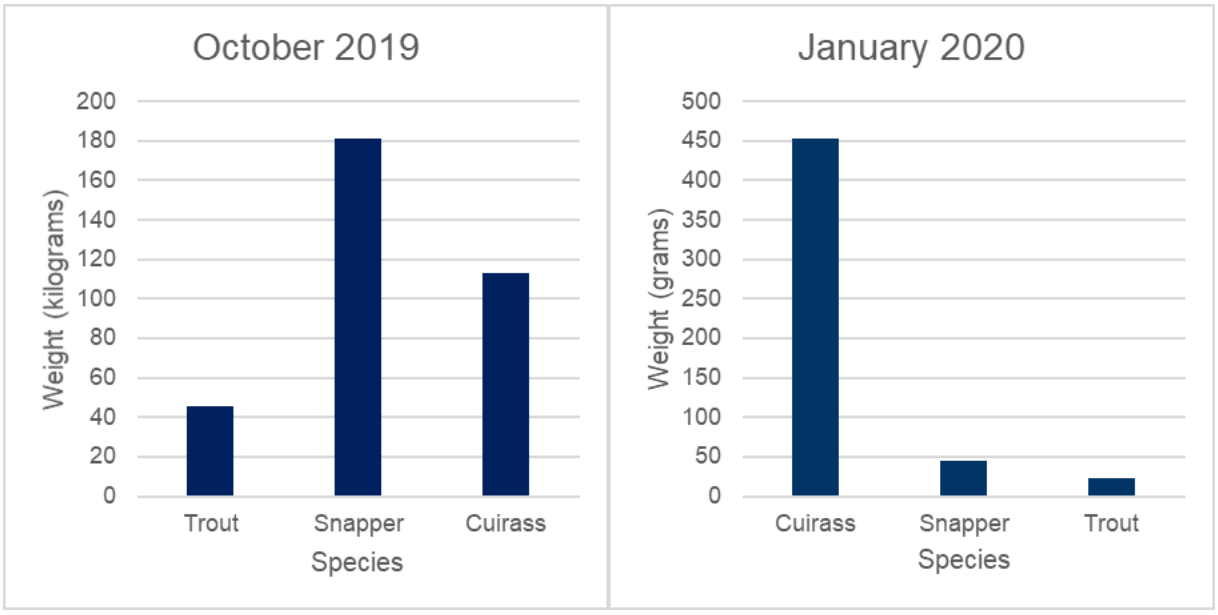


Figure U-8: Catch Composition of Commercially Viable Species of the Vessels Assessed during the QA/QC Exercises

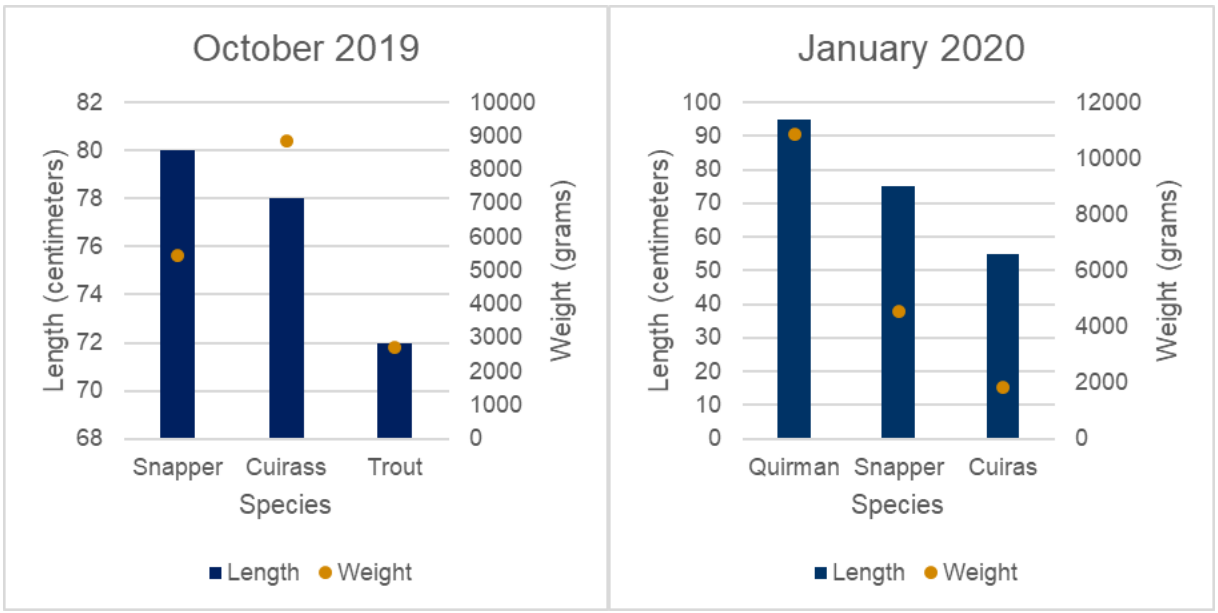


Figure U-9: Lengths and Weights of Fishes Measured during the QA/QC Exercises

APPENDIX E

Ambient Onshore Air Quality Monitoring Report

Resubmitted without changes

March 2022

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Onshore Ambient Air Quality Monitoring Report

Esso Exploration and Production Guyana Limited

Guyana – 15 August 2018 through 26 August 2019

February 2020, Revised October 2021

Revised October 2021

Project Nos.: 0408107 & 0484443

The business of sustainability

ERM

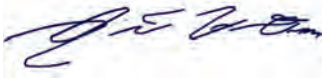
Signature Page

February 2020, Revised October 2021

Revised October 2021

Onshore Ambient Air Quality Monitoring Report

Guyana – 15 August 2018 through 26 August 2019



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Acronyms and Abbreviations

Name	Description
µg/m^3	micrograms per cubic meter
BTEX	benzene, toluene, ethylbenzene, and xylenes
CO	carbon monoxide
EEPGL	Esso Exploration and Production Guyana Limited
ERM	Environmental Resources Management
H_2S	hydrogen sulfide
NA	not applicable
ND	not detected (below laboratory minimum reporting level)
NO_2	nitrogen dioxide
$PM_{2.5}$	fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers)
PM_{10}	inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers)
ppb	parts per billion
ppb(v)	parts per billion by volume
ppm	parts per million
SO_2	sulfur dioxide
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WHO	World Health Organization

EXECUTIVE SUMMARY

Environmental Resources Management (ERM) conducted an onshore ambient air quality monitoring program at three sites in Guyana over the period of 15 August 2018 through 25 August 2019. The monitoring program was designed to characterize existing ambient air quality conditions at selected onshore locations. In the absence of applicable Guyana regulatory guidance, ERM used standard methods for selecting air pollutants to monitor, selecting monitoring sites, and establishing other program parameters. Resulting measurements have been compared to the World Health Organization's (WHO) Air Quality Guideline Values and criteria from the U.S. Environmental Protection Agency (USEPA) (guidelines).

At least 6 weeks of monitoring data were collected at each of three sites: Rose Hall Estate in New Amsterdam, Berbice; Carifesta, just off the sea wall in Georgetown; and New Guyana School, in Georgetown near the east bank of the Demerara River. Monitoring occurred during two different periods at the Carifesta site. The first took place over the period of 15 August 2018 through 4 October 2018, and the second took place over the period of 11 December 2018 through 19 March 2019. Figure 1 illustrates the locations of the three monitoring sites.

Monitored air quality parameters included inhalable and fine particulate matter (PM_{10}[1] and $PM_{2.5}$[2], respectively), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), carbon monoxide (CO), and selected volatile organic compounds.

At the Carifesta and New Amsterdam sites, local meteorological conditions were monitored by a third-party using equipment co-located with the air quality monitoring equipment. The meteorological data were made available to ERM for use in data validation and interpretation. At the New Guyana School site, ERM operated a tripod-mounted instrument to monitor local wind speed and wind direction.

In general, measured gaseous pollutant concentrations were quite low in absolute terms, as well as in comparison to applicable guidelines. Particulate matter concentrations (both PM_{10} and $PM_{2.5}$) were near or exceeded applicable guidelines at all three monitoring sites. The only measured exceedance of a gaseous pollutant criterion was for 24-hour average benzene levels at the Carifesta monitoring site.

Tables 1 through 4 summarize the ambient air quality measurements during both monitoring periods at Carifesta (designated as "Carifesta #1" and "Carifesta #2"), the monitoring period at New Amsterdam, and the monitoring period at New Guyana School, and compares them to applicable guidelines. The tables summarize the measured concentrations for each of the pollutants / averaging periods for which a guideline value is provided by the WHO or USEPA. Note that some of the guidelines are meant to be compared to a statistical value (e.g., the 98th percentile value for 1-hour NO_2, the 99th percentile value for 1-hour SO_2). For the purpose of Tables 1 through 4, the maximum value from the appropriate averaging period is presented. These values are directly comparable to the guidelines that are intended to be compared to maximum values (e.g., 1-hour WHO value for NO_2, 1-hour and 8-hour WHO values for CO), but are higher than the values that are intended to be compared to other guidelines that have a statistical basis.

[1] Particulate matter with aerodynamic diameter of less than 10 micrometers

[2] Particulate matter with aerodynamic diameter of less than 2.5 micrometers

Figure 1: Onshore Ambient Air Quality Monitoring Locations

Table 1: Summary of Ambient Air Quality Monitoring Data—Carifesta #1

Pollutant	Units	Basis	Measured Value	Guideline [a]	Notes
PM_{10}	$\mu g/m^3$	Maximum 24-Hour Average	37.3	45 (WHO) [b] 150 (USEPA) [c]	
		Annual Average	17.3 [o]	15 (WHO) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
$PM_{2.5}$	$\mu g/m^3$	Maximum 24-Hour Average	13.1	15 (WHO) [b] 35 (USEPA) [p]	
		Annual Average	7.1 [o]	5 (WHO) [d] 12 (USEPA) [e]	Measured value represents the average for the duration of monitoring, not a true annual average.
CO	ppm	Maximum 1-Hour Average	1.4	30.5 (WHO) [f] 35 (USEPA) [g]	
		Maximum 8-Hour Average	1.0	8.7 (WHO) [h] 8.7 (USEPA) [i]	
NO_2	ppb	Maximum 1-Hour Average	15.0	106.4 (WHO) [j] 100 (USEPA) [k]	
		Annual Average	3.1 [o]	5.3 (WHO) [d] 53 (USEPA) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
SO_2	ppb	Maximum1-Hour Average	7.2	75 (USEPA) [l]	
		Maximum 24-Hour Average	0.3	15 (WHO) [b]	
H_2S	ppb	Maximum 24-Hour Average	1.9	107.6 (WHO) [m]	
Benzene	ppb	Maximum 24-Hour Average	131.9	9.4 (USEPA) [m]	
Toluene	ppb	Maximum 1-Week Average	20.7	69 (WHO) [n]	
Ethylbenzene	ppb	Annual Average	0.08 [o]	0.23 (USEPA) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
Xylene	ppb	Maximum 24-Hour Average	12.3	100 (USEPA) [m]	

$\mu g/m^3$ = micrograms per cubic meter; ppb = parts per billion; ppm = parts per million
[a] Some guidelines may be of a statistical form and not be directly comparable to the measured values presented.
[b] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[c] Maximum of the second-highest 24-hour average concentrations across all measurement period
[d] Maximum of the annual average concentrations for all years in the measurement period
[e] Average of the annual average concentrations for all years in the measurement period
[f] Maximum of the 1-hour average concentrations across measurement period
[g] Maximum of the second-highest 1-hour average concentrations across measurement period
[h] Maximum of the 8-hour average concentrations across measurement period
[i] Maximum of the second-highest 8-hour average concentrations across measurement period
[j] Maximum of the 1-hour average concentrations across measurement period
[k] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[l] Average of the 99th percentile 1-hour average concentrations for all years in the measurement period

[m] Maximum of the 24-hour average concentrations across measurement period.
[n] Maximum of the 1-week average concentrations across measurement period.
[o] Value represents data during monitoring period which was less than one full year
[p] Maximum of the 98th percentile 24-hour average concentrations across measurement period

Table 2: Summary of Ambient Air Quality Monitoring Data—New Amsterdam

Pollutant	Units	Basis	Measured Value [a]	Guideline [a]	Notes
PM_{10}	µg/m^3	Maximum 24-Hour Average	39.8	45 (WHO) [b] 150 (USEPA) [c]	
		Annual Average	20.6 [o]	15 (WHO) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
$PM_{2.5}$	µg/m^3	Maximum 24-Hour Average	13.5	15 (WHO) [b] 35 (USEPA) [p]	
		Annual Average	6.8 [o]	5 (WHO) [d] 12 (USEPA) [e]	Measured value represents the average for the duration of monitoring, not a true annual average.
CO	ppm	Maximum 1-Hour Average	1.05	30.5 (WHO) [f] 35 (USEPA) [g]	
		Maximum 8-Hour Average	0.66	8.7 (WHO) [h] 8.7 (USEPA) [i]	
NO_2	ppb	Maximum 1-Hour Average	21.7	106.4 (WHO) [j] 100 (USEPA) [k]	
		Annual Average	-1.4 [o,q]	5.3 (WHO) [d] 53 (USEPA) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
SO_2	ppb	Maximum1-Hour Average	-0.1 [q]	75 (USEPA) [l]	
		Maximum 24-Hour Average	-1.0 [q]	15 (WHO) [b]	
H_2S	ppb	Maximum 24-Hour Average	0.4	107.6 (WHO) [m]	
Benzene	ppb	Maximum 24-Hour Average	0.4	9.4 (USEPA) [m]	
Toluene	ppb	Maximum 1-Week Average	5.0	69 (WHO) [n]	
Ethylbenzene	ppb	Annual Average	0.0 [o]	0.23 (USEPA) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
Xylene	ppb	Maximum 24-Hour Average	0.9	100 (USEPA) [m]	

µg/m^3 = micrograms per cubic meter; ppb = parts per billion; ppm = parts per million
[a] Some guidelines may be of a statistical form and not be directly comparable to the measured values presented.
[b] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[c] Maximum of the second-highest 24-hour average concentrations across all measurement period
[d] Maximum of the annual average concentrations for all years in the measurement period
[e] Average of the annual average concentrations for all years in the measurement period
[f] Maximum of the 1-hour average concentrations across measurement period
[g] Maximum of the second-highest 1-hour average concentrations across measurement period
[h] Maximum of the 8-hour average concentrations across measurement period

[i] Maximum of the second-highest 8-hour average concentrations across measurement period
[j] Maximum of the 1-hour average concentrations across measurement period
[k] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[l] Average of the 99th percentile 1-hour average concentrations for all years in the measurement period
[m] Maximum of the 24-hour average concentrations across measurement period
[n] Maximum of the 1-week average concentrations across measurement period
[o] Value represents data during monitoring period which was less than one full year
[p] Maximum of the 98th percentile 24-hour average concentrations across measurement period.
[q] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 3: Summary of Ambient Air Quality Monitoring Data—Carifesta #2

Pollutant	Units	Basis	Measured Value [a]	Guideline [a]	Notes
PM_{10}	µg/m^3	Maximum 24-Hour Average	154.3	45 (WHO) [b] 150 (USEPA) [c]	
		Annual Average	33.3 [o]	15 (WHO) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
$PM_{2.5}$	µg/m^3	Maximum 24-Hour Average	53.1	15 (WHO) [b] 35 (USEPA) [p]	
		Annual Average	12.7 [o]	5 (WHO) [d] 12 (USEPA) [e]	Measured value represents the average for the duration of monitoring, not a true annual average.
CO	ppm	Maximum 1-Hour Average	1.45	30.5 (WHO) [f] 35 (USEPA) [g]	
		Maximum 8-Hour Average	1.15	8.7 (WHO) [h] 8.7 (USEPA) [i]	
NO_2	ppb	Maximum 1-Hour Average	12.5	106.4 (WHO) [j] 100 (USEPA) [k]	
		Annual Average	-0.7 [o,q]	5.3 (WHO) [d] 53 (USEPA) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
SO_2	ppb	Maximum1-Hour Average	2.9	75 (USEPA) [l]	
		Maximum 24-Hour Average	0.3	15 (WHO) [b]	
H_2S	ppb	Maximum 24-HourAverage	1.3	107.6 (WHO) [m]	
Benzene	ppb	Maximum 24-Hour Average	NA	9.4 (USEPA) [m]	
Toluene	ppb	Maximum 1-Week Average	NA	69 (WHO) [n]	
Ethylbenzene	ppb	Annual Average	NA	0.23 (USEPA) [d]	
Xylene	ppb	Maximum 24-Hour Average	NA	100 (USEPA) [m]	

µg/m^3 = micrograms per cubic meter; NA = not applicable; ppb = parts per billion; ppm = parts per million
[a] Some guidelines may be of a statistical form and not be directly comparable to the measured values presented.
[b] Maximum of the 99th percentile 24-hour average concentrations across measurement period

[c] Maximum of the second-highest 24-hour average concentrations across all measurement period
[d] Maximum of the annual average concentrations for all years in the measurement period
[e] Average of the annual average concentrations for all years in the measurement period
[f] Maximum of the 1-hour average concentrations across measurement period
[g] Maximum of the second-highest 1-hour average concentrations across measurement period
[h] Maximum of the 8-hour average concentrations across measurement period
[i] Maximum of the second-highest 8-hour average concentrations across measurement period
[j] Maximum of the 1-hour average concentrations across measurement period
[k] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[l] Average of the 99th percentile 1-hour average concentrations for all years in the measurement period
[m] Maximum of the 24-hour average concentrations across measurement period
[n] Maximum of the 1-week average concentrations across measurement period
[o] Value represents data during monitoring period which was less than one full year
[p] Maximum of the 98th percentile 24-hour average concentrations across measurement period
[q] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 4: Summary of Ambient Air Quality Monitoring Data—New Guyana School

Pollutant	Units	Basis	Measured Value [a]	Guideline [a]	Notes
PM_{10}	µg/m^3	Maximum 24-Hour Average	60.0	45 (WHO) [b] 150 (USEPA) [c]	
		Annual Average	25.5 [o]	15 (WHO) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
$PM_{2.5}$	µg/m^3	Maximum 24-Hour Average	18.2	15 (WHO) [b] 35 (USEPA) [p]	
		Annual Average	9.3 [o]	5 (WHO) [d] 12 (USEPA) [e]	Measured value represents the average for the duration of monitoring, not a true annual average.
CO	ppm	Maximum 1-Hour Average	1.2	30.5 (WHO) [f] 35 (USEPA) [g]	
		Maximum 8-Hour Average	0.86	8.7 (WHO) [h] 8.7 (USEPA) [i]	
NO_2	ppb	Maximum 1-Hour Average	15.8	106.4 (WHO) [j] 100 (USEPA) [k]	
		Annual Average	1.3 [o]	5.3 (WHO) [d] 53 (USEPA) [d]	Measured value represents the average for the duration of monitoring, not a true annual average.
SO_2	ppb	Maximum1-Hour Average	11.7	75 (USEPA) [l]	
		Maximum 24-Hour Average	3.3	15 (WHO) [b]	
H_2S	ppb	Maximum 24-Hour Average	16.0	107.6 (WHO) [m]	30-Minute
Benzene	ppb	Maximum 24-Hour Average	0.7	9.4 (USEPA) [m]	Measured value represents the average of eight 24-hour integrated Summa samples.
		Maximum 1-Week Average	0.8		Measured value represents data from Mocon installed on 27 June and operated until 22 August.

Toluene	ppb	Annual Average	NA	69 (WHO) [n]	
			0.0 [o]		Measured value represents data from Mocon installed on 27 June and operated until 22 August.
Ethylbenzene	ppb	Annual Average	0.0 [o]	0.23 (USEPA) [d]	Measured value represents data from Mocon installed on 27 June and operated until 22 August.
Xylene	ppb	Maximum 24-Hour Average	0.6	100 (USEPA) [m]	Measured value represents the average of eight 24-hour integrated Summa samples.
			0.0		Measured value represents data from Mocon installed on 27 June and operated until 22 August.

µg/m^3 = micrograms per cubic meter; NA = not applicable; ppb = parts per billion; ppm = parts per million
µg/m^3 = micrograms per cubic meter; NA = not applicable; ppb = parts per billion; ppm = parts per million
[a] Some guidelines may be of a statistical form and not be directly comparable to the measured values presented.
[b] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[c] Maximum of the second-highest 24-hour average concentrations across all measurement period
[d] Maximum of the annual average concentrations for all years in the measurement period
[e] Average of the annual average concentrations for all years in the measurement period
[f] Maximum of the 1-hour average concentrations across measurement period
[g] Maximum of the second-highest 1-hour average concentrations across measurement period
[h] Maximum of the 8-hour average concentrations across measurement period
[i] Maximum of the second-highest 8-hour average concentrations across measurement period
[j] Maximum of the 1-hour average concentrations across measurement period
[k] Maximum of the 99th percentile 24-hour average concentrations across measurement period
[l] Average of the 99th percentile 1-hour average concentrations for all years in the measurement period
[m] Maximum of the 24-hour average concentrations across measurement period
[n] Maximum of the 1-week average concentrations across measurement period
[o] Value represents data during monitoring period which was less than one full year
[p] Maximum of the 98th percentile 24-hour average concentrations across measurement period

PM_{10}, and to a lesser extent $PM_{2.5}$, is generated by physical operations. It is likely that the elevated concentrations measured at all three sites were influenced by vehicle traffic (engine emissions, rubber tire dust, resuspended road dust) and open burning. The Carifesta site may have also received sea salt inputs due to its proximity to the coast. The sources of New Amsterdam PM_{10} ambient air impacts likely included agricultural emission sources (tilling, harvesting, and residue burning). At New Guyana School, the sources of PM_{10} ambient air impacts likely included agricultural emission sources, as well as vehicle emissions.

In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning are probably also $PM_{2.5}$ emission sources impacting the three monitoring sites.

With respect to PM_{10} and $PM_{2.5}$, the comparison between the full monitoring period averages and the WHO and USEPA annual average guideline values should be considered indicative, rather than directly comparable, as the monitoring durations at each of the three sites were less than 365 days (between 50 and 141 days). The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Additionally, the measured maximum 24-hour average PM_{10} and $PM_{2.5}$ values cannot be directly compared with the USEPA and WHO guideline values since those guidelines are intended for comparison to statistical values (i.e., not the single highest average values), which would be lower than the highest average values.

The monitoring results for CO, NO_2, H_2S, and SO_2 were all below the WHO and USEPA guideline values. The low concentrations limit the extent to which NO_2 or SO_2 would be likely to promote ozone or secondary $PM_{2.5}$ formation.

The only measured exceedance of a gaseous pollutant criterion was the 24-hour average benzene levels at the Carifesta monitoring site. At Carifesta, the maximum 24-hour average was significantly higher than the 24-hour USEPA guideline value. The measured maximum 24-hour average value includes a single 6-minute sample that registered well above the calibration range of the analyzer. While this anomalous measurement is considered to be an outlier, it was not invalidated since all quality control parameters were within tolerance. Even if the outlier value is excluded, the maximum 24-hour average would still have exceeded the guideline value by more than 50 percent at the Carifesta site. Motor vehicle emissions may have been responsible for the measured values, since there are no obvious nearby stationary benzene emission sources upwind of the Carifesta site. The Carifesta site is situated between two roadways that are often busy and sometimes congested. The sample inlet was located 34 meters (111.5 feet) from Carifesta Road and 69 meters (226.4 feet) from Seawall Public Road—making vehicle emissions a likely source. At the New Amsterdam and the New Guyana School monitoring sites, the maximum 24-hour average benzene measurements were significantly lower than the USEPA guideline value.

1. AIR MONITORING PROGRAM DESCRIPTION

Environmental Resources Management (ERM) conducted an onshore ambient air quality monitoring program on behalf of Esso Exploration and Production Guyana Limited (EEPGL) over the period of 15 August 2018 through 25 August 2019 at three sites in Guyana: Rose Hall Estate in New Amsterdam, Berbice (the "New Amsterdam" site); Carifesta, just off the sea wall in Georgetown (the "Carifesta" site); and New Guyana School, also in Georgetown, near the east bank of the Demerara River (the "New Guyana School" site).

1.1. Monitored Air Quality Parameters

The monitored air pollutants included in the program were:

- Particulate matter—two size ranges:
  - PM_{10} (inhalable particulate matter with aerodynamic diameter of less than 10 micrometers)
  - $PM_{2.5}$ (fine particulate matter with aerodynamic diameter of less than 2.5 micrometers)
- Carbon monoxide (CO)
- Sulfur dioxide (SO_2)
- Hydrogen sulfide (H_2S)
- Nitrogen dioxide (NO_2)
- Selected volatile organic compounds (VOCs)[3]:
  - Benzene
  - Toluene
  - Ethylbenzene
  - Xylenes

Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment were those established by the World Health Organization (WHO) in *WHO Global Air Quality Guidelines: Particulate Matter (PM2.5 and PM10), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide* (WHO 2021), except for toluene, CO, and H_2S, for which WHO guidelines were published in WHO's *Air Quality Guidelines for Europe, 2nd edition, 2000* (WHO 2000). Since ozone is a secondary pollutant not directly emitted by industrial sources, it was not included in the suite of monitored parameters. While no WHO guidelines have been published for benzene, ethylbenzene, or xylenes, criteria for these species have been established by the U.S. Environmental Protection Agency (USEPA) and these were used for the assessment of results (USEPA 2019c).

1.2. Monitoring Sites

The monitoring sites were selected by EEPGL and ERM based on the sites' ability to characterize existing ambient air quality in areas upwind and downwind of urban Georgetown (where urban emission levels are anticipated to be highest).

Historical climatological data (such as prevailing wind patterns) and USEPA siting criteria were also considered in selecting specific sites. Finally, site accessibility and availability of power supply were factored into the final site selection.

[3] As noted in the report, during the 12 April through 27 June 2019 monitoring period, an electrochemical sensor was employed at the New Guyana School site to measure total VOCs when the gas chromatograph that normally measures speciated BTEX was out of service. While this sensor does not speciate VOCs, the total VOC measurements represent a maximum limit on the sum of the BTEX compounds' concentrations. The sensor data was supplemented by several evacuated canister ("Summa") samples that collected whole air for subsequent laboratory analysis. These analyses provided speciated BTEX values.

The Carifesta monitoring site was established adjacent to Guyana Telephone & Telegraph's Carifesta Avenue location. See Figure 2 for a map of the Carifesta monitoring site. The New Amsterdam monitoring site was established at Rose Hall Estate, adjacent to the Rose Hall Sugar Factory in New Amsterdam, Berbice, as shown on Figure 3.

The New Guyana School monitoring site was established in Georgetown, on the school's property, near the east bank of the Demerara River. Figure 4 illustrates the location of this site.

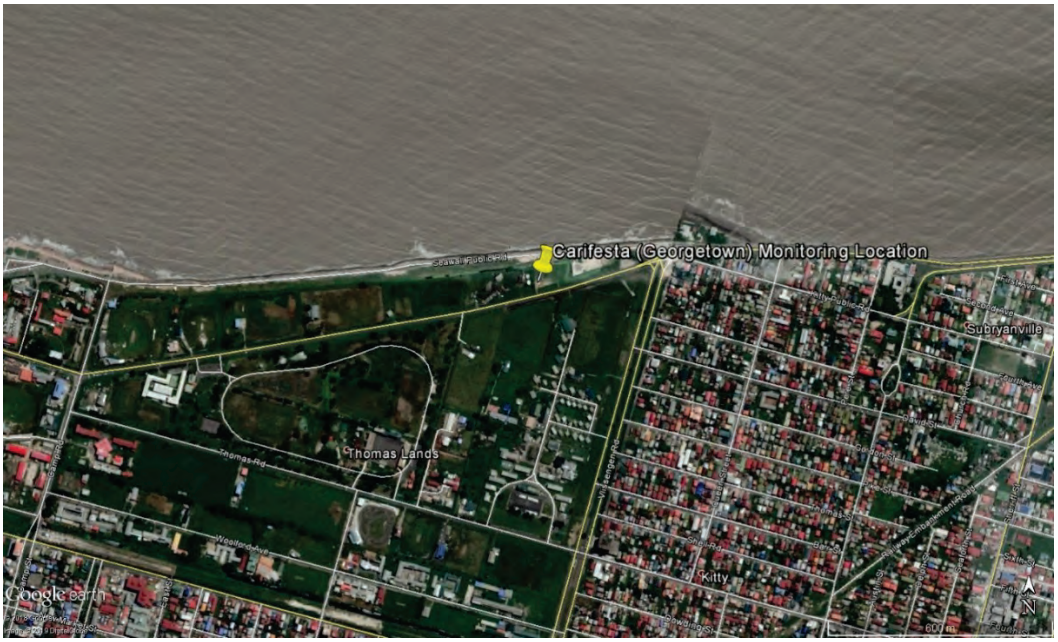


Figure 2: Carifesta (Georgetown) Monitoring Site Location

Figure 3: New Amsterdam (Berbice) Monitoring Site Location

Figure 4: New Guyana School (Georgetown) Monitoring Site Location

At each location, the air quality analyzers were housed in a climate-controlled shelter, with ambient air drawn in for analysis through sample inlets. For PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and H_2S measurements, ambient air was analyzed using continuous analyzers. Data from these continuous analyzers were reduced to 1-minute averages for storage and use in averaged concentration calculations. The VOC analyzer operated semi-continuously, with measurements recorded once every 6 minutes. The 6-minute data were then reduced to hourly averages.

An electrochemical total VOC sensor was used at the New Guyana School site, as the VOC analyzer was out of service during the New Guyana School site monitoring period (as described in Section 3). The sensor provided continuous output data. In conjunction with use of the total VOC sensor, eight passivated, evacuated Summa® canisters[4] were used to sequentially collect 24-hour integrated whole air samples for subsequent laboratory analysis via USEPA Method TO-15 (gas chromatography/mass spectrometry). These samples were analyzed for a suite of 75 organic compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX).

Carifesta site monitoring began on 15 August 2018 and concluded on 3 October 2018. Monitoring at the New Amsterdam location began on 15 October 2018 and concluded on 3 December 2018. A second Carifesta monitoring period was conducted from 11 December 2018 through 21 March 2019. New Guyana School site monitoring commenced on 12 April 2019 and concluded on 25 August 2019.

ERM considers 6 weeks (approximately 1,000 hours) of ambient air quality monitoring to be adequate to characterize baseline air quality in environments where there are relatively few major emission sources, the topography is simple, and climate conditions lack significant seasonality. The quantity of data exceeded this objective by more than 10 percent at each of the monitoring sites. Monitoring at New Guyana School was extended beyond 6 weeks to provide a dataset representative of the wet season.

[4] Summa canisters are specially treated to make them chemically non-reactive with specific air pollutants so that collected whole air samples do not degrade significantly during the interval between sampling and analysis.

2. AMBIENT AIR MONITORING RESULTS

2.1. PM_{10} Monitoring Results

Ambient concentrations of PM_{10} were measured continuously by a Teledyne API T640X, optical aerosol spectrometer. PM_{10} valid data recovery[5] was 91 percent during the first Carifesta monitoring period, 99 percent during the New Amsterdam monitoring, 97 percent during the second Carifesta monitoring period, and 97 percent during the monitoring at the New Guyana School site. Valid data recovery is a convenient metric on which to judge a monitoring program's technical performance. Valid data loss can result from power outage, instrument malfunction, or calibration/maintenance work that detracts from the time an instrument is measuring ambient air.

Since there are particulate matter guideline criteria for 24-hour average values, only those days for which sufficient hours of data were collected are appropriate for comparison to the 24-hour average particulate matter criterion. ERM used a threshold of at least 75 percent of possible hours (i.e., 18 hours) to be valid for the daily average to be considered valid. During the first Carifesta monitoring period, 45 days were designated as valid[6] for use in comparison with criteria. At New Amsterdam, 50 monitoring days were designated as valid for use in comparison with criteria. During the second Carifesta monitoring period, 93 days were designated as valid for use in comparison with criteria. At The New Guyana School, 132 days were designated as valid for use in comparison with criteria. The proportion of valid monitoring days provides context with which to assess whether the data are adequate for comparison with an ambient air quality criterion.

Table 5 presents a summary of the results of PM_{10} monitoring for all four monitoring periods. ERM's ambient air quality data recovery goal is 80 percent—consistent with international standard practice. All four monitoring periods exceeded this goal. Measured concentrations at the monitoring locations were compared to the 24-hour and annual WHO Guideline Values for PM_{10} (WHO 2021). 24-hour values were also compared with the USEPA PM_{10} guideline value.

Table 5: Summary of PM_{10} Monitoring Results

Site	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	61.9	37.3	17.3	91%	45
Carifesta #2 (rainy season)	266.8	154.3	33.3	97%	93
Carifesta (combined)	266.8	154.3	28.3	95%	138
New Amsterdam	110.7	39.8	20.6	99%	50
New Guyana School	103.3	60.0	25.5	97%	132
Guideline(s)	—	45 (WHO) 150 (USEPA)	15 (WHO Annual)		

$\mu g/m^3$ = micrograms per cubic meter
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

[5] Valid data recovery percentage is the number of valid hourly measurements divided by total number of hours monitored, multiplied by 100.
[6] A valid monitoring day is one that obtained data for at least 18 of the 24 monitoring hours in the day.

At Carifesta during the first monitoring period, the maximum 24-hour average concentration was about 25 percent below the 24-hour WHO Guideline Value, while the average over the 45-day monitoring period was slightly above the WHO annual average criterion. The New Amsterdam monitoring yielded a maximum 24-hour average concentration that was about 20 percent below the 24-hour WHO Guideline Value, while the full monitoring period average of measured concentrations was slightly above the WHO annual average criterion. At Carifesta during the second monitoring period, the maximum 24-hour average concentration was approximately three times the corresponding WHO criterion, while the average over the 93-day monitoring period was about two times the annual average criterion. At New Guyana School, the maximum 24-hour average was about 33 percent above the criterion, while the full monitoring period average was approximately 70 percent over the annual WHO Guideline Value.

PM_{10} is generated primarily by physical operations. It is likely that the elevated concentrations monitored at all three sites were influenced by vehicle traffic (engine emissions, rubber tire dust, resuspended road dust) and open burning. Carifesta may have also received sea salt inputs due to its proximity to the coast. The New Amsterdam PM_{10} sources likely included impacts from agricultural emission sources (tilling, harvesting, and residue burning). At New Guyana School, the sources of PM_{10} ambient air impacts likely included agricultural, as well as vehicle emissions.

It should be noted that the comparison between the full monitoring period averages and the annual WHO Guideline Value should be considered indicative rather than directly comparable, as the guideline is an annual average, and the monitoring durations at all three sites were each less than 365 days. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases.

The daily monitoring statistics for all three sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.2. $PM_{2.5}$ Monitoring Results

Ambient concentrations of $PM_{2.5}$ were measured continuously by a Teledyne API T640X, optical aerosol spectrometer. $PM_{2.5}$ valid data recovery was 91 percent during the first Carifesta monitoring period, 99 percent during the New Amsterdam monitoring, 97 percent during the second Carifesta monitoring period, and 97 percent during the monitoring at the New Guyana School site. During the first Carifesta period, 45 monitoring days were designated as valid for use in comparison with criteria. At New Amsterdam, 50 monitoring days were designated as valid for use in comparison with criteria. During the second Carifesta period, 93 days were designated as valid for use in comparison with criteria. At the New Guyana School, 132 days were designated as valid for comparison to criteria. Table 6 presents a summary of the results of $PM_{2.5}$ monitoring at the three monitoring site locations. Measured concentrations at all three monitoring locations were compared to the 24-hour and annual WHO Guideline Values for $PM_{2.5}$.

At Carifesta during the first monitoring period, the maximum 24-hour average measurement was slightly below the corresponding WHO standard, and the monitoring period average concentration was approximately 50 percent above the WHO annual Guideline Value. The New Amsterdam maximum 24-hour average concentration was slightly below the corresponding WHO Guideline Value, and the monitoring period average was approximately 50 percent above the annual criterion. At Carifesta during the second monitoring period, the maximum 24-hour average measurement was approximately three times the corresponding WHO standard, and the monitoring period average concentration was approximately two and a half times the WHO annual Guideline Value. The New Guyana School maximum 24-hour average concentration was slightly above the WHO Guideline Value, and the monitoring period average was about two times the WHO annual Guideline Value.

Table 6: Summary of $PM_{2.5}$ Monitoring Results

Location	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	31.8	13.1	7.1	91%	45
Carifesta #2 (rain season)	92.7	53.1	12.7	97%	93
Carifesta (combined)	92.7	53.1	11.0	95%	138
New Amsterdam	38.3	13.5	6.8	99%	50
New Guyana School	45.8	18.2	9.3	97%	132
Guideline(s)	—	15 (WHO) 35 (USEPA)	5 (WHO Annual) 12 (USEPA Annual)		

$\mu g/m^3$ = micrograms per cubic meter
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

It should be noted that the comparison between the full monitoring period averages and the annual Guideline Values should be considered indicative rather than directly comparable, as the WHO Guideline Value is an annual average, and the duration of monitoring at each of the three locations was less than a full year. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. In addition, the USEPA guideline is stated as the average of 3 years of annual averages. The USEPA 24-hour guideline is meant to be compared to the 98th percentile maximum 24-hour average values.

In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning are probably also $PM_{2.5}$ emission sources impacting the three monitoring sites.

The daily monitoring statistics for all three sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.3. Carbon Monoxide Monitoring Results

Ambient concentrations of CO were measured continuously by a Thermofisher Scientific Model 48i gas filter correlation analyzer. Monitored concentrations were adjusted, as needed, in post-processing based on the automated zero test of the analyzer. CO valid data recovery was 99 percent at the Carifesta location during the first monitoring period, 98 percent at the New Amsterdam location, 99 percent at Carifesta during the second monitoring period, and 95 percent at New Guyana School.

At the Carifesta site during the first monitoring period, 50 monitoring days were designated as valid for use in comparison with criteria; at the New Amsterdam site, 50 monitoring days were designated as valid for use in comparison with criteria; at Carifesta during the second monitoring period, 98 days were designated as valid for use in comparison with criteria; at the New Guyana School site, 131 monitoring days were designated as valid for comparison with criteria. Table 7 presents a summary of the results of CO monitoring at all three monitoring sites.

Measured concentrations at the Carifesta site during the first monitoring period were adjusted in post-processing based on the automated zero tests of the analyzer, as necessary, to account for instrument drift. Measured concentrations at all three monitoring locations were compared to the 1-hour and 8-hour average WHO and USEPA Guideline Values for CO. The maximum 1-hour and 8-hour average measured concentrations for all three sites are well below the Guideline Values.

The daily monitoring statistics for all the sites are presented in Attachment A and the hourly data record is presented in Attachment B.

Table 7: Summary of Carbon Monoxide Monitoring Results

Location	Maximum 1-Hour Average (ppm)	Maximum 8-Hour Average (ppm)	Monitoring Period Average (ppm)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1.36	1.01	0.43	99%	50
Carifesta #2 (rainy season)	1.45	1.15	0.51	99%	98
Carifesta (combined)	1.45	1.15	0.48	99%	148
New Amsterdam	1.05	0.66	0.35	98%	50
New Guyana School	1.20	0.86	0.49	95%	131
Guidelines	30.5 (WHO) 35 (USEPA)	8.7 (WHO) 8.7 (USEPA)	—		

ppm = parts per million

2.4. Nitrogen Dioxide Monitoring Results

Ambient concentrations of NO_2 were measured continuously by a Thermofisher Scientific Model 42i chemiluminescent analyzer. Measured concentrations at New Amsterdam were adjusted, as necessary, in post-processing based on the automated zero and span tests of the analyzer. NO_2 valid data recovery was 96 percent at the Carifesta location during the first monitoring period, 79 percent at the New Amsterdam location, 95 percent during the second monitoring period at Carifesta, and 93 percent at the New Guyana School site.

The New Amsterdam data recovery was slightly below the data recovery goal of 80 percent. While not ideal, 79 percent data recovery is generally adequate for characterizing ambient air quality. Many governmental agencies use 75 percent as their data recovery objective.

At Carifesta during the first monitoring period, 50 monitoring days were designated as valid for use in comparison to criteria; at the New Amsterdam site, 50 monitoring days were designated as valid for use in comparison to criteria; during the second monitoring period at Carifesta, 98 monitoring days were designated as valid for use in comparison to criteria; at the New Guyana School, 130 monitoring days were designated as valid for use in comparison to criteria. Table 8 presents a summary of the results of NO_2 monitoring at all three monitoring locations.

Table 8: Summary of Nitrogen Dioxide Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Monitoring Period Average [a] (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	15.0	3.1	96%	50
Carifesta #2 (rainy season)	12.5	-0.7 [b]	95%	98
Carifesta (combined)	15.0	0.6	95%	148
New Amsterdam	21.7	-1.4 [b]	79%	40
New Guyana School	15.8	1.3	93%	130
Guideline	106.4 (WHO) 100 (USEPA)	5.3 (WHO Annual) 53 (USEPA Annual)		

ppb = parts per billion
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.
[b] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Data recovery at the New Amsterdam location was adversely affected by the failure of the analyzer's internal pump and several instances of significant bleed-over of the automated challenge concentration. The bleed-over occurred when the air compressor that is used to supply zero gas was off or did not supply enough pressure to allow for the proper dilution of the calibration gas.

The maximum 1-hour average and the full monitoring period average of the measured concentrations were compared to the 1-hour and annual WHO and USEPA Guideline Values, respectively, for NO_2. At all three monitoring sites, the averages are well below the applicable Guideline Values.

It should be noted that the comparison between the full monitoring period averages and the annual Guideline Values should be considered indicative rather than directly comparable, as the Guideline Values are annual averages, and the duration of monitoring at each of the three sites was less than a full year. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Therefore, it is expected that actual annual average values at the sites would be even further below the guideline value.

The daily monitoring statistics for both sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.5. Sulfur Dioxide Monitoring Results

Ambient concentrations of SO_2 were measured continuously by a Thermofisher Scientific Model 450i pulsed fluorescence analyzer. SO_2 valid data recovery was 96 percent at the Carifesta location during the first monitoring period, 95 percent at the New Amsterdam location, 95 percent during the second monitoring period at Carifesta, and 93 percent at the New Guyana School site. At the Carifesta site during the first monitoring period, 50 monitoring days were designated as valid for use in comparison to criteria; New Amsterdam had 50 days designated as valid for use in comparison to criteria; the second monitoring period at Carifesta had 98 days designated as valid for use in comparison to criteria; New Guyana School had 132 days designated as valid for use in comparison to criteria. Table 9 presents a summary of the results of SO_2 monitoring at all three locations.

Table 9: Summary of Sulfur Dioxide Monitoring Results

Location	Maximum Daily 1-hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	7.2	0.3	-1.0 [a]	96%	50
Carifesta #2 (rainy season)	2.9	0.3	-0.1 [a]	95%	98
Carifesta (combined)	7.2	0.3	-0.4 [a]	95%	148
New Amsterdam	-0.1 [a]	-1.0 [a]	-1.3 [a]	95%	50
New Guyana School	11.7	3.3	0.9	93%	132
Guideline	75 (USEPA)	15 (WHO)	—		

ppb = parts per billion
[a] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

The maximum 1-hour average and the maximum 24-hour average of the measured SO_2 concentrations at all three monitoring sites were compared to the 1-hour USEPA standard and the 24-hour WHO Guideline Value, respectively. At all three monitoring sites, the averages are well below the SO_2 criteria.

The daily monitoring statistics for both sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.6. Hydrogen Sulfide Monitoring Results

Ambient concentrations of H_2S were measured continuously by a Thermofisher Scientific Model 450i pulsed fluorescence analyzer. H_2S valid data recovery was 96 percent at the Carifesta location during the first monitoring period, 95 percent at the New Amsterdam location, 95 percent during the second monitoring period at Carifesta, and 93 percent at the New Guyana School site.

At Carifesta during the first monitoring period, 50 monitoring days were designated as valid for use in comparison to criteria; at the New Amsterdam site, 50 days were designated as valid for use in comparison to criteria; during the second monitoring period at Carifesta, 98 days were designated as valid for use in comparison to criteria; at New Guyana School 132 days were designated as valid for use in comparison to criteria. Table 10 presents a summary of the results of H_2S monitoring at all three locations.

The maximum 24-hour average of the measured concentrations at all three monitoring sites was compared to the 24-hour WHO Guideline Value for H_2S. The averages at all three sites are well below the WHO Guideline Value.

The daily monitoring statistics for all three sites are presented in Attachment A and the hourly data record is presented in Attachment B.

Table 10: Summary of Hydrogen Sulfide Monitoring Results

Location	Maximum 30-Minute Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	14.2	1.9	0.4	96%	50
Carifesta #2 (rainy season)	32.4	1.3	0.1	95%	98
Carifesta (combined)	32.4	1.9	0.2	95%	148
New Amsterdam	5.8	0.4	-0.1 [a]	95%	50
New Guyana School	110.6	16.0	2.8	93%	132
Guideline		107.6 (WHO 24-hour)	—		

ppb = parts per billion
[a] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

2.7. Benzene Monitoring Results

Ambient concentrations of benzene were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta site (Carifesta #1 only), at the New Amsterdam site, and for a portion of the monitoring period at the New Guyana School site. The gas chromatograph failed subsequent to the New Amsterdam deployment and was sent back to the manufacturer to be serviced before being reinstalled at New Guyana School on 27 June. In the place of the Mocon, eight Summa air samples were collected at New Guyana School and analyzed for benzene in addition to other VOCs.

Benzene valid data recovery was 95 percent at the Carifesta location, 99 percent at the New Amsterdam location, and 74 percent at New Guyana School.

At Carifesta, 47 monitoring days were designated as valid for use in comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for use in comparison to criteria; and at New Guyana School, 21 monitoring days were designated as valid for use in comparison to criteria. Analyses of all eight New Guyana School Summa samplers were valid. Table 11 presents a summary of the results of benzene monitoring at each location.

Table 11: Summary of Benzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1,272.6	131.9	18.4	95%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	7.9	0.4	0.0	99%	50
New Guyana School [a]	NA	0.7	NA	NA	8
New Guyana School [b]	16.1	0.8	0.0	74%	21
Guideline	—	9.4 (USEPA)	—		

NA = not applicable; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August

The maximum 24-hour average of the measured concentrations at each of the three monitoring locations was compared to the 24-hour USEPA Reference Concentration. At Carifesta, the maximum 24-hour average was significantly higher than the Reference Concentration. The maximum 24-hour average value includes a single 6-minute sample that registered well above the calibration range of the analyzer. While this anomalous measurement is considered to be an outlier, it was not invalidated since all quality control parameters were within tolerance.

Even if the outlier value is excluded, the maximum 24-hour average would still have exceeded the Reference Concentration by more than 50 percent at the Carifesta site. Motor vehicle emissions may have been responsible for the measured values, since there are no obvious nearby stationary benzene emission sources upwind of the Carifesta site.

At the New Amsterdam and the New Guyana School monitoring sites, the maximum 24-hour average benzene measurements were significantly lower than the Reference Concentration.

The daily monitoring statistics for the Carifesta and New Amsterdam sites are presented in Attachment A and the hourly data record is presented in Attachment B. The New Guyana School measurements were limited to eight values from Summa samples. The benzene results for all eight samples are discussed in Section 2.11.

2.8. Toluene Monitoring Results—Carifesta and New Amsterdam

Ambient concentrations of toluene were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta site (Carifesta #1 only), the New Amsterdam site, and for a portion of the monitoring period at the New Guyana School site. The eight Summa air samples collected at New Guyana School were analyzed for toluene in addition to other VOCs. Toluene valid data recovery was 94 percent at the Carifesta location, 99 percent at the New Amsterdam location, and 74 percent at the New Guyana School location. Analyses of all eight New Guyana School Summa samples were valid.

At Carifesta, 47 monitoring days were designated as valid for comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for comparison to criteria; at New Guyana School, 21 monitoring days were designated as valid for comparison to criteria. Table 12 presents a summary of the results of toluene monitoring at each location.

Table 12: Summary of Toluene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1,134.6	169.5	20.7	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	6.7	5.4	5.0	99%	50
New Guyana School [a]	NA	6.0	NA	100%	8
New Guyana School [b]	2,396.7	99.9	0.0	74%	21
Guideline	—	—	69 (WHO)		

NA = not applicable; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August

The maximum weekly averages at the Carifesta, New Amsterdam, and New Guyana School sites were compared to the WHO 1-week Guideline Value. At all three sites, the weekly averages are below the WHO Guideline Value.

The daily monitoring statistics for all sites are presented in Attachment A and the hourly data record is presented in Attachment B. The toluene results for all eight Summa samples are discussed in Section 2.11.

2.9. Ethylbenzene Monitoring Statistics—Carifesta and New Amsterdam

Ambient concentrations of ethylbenzene were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta site (Carifesta #1 only), at the New Amsterdam site, and for a portion of the monitoring period at the New Guyana School site. The eight Summa air samples collected at New Guyana School were analyzed for ethylbenzene in addition to other VOCs. Ethylbenzene valid data recovery was 94 percent at the Carifesta location, 99 percent at the New Amsterdam location, and 74 percent at New Guyana School. Analyses of all eight Summa samples collected at the New Guyana School site were valid.

At Carifesta, 47 monitoring days were designated as valid for comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for comparison to criteria; at New Guyana School, 21 monitoring days were designated as valid for comparison to criteria. Table 13 presents a summary of the results of ethylbenzene monitoring at the three monitoring sites.

The full monitoring period average concentrations at all three sites were compared to the USEPA annual average Reference Concentration for ethylbenzene. The monitoring period averages are well below the USEPA Reference Concentration at all three sites.

It should be noted that the comparison between the full monitoring period average and the annual USEPA Reference Concentration should be considered indicative rather than directly comparable, as the USEPA Reference Concentration is an annual average and the duration of monitoring at each site was considerably less than 365 days. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Therefore, it is expected that actual annual average values at all three sites would be even further below the USEPA annual Reference Concentration.

Table 13: Summary of Ethylbenzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	31.6	3.3	0.08	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	0.6	0.1	0.0	99%	50
New Guyana School [a]	NA	0.2	ND	100%	8
New Guyana School [b]	18.4	0.0	0.0	74%	21
Guideline	—	—	0.23 [c] (USEPA Annual)		

NA = not applicable; ND = below minimum laboratory reporting level of 0.14 ppb by volume; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August
[c] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

The Carifesta and New Amsterdam daily monitoring statistics for all sites are presented in Attachment A and the hourly data record is presented in Attachment B. The New Guyana School ethylbenzene Summa results for all eight samples are discussed in Section 2.11.

2.10. Xylenes Monitoring Statistics—Carifesta and New Amsterdam

Ambient concentrations of xylenes were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta site (Carifesta #1 only), at the New Amsterdam site, and for a portion of the monitoring period at the New Guyana School site. The eight Summa air samples collected at New Guyana School were analyzed for xylenes in addition to other VOCs. Xylenes valid data recovery was 94 percent at the Carifesta location, 99 percent at the New Amsterdam location, and 74 percent at the New Guyana School location. Xylenes analyses of all eight New Guyana School Summa samples were valid. At Carifesta, 47 monitoring days were designated as valid for comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for comparison to criteria; at New Guyana School, 21 days were designated as valid for comparison to criteria. Table 14 presents a summary of the results of xylenes monitoring at all three locations.

Table 14: Summary of Xylenes Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	137.1	12.3	0.4	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	14.4	0.9	0.1	99%	50
New Guyana School [a]	NA	0.6	NA	100%	8
New Guyana School [b]	0.0	0.0	0.0	74%	21
Guideline	—	100 (USEPA)	—		

NA = not applicable; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August

The maximum 24-hour averages of the measured concentrations at all three monitoring locations were compared to the 24-hour USEPA Reference Concentration. At Carifesta, New Amsterdam, and New Guyana School, the 24-hour averages are well below the USEPA Reference Concentration.

The Carifesta and New Amsterdam daily monitoring statistics for both sites are presented in Attachment A and the hourly data record is presented in Attachment B. The New Guyana School xylenes Summa results for all eight samples are discussed in Section 2.11.

2.11. Total Volatile Organic Compound Sensor Monitoring and Summa Canister Analysis Statistics—New Guyana School

Quality control checks revealed that the Mocon Baseline Series 9100 gas chromatograph failed at the beginning of the monitoring system's second Carifesta deployment. Upon installation at the New Guyana School site, the gas chromatograph was replaced by an electrochemical total VOC sensor until the Mocon could be serviced by the manufacturer and returned for operation. While the VOC sensor was not capable of discerning between VOC species, total VOC constitutes an upper limit on the concentration of a single or combination of VOC components. The sensor provided continuous data output until 27 June 2019 when the Mocon was successfully reinstalled and verified.

In conjunction with the use of the total VOC sensor, eight passivated, evacuated Summa canisters were used to sequentially collect 24-hour integrated whole air samples for subsequent laboratory analysis via USEPA Method TO-15 (gas chromatography/mass spectrometry). These samples were analyzed for a suite of 75 organic compounds, including the BTEX compounds. The Summa results, presented in Table 15, were used to directly compare ambient air quality to the BTEX compound criteria.

Data recovery from the total VOC sensor at the New Guyana School site was 90 percent through 27 June 2019. Table 16 presents a summary of the results of the total VOC concentrations measured at New Guyana School.

Table 15: Summary of New Guyana School Summa BTEX Monitoring Results

Sample Date	24-Hour Average Concentration [ppb(v)]			
	Benzene	Toluene	Ethylbenzene	Xylenes
16 April 2019	0.69	6.00	ND	0.42
17 April 2019	ND	3.80	ND	ND
26 April 2019	ND	0.81	ND	ND
27 April 2019	0.24	0.68	ND	ND
16 May 2019	0.52	2.1	0.21	0.62
27 May 2019	0.24	4.8	0.19	0.64
29 May 2019	0.43	3.0	0.17	0.47
3 June 2019	0.36	0.26	ND	ND
Maximum	**0.69**	**6.00**	**0.21**	**0.64**
WHO 1-Week Average Criterion	—	59	—	—
USEPA 24-Hour Average Criterion	9.4	—	—	100
USEPA Annual Average Criterion	—	—	0.23	—

ND = below laboratory minimum reporting level; ppb(v) = parts per billion by volume
Note: Summa results are only available as 24-hour average values. Caution must be exercised in comparing these data with criteria that are stated in terms of different averaging times.

There are no generally accepted ambient air quality criteria for total VOCs. Therefore, the maximum total VOC measurements were compared to the WHO/USEPA criteria for each of the BTEX compounds. Since total VOC represents the maximum potential concentration of any single VOC compound, this assessment is conservative. The daily total VOC monitoring statistics are presented in Attachment A and the hourly data record is presented in Attachment B.

Table 16: Summary of New Guyana School Total VOC Sensor Monitoring Results

		Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Monitoring Period Average (ppb)
Monitoring Results		39.0	14.8	7.90	4.93
Compound	**Source**	**Criteria**			
Benzene	USEPA	—	9.4	—	—
Toluene	WHO	—	—	59	
Ethylbenzene	USEPA	—	—	—	0.23 (annual average [a])
Xylenes	USEPA	—	100	—	—

ppb = parts per billion
[a] While the monitoring period data average is compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 17 compares the Summa canister total VOC results with the corresponding VOC sensor measurements. The sensor concentrations are uniformly lower than the Summa laboratory values. While most sensor values agree with the Summa concentrations within a factor of ten, in one case the sensor result is more than two orders of magnitude less than the Summa measurement over the same time period.

Table 17: New Guyana School VOC Sensor vs VOC Summa Canister Results

Sample Date	24-Hour Average Concentration [ppb(v)]	
	Summa Canisters	VOC Sensor
16 April 2019	148.3	1.3
17 April 2019	80.5	1.7
26 April 2019	103.1	4.0
27 April 2019	88.0	4.4
16 May 2019	21.4	4.9
27 May 2019	45.3	4.1
29 May 2019	35.2	4.8
3 June 2019	93.0	10.3
Maximum	**148.3**	**10.3**

Criteria				
	Benzene	**Toluene**	**Ethylbenzene**	**Xylene**
WHO 1-Week Average Criterion	—	59	—	—
USEPA 24-Hour Average Criterion	9.4	—	—	100
USEPA Annual Average Criterion	—	—	0.23	—

ppb(v) = parts per billion by volume

These results are consistent with other studies comparing reference methods with low-cost sensor measurements. Based on comparison with the Summa results, the sensor data should only be used on a qualitative basis (i.e., to assess variability concentrations) and the Mocon gas chromatograph and Summa canister results should be relied upon for quantifying concentrations.

3. NEW GUYANA SCHOOL: DRY VS. WET SEASON COMPARISON

EEPGL extended monitoring at New Guyana School past the initially-planned 6-week monitoring period, to explore possible inter-seasonal differences. Guyana's climate is such that ambient temperatures are fairly constant year-round. The only significant seasonal variation is in the amount of rainfall. This section presents the results of our analysis of ambient air quality variation as a function of "wet" versus "dry" season.

The expanded monitoring period ran from 12 April until 25 August 2019, which encompassed the entire main wet season that occurs from May to mid-July. Since the wet season occurred in the middle of the monitoring period, the statistics are broken down into three sub-periods: the first being 19 days before the start of the wet season ("Dry #1"), the second being the 72 days during the wet season ("Wet"), and the third being the 41 days after the wet season, until the end of the monitoring period ("Dry #2").

In some cases, air contaminant concentrations have been found to have a seasonal dependence due to either seasonal variation in emission patterns or meteorological factors. It is common to see a negative correlation between ground-level contaminant concentrations and rain intensity due to scavenging of pollutants by the rain. The actual mechanism by which precipitation scavenges a pollutant depends on the target pollutant. Rainout, washout, dissolution, and heterogeneous chemical reaction are all potential mechanisms. This section provides an initial assessment as to whether Georgetown air quality, of which the New Guyana School is representative, showed a seasonal variation during the monitoring period. The relatively short monitoring period does not support definitive conclusions—just observational descriptions.

Tables 18 through 23 present summaries of the New Guyana School monitoring results during the three sub-periods. Measured concentrations during all three sub-periods were compared to their respective WHO Guideline Values. Figures 5 through 10 are time series graphs of each parameter, differentiated by each of the three sub-periods. The vertical green line on each graph represents the beginning of the wet season (1 May) and the vertical red line represents the end of the wet season (15 July).

The horizontal black line represents the WHO Guideline for each respective parameter. Visual inspection does not illustrate an obvious season-dependent concentration difference for any of the monitored air contaminants. The lack of any clear relationships between rainfall and concentrations may be due to the relatively low measured concentrations of most parameters.

3.1. PM_{10} Dry Season vs. Wet Season Analysis

At New Guyana School, the wet season sub-period average for PM_{10} was 26.4 micrograms per cubic meter (µg/m^3)—in between Dry #1's and Dry #2's 33.2 and 20.5 µg/m^3 period averages, respectively. Reviewing the time series graph (Figure 5) does not indicate a strong seasonal difference.

Table 18: Summary of New Guyana School Wet vs. Dry Season PM_{10} Statistics

PM_{10} Concentration (µg/m³)					
New Guyana School Dry Season #1 (12/04/2019–30/04/2019)					
New Guyana School Wet Season (01/05/19–15/07/19)					
New Guyana School Dry Season #2 (16/07/19–25/08/19)					
Season	Maximum 1-Hour Average	Maximum 24-Hour Average	Period Average	Data Recovery	Valid Data Days
Dry #1	84.9	47.7	33.2	100%	19
Wet	82.2	60.0	26.4	95%	72
Dry #2	103.3	35.8	20.5	99%	41
Air Quality Guideline Values		45 (WHO) 150 (USEPA)	15 (WHO Annual)		

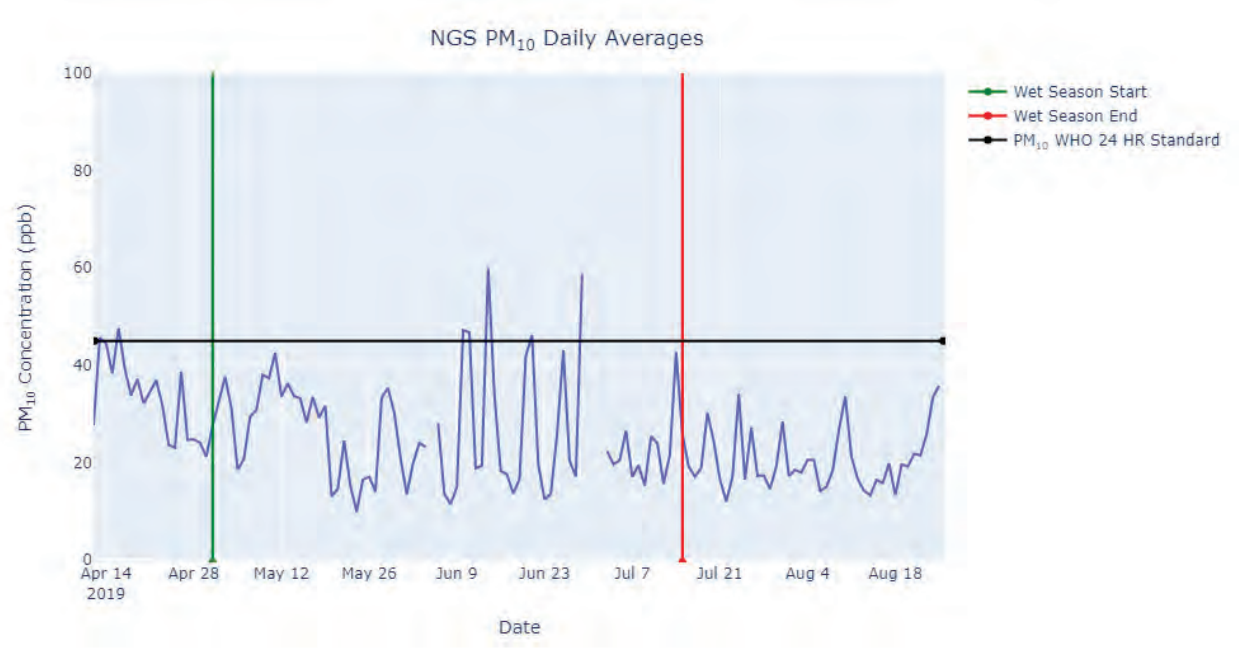


Figure 5: New Guyana School PM_{10} Time Series

3.2. $PM_{2.5}$ Dry Season vs. Wet Season Analysis

At New Guyana School, the wet season sub-period average for $PM_{2.5}$ was 9.3 µg/m³—in between Dry #1's and Dry #2's 12.3 and 7.9 µg/m³ period averages, respectively. Reviewing the time series graph (Figure 6) does not indicate a strong seasonal difference.

Table 19: Summary of New Guyana School Wet vs. Dry Season $PM_{2.5}$ Statistics

$PM_{2.5}$ Concentration ($\mu g/m^3$)					
New Guyana School Dry Season #1 (12/04/2019–30/04/2019)					
New Guyana School Wet Season (01/05/19–15/07/19)					
New Guyana School Dry Season #2 (16/07/19–25/08/19)					
Season	Maximum 1-Hour Average	Maximum 24-Hour Average	Period Average	Data Recovery	Valid Data Days
Dry #1	45.8	16.4	12.3	100%	19
Wet	32.1	18.2	9.3	95%	72
Dry #2	40.5	14.0	7.9	99%	41
Air Quality Guideline Values		15 (WHO) 35 (USEPA)	5 (WHO Annual) 12 (USEPA Annual)		

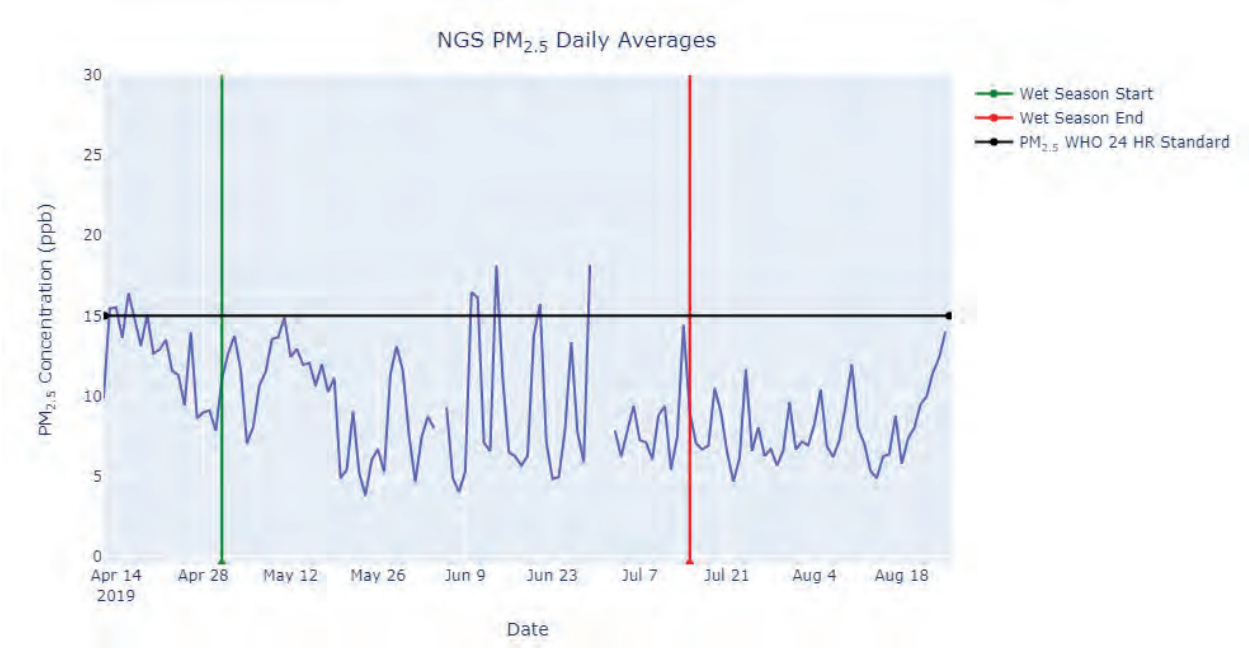


Figure 6: New Guyana School $PM_{2.5}$ Time Series

3.3. CO Dry Season vs. Wet Season Analysis

At New Guyana School, the wet season sub-period average for CO was 0.52 parts per million (ppm)—in between Dry #1's and Dry #2's 0.11 and 0.63 ppm period averages, respectively. Reviewing the time series graph (Figure 7) does not indicate a strong seasonal difference.

Table 20: Summary of New Guyana School Wet vs. Dry Season CO Statistics

CO Concentration (ppm)					
New Guyana School Dry Season #1 (12/04/2019–30/04/2019)					
New Guyana School Wet Season (01/05/19–15/07/19)					
New Guyana School Dry Season #2 (16/07/19–25/08/19)					
Season	Maximum 1-Hour Average	Maximum 8-Hour Average	Period Average	Data Recovery	Valid Data Days
Dry #1	0.76	0.34	0.11	99%	19
Wet	1.20	0.86	0.52	94%	72
Dry #2	1.09	0.86	0.63	96%	40
Air Quality Guideline Values	30.5 (WHO) 35 (USEPA)	8.7 (WHO) 8.7 (USEPA)			

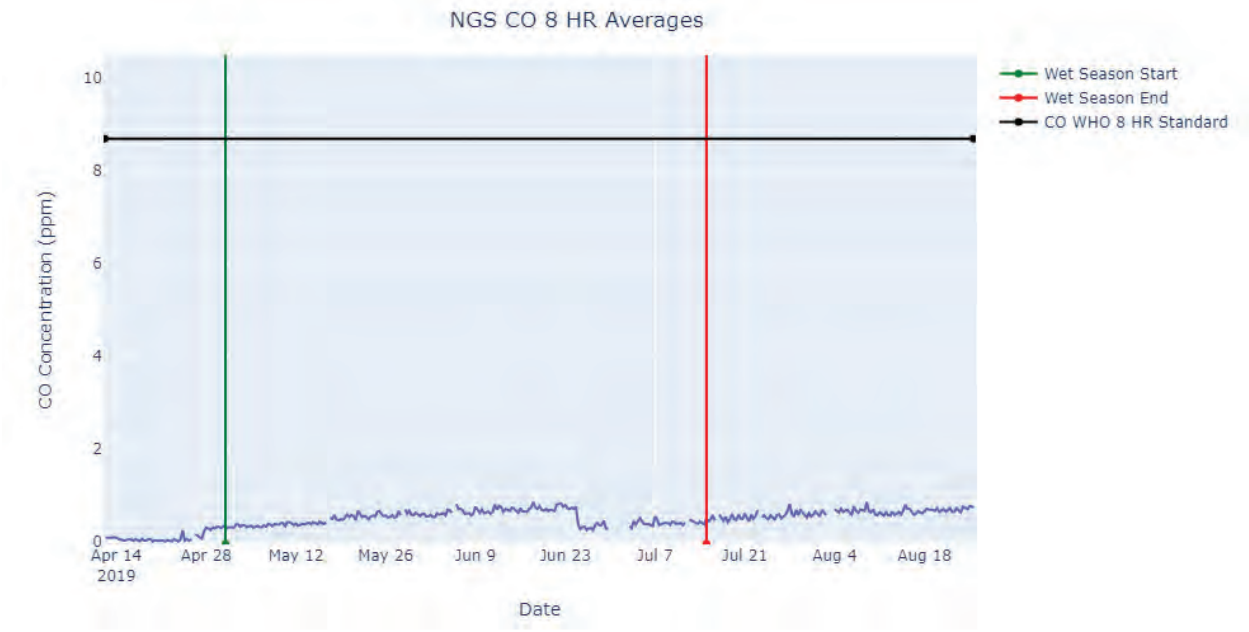


Figure 7: New Guyana School CO Time Series

3.4. NO_2 Dry Season vs. Wet Season Analysis

At New Guyana School, the wet season sub-period average for NO_2 was 1.1 parts per billion (ppb)—slightly below Dry #1's and Dry #2's 1.2 and 1.6 ppb period averages, respectively. Reviewing the time series graph (Figure 8) does not indicate a strong seasonal difference.

Table 21: Summary of New Guyana School Wet vs. Dry Season NO_2 Statistics

NO_2 Concentration (ppb)				
New Guyana School Dry Season #1 (12/04/2019–30/04/2019)				
New Guyana School Wet Season (01/05/19–15/07/19)				
New Guyana School Dry Season #2 (16/07/19–25/08/19)				
Season	Maximum 1-Hour Average	Period Average	Data Recovery	Valid Data Days
Dry #1	7.7	1.2	95%	19
Wet	12.2	1.1	92%	71
Dry #2	15.8	1.6	93%	40
Air Quality Guideline Values	106.4 (WHO) 100 (USEPA)	5.3 (WHO Annual) 53 (USEPA Annual)		

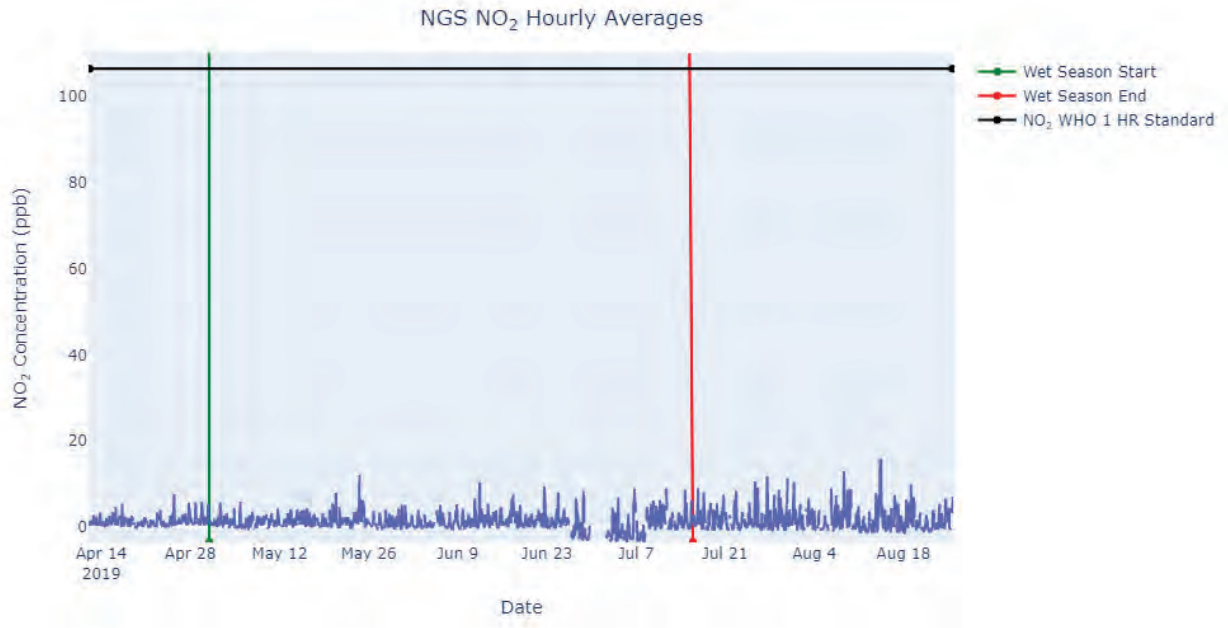


Figure 8: New Guyana School NO_2 Time Series

3.5. SO_2 Dry Season vs. Wet Season Analysis

At New Guyana School, the wet season sub-period average for SO_2 was 0.9 ppb—the same as for Dry #1 and slightly below Dry #2's 1.1 ppb period average. Reviewing the time series graph (Figure 9) does not indicate a strong seasonal difference.

Table 22: Summary of New Guyana School Wet vs. Dry Season SO_2 Statistics

SO_2 Concentration (ppb)					
New Guyana School Dry Season #1 (12/04/2019–30/04/2019)					
New Guyana School Wet Season (01/05/19–15/07/19)					
New Guyana School Dry Season #2 (16/07/19–25/08/19)					
Season	Maximum Daily 1-hour Average	Maximum 24-Hour Average	Period Average	Data Recovery	Valid Data Days
Dry #1	3.6	1.1	0.9	95%	19
Wet	11.7	1.7	0.9	92%	72
Dry #2	7.9	3.3	1.1	94%	41
Air Quality Guideline Values	75 (USEPA)	15 (WHO)			

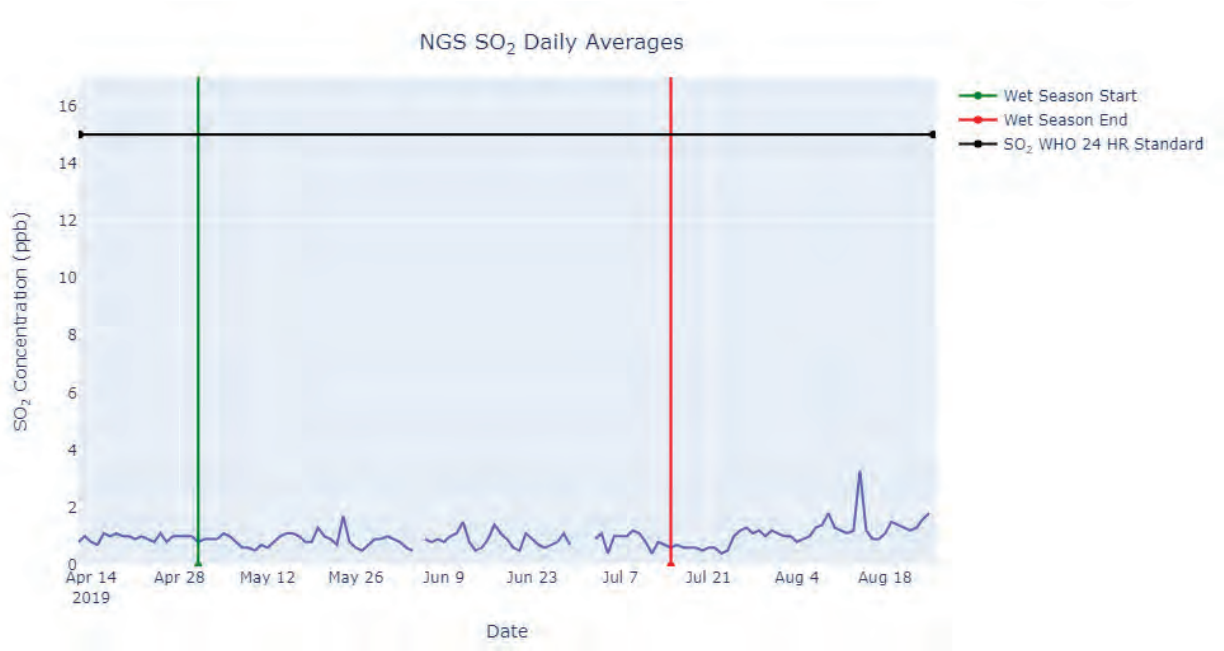


Figure 9: New Guyana School SO_2 Time Series

3.6. H_2S Dry Season vs. Wet Season Analysis

At New Guyana School, the wet season sub-period average for H_2S was 3.0 ppb—in between Dry #1's and Dry #2's 6.0 and 0.8 ppb period averages, respectively. Reviewing the time series graph (Figure 10) does not indicate a strong seasonal difference.

Table 23: Summary of New Guyana School Wet vs. Dry Season H_2S Statistics

H_2S Concentration (ppb)					
New Guyana School Dry Season #1 (12/04/2019–30/04/2019)					
New Guyana School Wet Season (01/05/19–15/07/19)					
New Guyana School Dry Season #2 (16/07/19–25/08/19)					
Season	Maximum 1-Hour Average	Maximum 24-Hour Average	Period Average	Data Recovery	Valid Data Days
Dry #1	71.8	14.5	6.0	95%	19
Wet	69.6	16.0	3.0	92%	72
Dry #2	75.9	5.7	0.8	94%	41
Air Quality Guideline Values	—	107.6 (WHO 24-hour)			

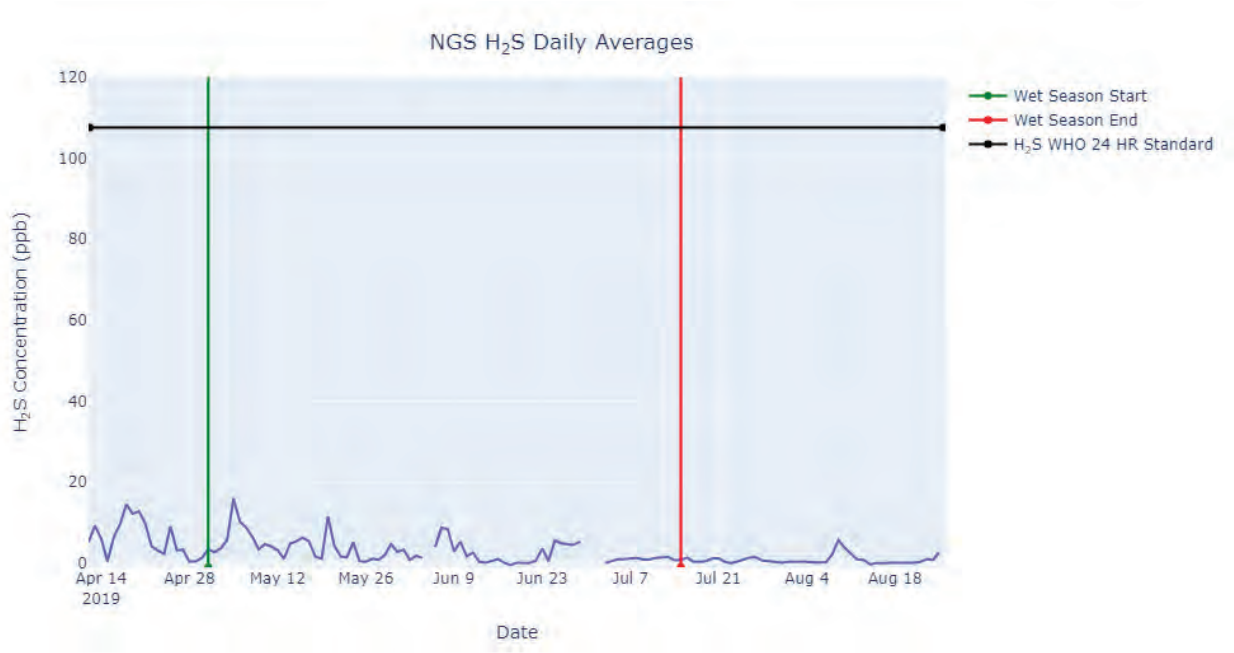


Figure 10: New Guyana School H_2S Time Series

4. WIND SPEED AND DIRECTION

Ambient wind speed and direction were continuously monitored by an RM Young Model 05305-5 mechanical anemometer, which was tripod-mounted on top of the monitoring shelter. The monitoring program statistics for wind speed are presented in Table 24; statistics for standard deviation of wind direction ("sigma theta"—an indicator of turbulence) are presented in Table 25. Data recovery goals were met for all meteorological parameters.

Table 24: Wind Speed Summary Statistics

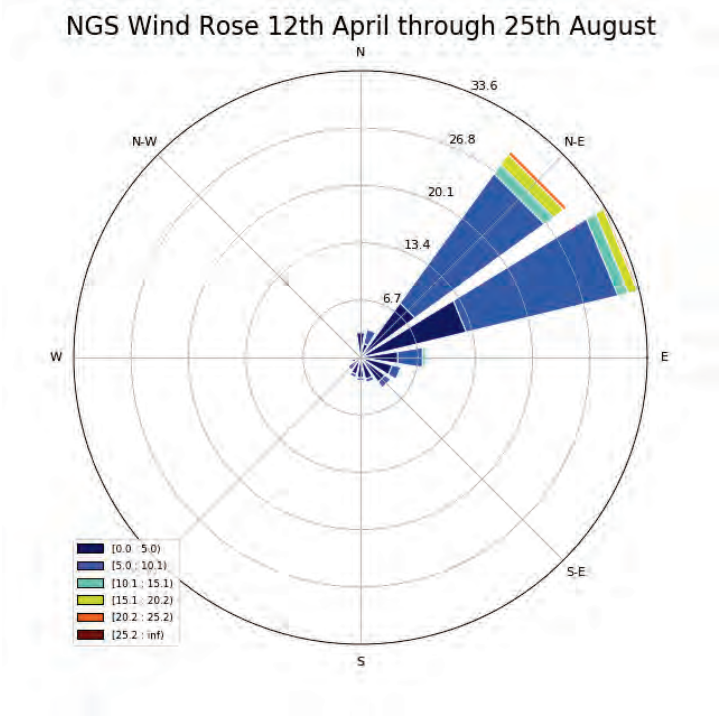
New Guyana School: 12/04/2019–25/08/2019			
Wind Speed (miles per hour)			
Minimum	Maximum	Average	Recovery
0.0	25.2	5.5	99%

Table 25: Sigma Theta Summary Statistics

New Guyana School: 12/04/2019–25/08/2019			
Sigma Theta (deg.)			
Minimum	Maximum	Average	Recovery
0.0	51.23	18.14	99%

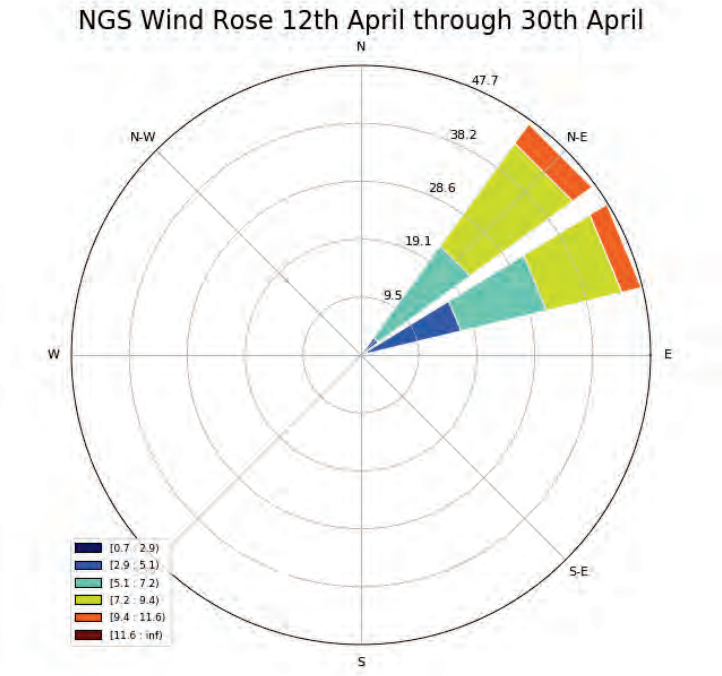
Sigma theta measurements, with an average of 18.14 degrees, are representative of relatively steady wind direction measurements—consistent with the climate of Guyana's coastal region, with its persistent east northeast winds. Such low sigma theta values are indicative of moderate turbulence—a limiting factor in atmospheric dispersion.

Figure 11 presents the wind rose for New Guyana School during the period of 12 April to 25 August 2019. The predominant wind direction during the monitoring period was from the east-northeast, which was observed approximately 31 percent of the monitoring period. Figures 12 through 14 present the wind roses for the New Guyana School broken down into the Dry #1 monitoring sub-period, the Wet monitoring sub-period, and the Dry #2 monitoring sub-period. The predominant wind directions during the monitoring periods were all from the east-northeast, and were observed 42 percent, 33 percent, and 20 percent of the time for the Dry #1, Wet, and Dry #2 monitoring periods, respectively.



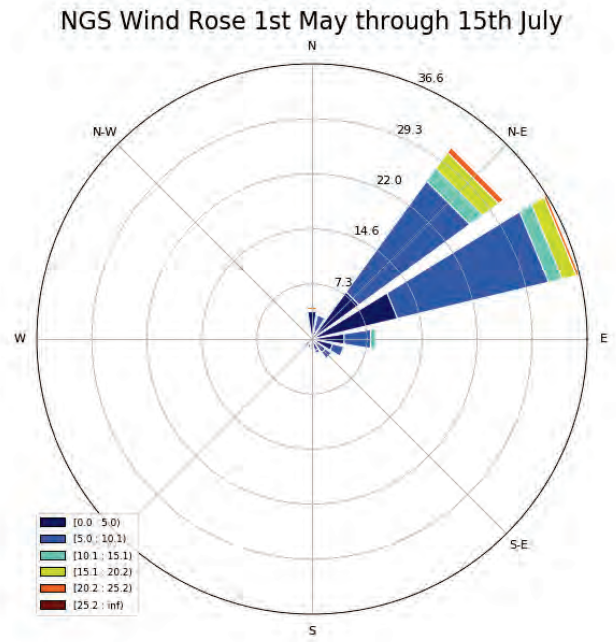
(Wind speed ranges presented in terms of miles per hour)

Figure 11: New Guyana School Wind Rose



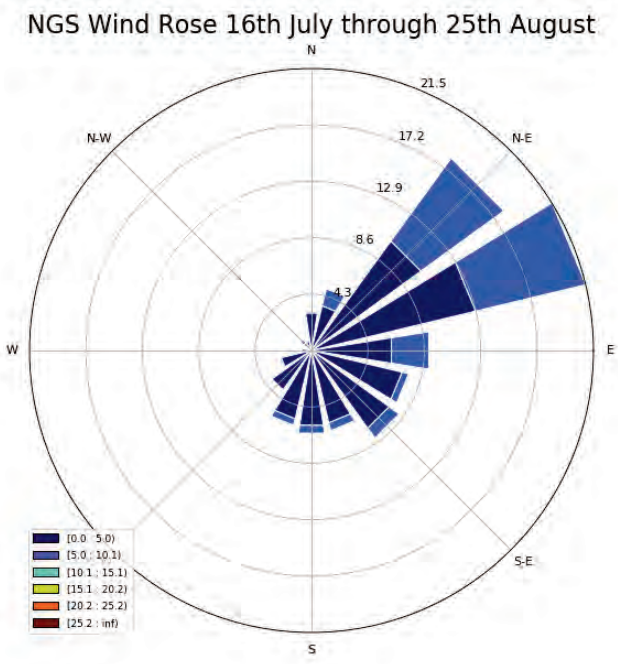
(Wind speed ranges presented in terms of miles per hour)

Figure 12: New Guyana School Wind Rose (Dry #1)



(Wind speed ranges presented in terms of miles per hour)

Figure 13: New Guyana School Wind Rose (Wet)



(Wind speed ranges presented in terms of miles per hour)

Figure 14: New Guyana School Wind Rose (Dry #2)

5. QUALITY CONTROL AND QUALITY ASSURANCE

Various quality assurance and quality control activities were performed during the monitoring periods to evaluate the performance of the monitoring analyzers and to demonstrate conformance to established criteria for data quality. These activities were performed either through automated means or manually, or were inherent to the design of the monitoring system. With the exception of NO_2 at the New Amsterdam monitoring location (discussed below), all measurements demonstrated general compliance with the established quality assurance and quality control criteria.

5.1. Quality Control Results

Automated quality control checks were initiated by the monitoring station's data logger on a weekly basis to assess the performance of the analyzers measuring CO, NO_2, SO_2, and H_2S. These precision checks assess the performance of the analyzer at or below an established air quality standard or near the expected ambient concentration. The precision value is a representation of the repeatability of the analyzer to respond accurately to the control concentration. The bias value is a representation of the analyzer's tendency to respond higher or lower than the control concentration.

Table 26 presents the precision and bias calculations for the four gaseous parameters at the Carifesta monitoring location during the first monitoring period. The results demonstrate that the analyzers were operating well within the acceptance criteria, indicating high quality, reliable data.

Table 26: Carifesta #1 Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criterion (%)
CO	8	8.7	+6.5	± 10%
NO_2	8	1.8	-2.3	± 15%
SO_2	8	3.3	-4.9	± 10%
H_2S	8	4.4	+6.5	± 10%

Table 27 presents the precision and bias calculations for the four gaseous parameters at the New Amsterdam monitoring location. The results of these precision checks demonstrate that the CO and SO_2 analyzers were operating well within the acceptance criteria.

For H_2S, the analyzer passed the precision criterion but exceeded the bias criterion, suggesting that the measured ambient concentrations may be biased high, but the analyzer responded consistently to the changes in ambient concentration. For NO_2, the precision and bias calculations demonstrate that the analyzer was not performing within the acceptance criteria. The degradation in the analyzer's internal pump, which eventually resulted in its failure, significantly affected the analyzer's ability to respond accurately to challenge and ambient concentrations. The NO_2 data collected at the New Amsterdam location, therefore, are of lesser quality and should only be used when qualified as such.

Table 28 presents the precision and bias calculations for the four gaseous parameters at the Carifesta monitoring location during the second monitoring period. The results demonstrate that the analyzers were operating well within the acceptance criteria, indicating high quality, reliable data.

Table 29 presents the precision and bias calculations for the four gaseous parameters at the New Guyana School monitoring location. The results demonstrate that the analyzers were operating well within the acceptance criteria, indicating high quality, reliable data.

Table 27: New Amsterdam Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criterion (%)
CO	6	1.7	+2.8	± 10%
NO_2	6	20.9	-32.5	± 15%
SO_2	6	2.1	+2.9	± 10%
H_2S	6	5.2	+11.2	± 10%

Table 28: Carifesta #2 Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criterion (%)
CO	14	4.3	±4.3	± 10%
NO_2	14	1.5	+5.6	± 15%
SO_2	14	1.6	-2.6	± 10%
H_2S	14	1.7	+4.2	± 10%

Table 29: New Guyana School Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criteria (%)
CO	14	7.6	±6.7	± 10%
NO_2	14	3.7	-5.3	± 15%
SO_2	14	2.0	+3.0	± 10%
H_2S	14	2.9	± 2.4	± 10%

5.2. Quality Assurance

The analyzers measuring PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and H_2S are certified by the USEPA for use in assessing ambient air quality. All challenges of the analyzers' performance, manual or automated, were performed in general conformance to accepted quality assurance procedures. The monitoring shelter temperature was maintained within the operational assurance range.

All analyzers were calibrated prior to the start of monitoring at each location. A multipoint quality assurance verification of the analyzers immediately following calibration demonstrated that the analyzers were operating well within the acceptance criteria. With one exception, the multipoint quality assurance verifications were repeated at the conclusion of the monitoring at each location, as long as the analyzer was operational.

At Carifesta during the first monitoring period, these multipoint quality assurance verifications demonstrated that the analyzers were operating within the acceptance criteria.

At New Amsterdam, with the exception of NO_2, these multipoint quality assurance verifications demonstrated that the analyzers were operating within the acceptance criteria. The failure of the NO_2 analyzer prior to the conclusion of the monitoring period did not allow for a multipoint evaluation of the analyzer's performance. A final calibration of the VOC analyzer was not possible following its New Amsterdam deployment due to expected contamination of the calibration gas standard.[7] Nevertheless, data have been validated on the basis of its initial calibration and other quality control checks.

At Carifesta during the second monitoring period, these multipoint quality assurance verifications demonstrated that the analyzers were operating within the acceptance criteria.

The final multipoint quality assurance verifications at the New Guyana School monitoring location demonstrated that the analyzers were operating within the quality assurance criteria. Further quality assurance measures included frequent manual data review (at least twice per week), and monitoring and documenting instrument diagnostic parameters (column temperature, sample flow rate, etc.).

[7] Substantial SO_2 artifact was found in this tank while calibrating the H_2S analyzer. Subsequent challenge of the VOC analyzer showed apparent response shift. Based on these results, it was concluded that the tank had been contaminated with air. Rather than calibrate the VOC analyzer with a standard of uncertain quality, it was decided to rely on the installation calibration for its validation.

6. REFERENCES

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ATTACHMENT A DAILY MONITORING STATISTICS

Carifesta										
	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
Day	24-Hour Average	24-Hour Average	8-Hour Maximum	1-Hour Maximum	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
15/08/2018	37.3	13.1	0.32	12.8	-1.3	0.2	29.0	0.9	0.0	0.2
16/08/2018	16.6	6.2	0.32	8.9	-1.3	0.4	27.3	16.7	0.0	0.5
17/08/2018	15.2	6.3	0.27	5.9	-1.3	0.2	5.3	7.4	0.0	0.0
18/08/2018	18.9	8.8	0.48	11.3	-0.8	1.8	2.6	25.9	0.0	0.1
19/08/2018	15.4	7.5	0.32	4.6	-1.5	0.6	58.5	12.4	0.0	0.0
20/08/2018	12.7	5.3	0.32	9.5	-1.3	0.7	131.9	92.2	0.0	0.0
21/08/2018	14.4	6.5	0.33	8.8	-1.1	1.0	52.9	34.4	0.0	0.0
22/08/2018	16.5	7.8	0.29	8.7	-1.4	0.3	4.3	120.9	0.0	0.0
23/08/2018	13.3	5.4	0.26	8.0	-1.5	0.1	13.3	8.2	0.0	1.5
24/08/2018	12.6	5.3	0.33	8.1	-1.3	0.4	58.0	35.9	0.0	0.0
25/08/2018	13.4	6.0	0.35	5.7	-1.4	0.2	36.1	0.7	0.0	0.0
26/08/2018	16.4	7.3	0.39	6.3	-1.4	0.0	36.8	28.6	0.0	0.0
27/08/2018	16.1	7.6	0.38	7.4	-1.0	0.0	10.0	36.6	0.0	0.0
28/08/2018	15.2	5.9	0.34	10.0	-1.2	0.0	3.0	17.8	0.0	0.0
29/08/2018	18.6	8.1	0.42	8.0	-0.6	0.1	10.9	27.6	0.0	0.0
30/08/2018	12.7	5.3	0.37	7.4	-1.5	0.0	13.5	21.3	0.0	0.0
31/08/2018	16.7	6.8	0.45	10.3	-1.1	-0.1	ID	ID	ID	ID
01/09/2018	18.5	7.1	0.42	9.3	-1.3	0.0	ID	ID	ID	ID
02/09/2018	ID	ID	0.75	8.1	-0.7	0.7	ID	ID	ID	ID
03/09/2018	15.2	7.0	0.65	13.7	-1.0	1.9	47.2	17.7	0.0	0.0
04/09/2018	17.1	6.9	0.69	11.2	-0.3	0.2	23.7	11.4	0.0	0.0
05/09/2018	26.6	9.7	0.89	11.2	-0.2	1.1	13.0	5.0	0.0	0.0
06/09/2018	19.3	6.9	0.66	8.2	-0.4	0.4	5.8	5.7	0.0	0.0
07/09/2018	14.6	5.8	0.70	8.4	-1.0	0.9	6.3	52.9	0.0	0.0
08/09/2018	14.3	5.5	0.67	9.9	-1.2	0.7	16.3	7.3	0.0	0.0
09/09/2018	14.5	5.6	1.01	9.1	-1.0	0.1	1.2	0.4	0.0	0.1
10/09/2018	21.6	8.9	0.96	8.9	-0.2	0.4	18.2	9.5	0.0	0.0
11/09/2018	24.7	9.6	0.81	5.8	-1.1	0.0	1.1	10.5	0.0	0.0
12/09/2018	12.7	4.5	0.39	12.4	-0.5	0.5	11.8	0.0	0.0	0.0
13/09/2018	15.3	7.2	0.49	10.2	-0.3	0.7	0.5	6.4	0.0	0.0
14/09/2018	23.8	9.3	0.62	9.8	0.3	1.6	0.1	0.0	0.0	0.0
15/09/2018	18.4	7.9	0.44	7.5	-1.3	0.4	3.2	49.9	0.0	0.0
16/09/2018	13.0	5.2	0.56	6.5	-1.3	0.3	5.3	14.4	0.0	0.0
17/09/2018	14.9	6.6	0.55	15.0	-0.6	0.7	19.1	2.2	0.0	0.0
18/09/2018	13.9	6.4	0.45	11.4	-0.3	0.0	8.9	7.4	0.0	0.0
19/09/2018	15.9	5.9	0.45	8.8	-1.2	0.4	12.8	0.1	0.0	0.0
20/09/2018	29.7	11.0	0.46	10.5	-0.7	0.4	9.1	1.0	0.0	0.0
21/09/2018	17.5	7.2	0.56	11.6	-1.2	0.1	19.8	0.0	0.0	0.0
22/09/2018	ID	ID	0.44	6.3	-1.2	0.2	14.9	0.0	0.0	0.0
23/09/2018	ID	ID	0.53	3.9	-1.3	0.0	15.5	0.2	0.0	0.0
24/09/2018	ID	ID	0.41	10.3	-1.4	0.0	14.2	0.0	0.0	1.0
25/09/2018	ID	ID	0.43	9.3	-1.3	-0.1	3.8	0.0	0.0	0.3
26/09/2018	14.6	5.3	0.46	11.7	-0.1	0.9	37.2	0.0	0.0	0.1
27/09/2018	20.3	9.0	0.49	7.8	-1.2	0.2	23.6	0.0	0.0	0.0
28/09/2018	20.8	8.3	0.44	6.5	-1.3	0.1	0.6	0.0	0.0	0.0
29/09/2018	18.8	7.7	0.40	4.9	-1.5	0.0	1.0	0.7	0.0	0.1
30/09/2018	17.4	7.5	0.61	4.7	-1.2	0.0	12.3	0.6	0.0	0.0
01/10/2018	13.5	5.7	0.46	7.7	-1.4	-0.1	2.1	0.0	0.5	0.0
02/10/2018	17.1	6.4	0.50	9.2	-1.2	0.4	10.7	0.0	0.0	0.0
03/10/2018	19.8	8.5	0.43	8.5	-1.0	0.2	13.5	2.7	2.2	8.7

$\mu g/m^3$ = micrograms per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; NO_2 = nitrogen dioxide; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); ppb = parts per billion; SO2 = sulfur dioxide

New Amsterdam										
	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
Day	24-Hour Average	24-Hour Average	8-Hour Maximum	1-Hour Maximum	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
15/10/2018	14.4	5.8	0.40	2.3	-1.0	0.0	0.0	0.0	0.0	0.0
16/10/2018	14.3	5.0	0.48	-0.8	-1.0	0.1	0.0	0.0	0.0	0.0
17/10/2018	27.9	5.8	0.39	-0.1	-1.2	0.0	0.0	0.0	0.0	0.0
18/10/2018	30.1	6.5	0.66	-1.5	-1.3	-0.2	0.0	0.0	0.0	0.0
19/10/2018	21.8	7.7	0.46	-0.9	-1.4	-0.1	0.0	0.6	0.0	0.0
20/10/2018	21.9	9.9	0.48	1.2	-1.1	0.2	0.0	1.6	0.0	0.0
21/10/2018	20.2	8.4	0.50	0.3	-1.1	0.2	0.0	1.3	0.0	0.3
22/10/2018	16.0	6.4	0.38	2.2	-1.2	-0.1	0.0	3.8	0.0	0.0
23/10/2018	14.3	5.1	0.39	1.8	-1.3	-0.1	0.0	4.7	0.0	0.7
24/10/2018	17.3	5.9	0.40	0.6	-1.3	-0.2	0.0	5.2	0.0	0.0
25/10/2018	19.3	6.2	0.42	-1.3	-1.4	-0.2	0.0	5.3	0.0	0.0
26/10/2018	13.4	3.9	0.41	0.1	-1.4	-0.2	0.0	5.4	0.0	0.0
27/10/2018	13.2	4.5	0.48	ID	-1.6	-0.1	0.0	5.3	0.0	0.0
28/10/2018	10.5	4.1	0.44	4.1	-1.5	-0.2	0.0	5.3	0.0	0.0
29/10/2018	14.2	4.6	0.57	ID	-1.5	0.2	0.0	5.4	0.0	0.1
30/10/2018	24.5	7.2	0.53	ID	-1.5	0.0	0.0	4.6	0.0	0.0
31/10/2018	28.7	7.2	0.30	3.8	-1.6	-0.2	0.0	3.8	0.0	0.0
01/11/2018	21.3	7.9	0.34	3.8	-1.6	-0.1	0.0	2.5	0.0	0.0
02/11/2018	17.1	3.8	0.30	0.3	-1.6	0.0	0.0	1.9	0.0	0.0
03/11/2018	19.5	3.5	0.32	0.7	-1.6	-0.1	0.1	0.6	0.1	0.9
04/11/2018	19.5	3.5	0.44	4.2	-1.1	0.4	0.0	0.5	0.0	0.0
05/11/2018	15.0	4.2	0.41	2.7	-1.2	0.4	0.4	0.3	0.0	0.0
06/11/2018	14.0	5.7	0.37	0.1	-1.2	0.1	0.0	0.0	0.0	0.0
07/11/2018	17.3	4.7	0.31	-0.2	-1.5	0.0	0.0	0.1	0.0	0.0
08/11/2018	17.5	5.3	0.33	0.3	-1.5	-0.1	0.0	0.0	0.0	0.0
09/11/2018	20.0	5.9	0.30	-0.5	-1.5	-0.2	0.0	0.0	0.0	0.0
10/11/2018	20.0	6.5	0.30	ID	-1.7	-0.2	0.0	0.2	0.0	0.1
11/11/2018	19.1	7.4	0.34	2.9	-1.6	0.0	0.0	0.2	0.0	0.0
12/11/2018	16.4	5.3	0.43	21.7	-1.5	0.1	0.0	0.1	0.0	0.1
13/11/2018	24.8	9.2	0.41	ID	-1.4	-0.2	0.0	0.0	0.0	0.0
14/11/2018	23.1	6.1	0.30	1.9	-1.4	-0.2	0.0	0.1	0.0	0.0
15/11/2018	30.8	10.4	0.63	0.5	-1.3	0.0	0.0	0.0	0.0	0.1
16/11/2018	20.8	7.5	0.55	1.0	-1.3	-0.1	0.0	0.0	0.0	0.0
17/11/2018	17.4	6.4	0.30	0.9	-1.3	-0.2	0.0	0.0	0.0	0.0
18/11/2018	15.1	5.7	0.26	-0.3	-1.3	-0.2	0.0	0.1	0.0	0.0
19/11/2018	18.8	6.8	0.40	-1.1	-1.2	-0.1	0.0	0.1	0.0	0.5
20/11/2018	19.0	6.8	0.34	-2.8	-1.3	-0.2	0.0	0.0	0.0	0.0
21/11/2018	20.0	6.7	0.31	-1.9	-1.2	-0.3	0.0	0.0	0.0	0.0
22/11/2018	16.4	5.8	0.28	-3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
23/11/2018	18.3	5.8	0.28	0.2	-1.1	-0.2	0.0	0.1	0.0	0.0
24/11/2018	13.8	4.8	0.30	0.3	-1.1	-0.2	0.0	0.1	0.0	0.0
25/11/2018	19.5	7.1	0.39	-1.9	-1.2	-0.2	0.0	0.0	0.0	0.0
26/11/2018	24.5	9.4	0.36	-0.2	-1.1	-0.2	0.0	0.0	0.0	0.0
27/11/2018	20.6	7.5	0.45	0.7	-1.1	0.0	0.0	0.0	0.0	0.0
28/11/2018	30.2	10.6	0.33	0.6	-1.1	-0.1	0.0	0.0	0.0	0.0
29/11/2018	38.6	13.5	0.29	ID	-1.1	-0.2	0.0	0.0	0.0	0.0
30/11/2018	39.8	12.8	0.29	ID	-1.1	0.1	0.0	0.1	0.0	0.0
01/12/2018	28.2	10.1	0.26	ID	-1.1	-0.1	0.0	0.0	0.0	0.0
02/12/2018	20.6	7.4	0.25	ID	-1.3	-0.1	0.0	0.0	0.0	0.0
03/12/2018	32.4	10.6	0.30	ID	-1.1	-0.2	0.0	0.0	0.0	0.0

µg/m^3 = micrograms per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; NO_2 = nitrogen dioxide; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); ppb = parts per billion; SO2 = sulfur dioxide

New Guyana School										
	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
Day	24-Hour Average	24-Hour Average	8-Hour Maximum	1-Hour Maximum	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
12/04/2019	27.7	9.9	0.10	2.8	0.8	5.2	ID	ID	ID	ID
13/04/2019	45.6	15.5	0.10	3.5	1.0	9.2	ID	ID	ID	ID
14/04/2019	44.5	15.5	0.06	2.2	0.8	6.1	ID	ID	ID	ID
15/04/2019	38.3	13.6	0.06	3.5	0.7	0.4	ID	ID	ID	ID
16/04/2019	47.7	16.4	0.06	4.8	1.1	6.4	ID	ID	ID	ID
17/04/2019	39.2	14.7	0.07	5.5	1.0	9.6	ID	ID	ID	ID
18/04/2019	33.8	13.1	0.06	2.6	1.1	14.5	ID	ID	ID	ID
19/04/2019	37.2	15.1	0.06	1.2	1.0	12.2	ID	ID	ID	ID
20/04/2019	32.1	12.7	0.04	2.3	1.0	12.8	ID	ID	ID	ID
21/04/2019	34.4	12.9	0.04	1.8	0.9	9.8	ID	ID	ID	ID
22/04/2019	36.9	13.5	0.06	3.4	1.0	4.2	ID	ID	ID	ID
23/04/2019	31.7	11.6	0.05	4.0	0.9	3.1	ID	ID	ID	ID
24/04/2019	23.6	11.3	0.25	2.7	0.8	2.3	ID	ID	ID	ID
25/04/2019	23.0	9.4	0.06	7.7	1.1	9.1	ID	ID	ID	ID
26/04/2019	38.7	14.0	0.17	3.0	0.8	3.2	ID	ID	ID	ID
27/04/2019	24.7	8.6	0.31	5.7	1.0	3.3	ID	ID	ID	ID
28/04/2019	24.7	9.0	0.31	5.7	1.0	0.4	ID	ID	ID	ID
29/04/2019	24.0	9.1	0.33	6.0	1.0	0.4	ID	ID	ID	ID
30/04/2019	21.2	7.8	0.34	5.2	1.0	1.3	ID	ID	ID	ID
01/05/2019	27.5	11.1	0.32	1.9	0.8	3.4	ID	ID	ID	ID
02/05/2019	33.0	12.7	0.38	5.8	0.9	2.7	ID	ID	ID	ID
03/05/2019	37.7	13.8	0.37	3.2	0.9	3.7	ID	ID	ID	ID
04/05/2019	31.3	11.6	0.35	4.5	0.9	5.7	ID	ID	ID	ID
05/05/2019	18.5	7.0	0.35	5.9	1.1	16.0	ID	ID	ID	ID
06/05/2019	20.8	8.1	0.36	2.2	1.0	10.3	ID	ID	ID	ID
07/05/2019	29.5	10.7	0.39	3.6	0.8	8.8	ID	ID	ID	ID
08/05/2019	30.8	11.5	0.39	2.6	0.6	6.5	ID	ID	ID	ID
09/05/2019	38.1	13.5	0.41	2.9	0.6	3.4	ID	ID	ID	ID
10/05/2019	37.3	13.7	0.43	3.2	0.5	4.7	ID	ID	ID	ID
11/05/2019	42.5	14.9	0.40	4.3	0.7	4.1	ID	ID	ID	ID
12/05/2019	33.6	12.4	0.39	2.0	0.6	3.2	ID	ID	ID	ID
13/05/2019	36.3	12.9	0.42	4.2	0.8	1.1	ID	ID	ID	ID
14/05/2019	33.7	12.0	0.43	4.1	1.0	4.8	ID	ID	ID	ID
15/05/2019	33.2	12.1	0.44	4.1	1.1	5.4	ID	ID	ID	ID
16/05/2019	28.3	10.6	0.43	4.4	1.1	6.3	ID	ID	ID	ID
17/05/2019	33.5	12.0	0.58	3.1	1.0	5.3	ID	ID	ID	ID
18/05/2019	29.3	10.3	0.49	3.3	0.8	1.6	ID	ID	ID	ID
19/05/2019	31.7	11.1	0.59	4.1	0.8	1.1	ID	ID	ID	ID
20/05/2019	13.1	4.9	0.58	8.0	1.3	11.6	ID	ID	ID	ID
21/05/2019	14.6	5.4	0.67	4.8	1.0	4.3	ID	ID	ID	ID
22/05/2019	24.5	9.0	0.56	2.4	0.9	1.7	ID	ID	ID	ID
23/05/2019	15.2	5.2	0.57	3.6	0.7	1.4	ID	ID	ID	ID
24/05/2019	10.0	3.8	0.67	12.2	1.7	5.2	ID	ID	ID	ID
25/05/2019	16.5	6.0	0.60	6.2	0.8	0.5	ID	ID	ID	ID
26/05/2019	17.1	6.7	0.58	3.8	0.6	0.3	ID	ID	ID	ID
27/05/2019	14.0	5.3	0.67	3.3	0.5	1.1	ID	ID	ID	ID
28/05/2019	33.3	11.4	0.70	4.1	0.7	0.8	ID	ID	ID	ID
29/05/2019	35.3	13.1	0.68	3.1	0.9	2.0	ID	ID	ID	ID
30/05/2019	30.3	11.6	0.63	4.3	0.9	4.7	ID	ID	ID	ID
31/05/2019	21.0	7.5	0.61	5.3	1.0	2.8	ID	ID	ID	ID

$\mu g/m^3$ = micrograms per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; NO_2 = nitrogen dioxide; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); ppb = parts per billion; SO2 = sulfur dioxide

ATTACHMENT B MONITORING LOCATION DATA RECORD

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
15/08/2018	1:00	20.5	7.8	0.23	0.3	ZS	ZS	0.2	0.0	0.0	0.0
	2:00	21.3	8.1	0.22	0.2	-1.8	-0.2	0.1	0.0	0.0	0.0
	3:00	28.0	10.4	0.22	0.1	-1.9	-0.2	1.7	0.0	0.0	2.7
	4:00	31.1	11.7	0.23	0.5	-1.8	-0.5	0.0	0.0	0.0	0.0
	5:00	35.0	13.4	0.23	1.6	-1.9	1.4	508.9	0.0	0.0	0.0
	6:00	36.2	13.0	0.23	1.1	-2.1	0.9	0.0	0.0	0.0	0.0
	7:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	8:00	12.6	5.2	0.67	10.8	-0.4	2.0	0.0	0.1	0.0	0.1
	9:00	17.5	6.6	0.37	1.9	-1.5	0.6	0.0	0.1	0.1	0.0
	10:00	10.6	4.5	0.42	5.6	-1.3	0.4	0.2	0.0	0.0	0.2
	11:00	6.8	3.3	0.36	12.8	4.7	-0.3	8.4	2.5	0.1	0.1
	12:00	11.7	4.7	0.29	4.3	-0.4	-0.2	0.0	0.1	0.0	0.0
	13:00	40.4	13.8	0.29	1.2	-1.7	-0.5	56.9	0.4	0.0	0.2
	14:00	50.7	17.1	0.28	1.5	-1.5	-0.5	0.0	0.2	0.1	0.0
	15:00	54.3	19.2	0.31	1.6	-1.8	-0.1	0.2	15.6	0.0	0.8
	16:00	55.2	19.0	0.27	1.2	-1.5	-0.3	0.4	1.0	0.0	0.1
	17:00	61.9	20.3	0.25	1.9	-1.8	0.1	0.1	0.0	0.0	0.0
	18:00	60.4	20.3	0.26	2.3	-1.9	0.2	0.0	0.0	0.0	0.7
	19:00	59.3	20.0	0.28	4.0	-1.7	0.2	0.2	0.1	0.0	0.1
	20:00	59.0	20.1	0.29	3.8	-1.8	0.2	0.3	0.0	0.0	0.1
	21:00	58.3	19.6	0.26	1.6	-1.8	-0.3	90.1	0.0	0.0	0.0
	22:00	46.6	15.8	0.26	2.3	-2.1	0.5	0.0	0.1	0.0	0.2
	23:00	41.6	14.1	0.26	1.9	-1.9	2.2	0.0	0.0	0.0	0.2
	0:00	39.5	13.6	0.24	1.3	-1.7	-0.2	0.0	0.0	0.0	0.1
Min		6.8	3.3	0.2	0.1	-2.1	-0.5	0.0	0.0	0.0	0.0
Max		61.9	20.3	0.7	12.8	4.7	2.2	508.9	15.6	0.1	2.7
Average		37.3	13.1	0.3	2.8	-1.3	0.2	29.0	0.9	0.0	0.2

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
16/08/2018	1:00	37.3	13.0	0.22	0.7	-1.9	-0.3	29.2	194.2	0.0	0.0
	2:00	33.5	12.0	0.21	0.6	-2.2	-0.1	0.0	0.0	0.0	0.0
	3:00	31.2	11.3	0.21	0.6	-1.9	-0.4	0.0	0.1	0.0	0.0
	4:00	28.7	10.3	0.21	0.6	-2.1	-0.2	508.8	0.0	0.0	3.9
	5:00	26.1	9.3	0.21	0.7	-1.9	6.8	0.0	1.1	0.0	0.0
	6:00	20.8	7.7	0.23	1.7	-1.9	3.2	0.0	0.0	0.0	0.0
	7:00	12.5	4.9	0.35	5.2	-1.5	0.5	0.0	0.0	0.0	0.1
	8:00	12.7	4.6	0.47	6.4	-0.8	0.3	0.2	201.2	0.0	0.1
	9:00	10.3	4.0	0.29	3.7	-1.2	-0.4	0.5	0.0	0.0	0.1
	10:00	8.4	3.5	0.27	2.4	-1.6	-0.3	0.0	0.0	0.0	0.1
	11:00	14.3	6.7	0.34	4.7	-0.9	-0.2	0.0	1.4	0.0	7.1
	12:00	19.1	9.0	0.32	4.4	-0.4	0.6	0.0	0.1	0.0	0.1
	13:00	10.2	3.7	0.27	1.7	-1.6	-0.3	0.0	0.5	0.0	0.1
	14:00	11.1	3.7	0.27	1.6	-1.8	-0.2	67.6	0.0	0.0	0.0
	15:00	9.6	3.6	0.25	1.0	-1.8	-0.3	3.5	0.0	0.0	0.0
	16:00	9.1	3.8	0.31	2.1	-1.7	-0.2	0.0	0.0	0.0	0.0
	17:00	13.6	4.2	0.37	5.7	-0.8	-0.4	0.0	2.2	0.0	0.0
	18:00	16.0	6.0	0.42	6.6	-0.4	0.1	0.0	0.0	0.0	0.0
	19:00	22.7	7.6	0.52	8.9	0.1	0.5	0.0	0.0	0.0	0.0
	20:00	13.2	5.1	0.34	4.9	-0.5	0.0	0.0	0.0	0.0	0.0
	21:00	10.4	4.2	0.30	3.9	-1.1	0.3	45.6	0.0	0.0	0.0
	22:00	10.0	3.9	0.22	2.4	-1.6	1.0	0.0	1.2	0.0	0.0
	23:00	9.3	3.9	0.23	2.8	-1.5	0.5	0.0	0.0	0.0	0.0
	0:00	8.9	3.7	0.19	1.7	-1.6	0.3	0.0	0.0	0.0	0.0
Min		8.4	3.5	0.2	0.6	-2.2	-0.4	0.0	0.0	0.0	0.0
Max		37.3	13.0	0.5	8.9	0.1	6.8	508.8	201.2	0.0	7.1
Average		16.6	6.2	0.3	3.1	-1.3	0.4	27.3	16.7	0.0	0.5

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
17/08/2018	1:00	8.8	3.9	0.19	ZS	-1.8	0.0	0.0	0.0	0.0	0.0
	2:00	9.2	4.0	0.20	1.2	ZS	ZS	0.2	0.0	0.0	0.0
	3:00	10.3	4.3	0.21	2.0	-1.2	0.2	0.0	0.0	0.0	0.1
	4:00	11.3	4.7	0.22	3.4	-1.2	0.9	0.0	0.0	0.0	0.0
	5:00	10.6	4.8	0.21	3.4	-1.3	0.5	0.0	0.0	0.0	0.0
	6:00	15.4	6.9	0.29	4.9	-0.8	1.5	0.2	0.0	0.0	0.1
	7:00	19.4	8.7	0.44	5.9	-0.3	1.9	0.1	0.0	0.0	0.0
	8:00	14.7	6.2	0.40	4.2	-0.5	0.7	0.0	0.2	0.0	0.0
	9:00	13.5	5.7	0.34	3.6	-0.7	0.0	0.1	0.0	0.0	0.1
	10:00	16.5	5.8	0.29	3.9	-1.1	-0.1	6.8	0.0	0.0	0.0
	11:00	17.6	6.5	0.31	4.3	-1.1	0.0	0.0	0.0	0.0	0.0
	12:00	20.6	6.5	0.24	2.2	-1.3	-0.5	103.7	0.0	0.0	0.0
	13:00	17.9	6.7	0.28	2.2	-1.5	-0.2	0.0	0.0	0.0	0.0
	14:00	11.9	5.2	0.31	5.7	-1.1	0.1	0.0	1.2	0.0	0.0
	15:00	10.1	4.5	0.22	3.8	-0.9	0.2	6.6	1.0	0.0	0.0
	16:00	12.5	6.5	0.22	1.1	-1.8	0.0	0.2	0.0	0.0	0.0
	17:00	13.6	6.2	0.23	0.8	-1.6	-0.4	0.0	0.0	0.0	0.0
	18:00	17.2	7.3	0.22	1.2	-1.6	-0.4	0.0	0.0	0.0	0.0
	19:00	17.7	7.5	0.21	1.0	-1.6	-0.4	0.0	0.0	0.0	0.0
	20:00	19.3	7.8	0.20	1.1	-1.7	-0.5	5.5	0.0	0.0	0.0
	21:00	19.4	7.9	0.20	1.1	-1.6	-0.5	0.0	0.0	0.0	0.0
	22:00	19.5	8.2	0.21	1.3	-1.9	0.5	0.0	0.0	0.0	0.0
	23:00	18.7	8.1	0.25	3.2	-1.3	0.1	4.8	174.3	0.0	0.0
	0:00	18.9	8.4	0.27	ZS	-1.6	0.6	0.0	0.4	0.0	0.0
Min		8.8	3.9	0.2	0.8	-1.9	-0.5	0.0	0.0	0.0	0.0
Max		20.6	8.7	0.4	5.9	-0.3	1.9	103.7	174.3	0.0	0.1
Average		15.2	6.3	0.3	2.8	-1.3	0.2	5.3	7.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
18/08/2018	1:00	17.2	7.6	0.26	3.2	ZS	ZS	0.0	27.8	0.0	0.0
	2:00	16.8	6.8	0.39	7.3	-0.6	1.6	0.0	0.0	0.0	0.0
	3:00	17.6	6.7	0.47	9.4	-0.2	2.5	0.0	0.0	0.0	0.0
	4:00	18.5	7.5	0.51	10.1	0.4	4.0	1.3	0.5	0.0	0.0
	5:00	17.2	7.6	0.42	10.3	0.0	3.6	0.0	0.0	0.0	0.0
	6:00	21.0	9.3	0.54	11.3	0.5	6.9	0.0	0.2	0.0	0.0
	7:00	24.2	10.8	0.74	10.4	1.8	6.7	0.2	0.5	0.0	0.0
	8:00	24.3	10.6	0.51	7.8	0.7	1.5	0.3	0.1	0.0	0.0
	9:00	22.8	9.9	0.37	4.8	-0.3	-0.1	0.0	0.1	0.0	0.0
	10:00	21.5	10.0	0.30	4.0	-0.9	0.4	0.0	0.0	0.0	0.0
	11:00	20.2	9.4	0.26	2.5	-1.3	2.2	0.0	0.0	0.0	0.0
	12:00	18.5	9.6	0.25	2.2	-1.5	1.3	0.0	0.0	0.0	0.0
	13:00	17.7	8.3	0.28	4.3	-1.1	0.0	11.1	0.3	0.0	0.0
	14:00	19.2	9.1	0.24	2.4	-1.2	0.2	7.6	50.8	0.0	2.7
	15:00	19.9	9.3	0.25	2.4	-1.4	1.2	0.0	0.0	0.0	0.0
	16:00	17.5	8.6	0.29	3.0	-1.4	0.9	0.2	0.0	0.0	0.0
	17:00	15.6	7.9	0.29	3.9	-1.4	1.4	38.0	0.0	0.0	0.0
	18:00	17.2	8.5	0.30	5.2	-1.2	1.1	0.0	537.5	0.0	0.0
	19:00	16.5	8.8	0.34	6.3	-1.1	0.9	0.0	0.0	0.0	0.0
	20:00	16.6	8.8	0.29	4.3	-1.3	1.2	0.0	0.0	0.0	0.0
	21:00	20.0	9.4	0.25	2.3	-1.5	0.8	0.0	0.0	0.0	0.0
	22:00	18.5	9.0	0.23	2.2	-1.6	0.7	3.5	2.9	0.0	0.0
	23:00	18.0	9.1	0.23	2.5	-1.6	1.1	0.0	0.0	0.0	0.0
	0:00	16.9	9.1	0.24	3.0	-1.5	1.0	0.0	0.0	0.0	0.0
Min		15.6	6.7	0.2	2.2	-1.6	-0.1	0.0	0.0	0.0	0.0
Max		24.3	10.8	0.7	11.3	1.8	6.9	38.0	537.5	0.0	2.7
Average		18.9	8.8	0.3	5.2	-0.8	1.8	2.6	25.9	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
19/08/2018	1:00	17.2	8.6	0.21	3.1	-1.6	1.4	0.0	0.0	0.0	0.0
	2:00	16.0	8.4	0.20	2.0	-1.8	1.2	0.0	0.0	0.0	0.0
	3:00	16.1	8.5	0.19	1.8	-1.6	1.2	29.4	0.0	0.0	0.0
	4:00	17.2	8.7	0.19	1.7	-1.6	0.4	0.0	0.0	0.0	0.0
	5:00	16.6	8.9	0.20	1.9	-1.5	0.4	0.0	0.0	0.0	0.0
	6:00	16.9	8.9	0.23	2.9	-1.4	0.3	0.0	0.2	0.0	0.0
	7:00	19.4	9.7	0.29	4.6	-1.2	0.7	6.9	0.0	0.0	0.0
	8:00	19.2	9.3	0.24	3.6	-1.1	0.2	0.0	0.0	0.0	0.0
	9:00	16.5	8.5	0.23	2.6	-1.4	0.3	0.0	130.6	0.0	0.0
	10:00	16.1	8.2	0.23	2.6	-1.3	0.2	0.0	0.0	0.0	0.0
	11:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	12:00	PO	PO	PO	PO	PO	PO	0.0	0.1	0.0	0.0
	13:00	15.6	7.1	0.37	2.3	-1.2	0.2	0.0	0.0	0.0	0.0
	14:00	13.9	6.7	0.34	1.6	-1.6	0.0	5.7	0.0	0.0	0.0
	15:00	12.7	6.3	0.32	1.5	-1.6	-0.2	1242.1	0.0	0.0	0.0
	16:00	13.6	6.4	0.31	1.7	-1.7	-0.2	118.1	0.0	0.0	0.0
	17:00	14.5	6.6	0.29	1.4	-1.6	-0.2	0.0	0.0	0.0	0.0
	18:00	14.0	6.7	0.32	2.1	-1.7	0.9	0.0	0.0	0.0	0.0
	19:00	15.0	7.1	0.35	2.7	-1.6	0.6	0.0	0.0	0.0	0.0
	20:00	15.5	7.0	0.35	3.3	-1.3	0.8	0.8	70.6	0.0	0.0
	21:00	13.2	5.8	0.32	3.2	-1.3	1.3	0.0	0.0	0.0	0.0
	22:00	12.8	5.6	0.31	3.0	-1.6	1.6	0.0	94.2	0.0	0.0
	23:00	13.0	5.6	0.33	2.8	-1.4	0.9	0.0	0.0	0.0	0.0
	0:00	13.1	5.7	0.28	ZS	ZS	ZS	0.0	1.7	0.0	0.0
Min		12.7	5.6	0.2	1.4	-1.8	-0.2	0.0	0.0	0.0	0.0
Max		19.4	9.7	0.4	4.6	-1.1	1.6	1242.1	130.6	0.0	0.0
Average		15.4	7.5	0.3	2.5	-1.5	0.6	58.5	12.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
20/08/2018	1:00	12.6	6.1	0.30	3.7	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	12.9	6.2	0.24	2.3	-1.1	1.1	28.3	0.0	0.0	0.0
	3:00	11.9	5.9	0.23	1.8	-1.5	1.5	0.0	0.0	0.0	0.0
	4:00	12.1	6.0	0.24	1.9	-1.4	1.0	10.5	563.5	0.0	0.0
	5:00	11.9	6.1	0.23	2.4	-1.3	1.5	0.0	652.0	0.0	0.0
	6:00	13.2	6.4	0.31	5.1	-1.3	0.8	0.0	0.0	0.0	0.0
	7:00	17.3	7.5	0.51	9.5	-0.6	1.5	0.0	0.0	0.0	0.0
	8:00	17.0	6.9	0.47	7.8	-0.3	0.7	0.0	0.0	0.0	0.0
	9:00	13.7	5.7	0.39	6.0	-0.7	0.4	1272.6	9.2	0.0	0.0
	10:00	13.4	5.1	0.29	3.7	-1.0	0.1	85.1	28.7	0.0	0.0
	11:00	14.4	5.1	0.26	2.8	-1.5	0.5	0.0	0.0	0.0	0.0
	12:00	11.5	4.8	0.27	2.6	-1.5	0.1	1258.1	0.0	0.0	0.0
	13:00	13.8	4.9	0.26	2.3	-1.5	0.1	0.0	275.9	0.0	0.0
	14:00	11.2	4.5	0.26	2.6	-1.5	-0.1	174.5	1.8	0.0	0.0
	15:00	14.7	4.4	0.25	NT	-1.5	-0.1	0.0	0.0	0.0	0.0
	16:00	10.9	4.4	0.25	NT	-1.3	-0.2	0.0	681.7	0.0	0.0
	17:00	14.2	4.8	0.35	5.3	-1.2	-0.2	0.0	0.0	0.0	0.0
	18:00	11.8	4.7	0.47	7.5	-0.8	0.7	78.2	0.0	0.0	0.0
	19:00	13.0	4.8	0.24	2.3	-1.3	0.0	254.8	0.2	0.0	0.0
	20:00	11.3	4.7	0.21	1.1	-1.6	-0.2	0.0	0.0	0.0	0.0
	21:00	10.2	4.6	0.23	2.2	-1.5	1.0	0.0	0.0	0.0	0.0
	22:00	11.0	4.5	0.22	1.7	-1.5	2.0	0.0	0.0	0.0	0.0
	23:00	10.6	4.3	0.22	1.6	-1.7	1.3	0.0	0.0	0.0	0.0
	0:00	10.1	4.3	0.24	2.3	-1.8	2.0	2.9	0.0	0.0	0.0
Min		10.1	4.3	0.2	1.1	-1.8	-0.2	0.0	0.0	0.0	0.0
Max		17.3	7.5	0.5	9.5	-0.3	2.0	1272.6	681.7	0.0	0.0
Average		12.7	5.3	0.3	3.6	-1.3	0.7	131.9	92.2	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
21/08/2018	1:00	10.0	4.6	0.21	ZS	-1.7	1.7	0.0	8.0	0.0	0.0
	2:00	10.1	4.8	0.20	1.5	ZS	ZS	0.0	0.3	0.0	0.0
	3:00	9.7	4.6	0.20	1.5	-1.3	1.1	0.0	0.2	0.0	0.0
	4:00	11.4	5.1	0.21	2.0	-1.6	0.6	0.0	0.0	0.0	0.0
	5:00	20.4	9.3	0.26	4.8	-0.9	1.6	0.0	0.0	0.0	0.0
	6:00	15.2	6.9	0.36	6.4	-0.5	2.6	0.0	0.0	0.0	0.0
	7:00	15.9	6.4	0.51	8.8	0.1	2.6	0.0	0.0	0.0	0.0
	8:00	16.9	6.9	0.48	7.7	0.1	0.8	11.6	0.0	0.0	0.0
	9:00	13.1	5.9	0.32	4.4	-0.7	0.0	651.2	0.0	0.0	0.0
	10:00	14.2	5.3	0.21	1.6	-1.5	0.1	0.0	345.3	0.0	0.0
	11:00	12.5	5.4	0.22	1.5	-1.6	0.1	0.0	0.0	0.0	0.0
	12:00	14.1	5.5	0.22	1.6	-1.5	-0.2	12.9	0.3	0.0	0.0
	13:00	14.1	5.9	0.28	3.1	-1.4	0.2	12.6	0.0	0.0	0.0
	14:00	14.2	6.4	0.27	2.6	-1.4	-0.2	0.0	137.6	0.0	0.0
	15:00	13.8	6.5	0.25	2.8	-1.5	-0.1	0.0	0.0	0.0	0.0
	16:00	15.6	6.7	0.26	3.1	-1.4	-0.5	0.0	0.8	0.0	0.0
	17:00	14.5	6.8	0.33	5.2	-1.3	0.1	0.0	0.0	0.0	0.0
	18:00	15.0	7.1	0.36	6.3	-1.2	0.7	0.0	0.0	0.0	0.0
	19:00	15.4	7.0	0.43	8.8	-0.9	1.1	0.0	0.3	0.0	0.0
	20:00	17.6	8.7	0.41	8.1	-0.8	0.6	12.8	0.0	0.0	0.0
	21:00	15.2	7.1	0.34	6.5	-1.0	3.8	0.0	0.0	0.0	0.0
	22:00	15.0	7.1	0.28	4.3	-1.4	1.2	186.7	13.2	0.0	0.0
	23:00	14.7	7.2	0.24	2.7	-1.5	3.4	0.0	0.0	0.0	0.0
	0:00	17.3	7.6	0.23	ZS	-1.8	0.8	381.4	318.5	0.0	0.0
Min		9.7	4.6	0.2	1.5	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		20.4	9.3	0.5	8.8	0.1	3.8	651.2	345.3	0.0	0.0
Average		14.4	6.5	0.3	4.3	-1.1	1.0	52.9	34.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
22/08/2018	1:00	16.8	8.1	ZS	1.0	ZS	ZS	0.0	277.5	0.0	0.0
	2:00	16.1	8.3	0.22	1.1	-1.4	0.7	0.0	0.0	0.0	0.0
	3:00	15.8	8.4	0.24	2.7	-1.4	1.2	0.0	0.0	0.0	0.0
	4:00	15.7	8.5	0.22	1.7	-1.5	1.6	40.5	0.4	0.0	0.0
	5:00	15.2	8.4	0.23	3.6	-1.3	0.8	1.6	1009.3	0.0	0.0
	6:00	15.2	8.2	0.29	5.5	-1.0	0.7	0.0	0.0	0.0	0.0
	7:00	19.8	9.2	0.41	8.7	-0.7	1.7	0.0	0.0	0.0	0.0
	8:00	17.1	8.2	0.33	5.0	-0.9	0.8	0.0	0.0	0.0	0.0
	9:00	14.8	7.7	0.25	2.6	-1.5	0.5	0.0	25.9	0.0	0.0
	10:00	15.6	7.8	0.25	1.9	-1.5	0.2	20.0	0.0	0.0	0.0
	11:00	18.4	7.8	0.22	1.0	-1.5	-0.3	12.6	0.0	0.0	0.0
	12:00	17.6	7.4	0.22	1.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	13:00	15.0	7.3	0.23	1.4	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	14.2	7.0	0.23	1.6	-1.7	-0.2	0.0	0.0	0.0	0.0
	15:00	15.2	7.3	0.22	0.9	-1.6	-0.4	3.9	410.4	0.0	0.0
	16:00	16.4	7.4	0.22	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	17:00	22.7	8.3	0.24	1.3	-1.4	-0.6	13.0	0.0	0.0	0.0
	18:00	17.9	8.2	0.27	1.5	-1.5	-0.5	0.0	0.0	0.0	0.0
	19:00	19.1	8.0	0.29	1.6	-1.5	-0.2	0.0	418.0	0.0	0.0
	20:00	17.1	7.9	0.31	2.4	-1.5	0.3	0.0	644.1	0.0	0.0
	21:00	14.3	7.3	0.36	6.1	-1.3	1.2	0.0	0.0	0.0	0.0
	22:00	16.6	7.0	0.32	3.2	-1.3	-0.2	12.5	0.0	0.0	0.0
	23:00	16.1	7.1	0.30	2.2	-1.4	-0.1	0.0	115.5	0.0	0.0
	0:00	13.2	6.6	0.25	2.7	-1.3	0.4	0.1	0.0	0.0	0.0
Min		13.2	6.6	0.2	0.9	-1.7	-0.6	0.0	0.0	0.0	0.0
Max		22.7	9.2	0.4	8.7	-0.7	1.7	40.5	1009.3	0.0	0.0
Average		16.5	7.8	0.3	2.6	-1.4	0.3	4.3	120.9	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
23/08/2018	1:00	15.6	6.7	0.22	1.1	-1.4	0.1	0.0	0.3	0.0	0.0
	2:00	14.1	6.2	0.20	0.7	-1.6	-0.1	0.0	0.0	0.0	0.0
	3:00	15.3	6.3	0.20	0.5	-1.8	-0.2	0.0	0.0	0.0	0.0
	4:00	13.0	5.9	0.20	0.4	-1.8	-0.4	0.0	0.0	0.0	0.0
	5:00	11.3	5.6	0.20	0.7	-1.9	0.3	13.5	0.0	0.0	0.0
	6:00	10.9	5.4	0.22	0.9	-1.8	0.1	273.7	0.0	0.0	24.1
	7:00	11.2	5.5	0.26	1.6	-1.6	0.0	8.3	0.0	0.0	0.0
	8:00	18.6	8.5	0.57	8.0	0.2	1.0	0.0	0.0	0.0	0.0
	9:00	14.8	6.4	0.28	3.9	-0.6	-0.1	0.0	0.0	0.0	0.0
	10:00	11.9	5.5	0.23	1.0	-1.6	-0.1	0.0	0.0	0.0	0.0
	11:00	11.4	5.2	0.23	1.1	-1.4	-0.4	0.0	0.0	0.0	0.0
	12:00	13.4	4.8	0.22	1.0	-1.5	-0.5	0.0	0.0	0.0	0.0
	13:00	11.6	4.7	0.22	0.9	-1.6	-0.4	0.0	0.4	0.0	0.0
	14:00	15.0	4.7	0.23	1.5	-1.7	-0.2	0.0	0.0	0.0	0.0
	15:00	13.3	4.6	0.23	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	16:00	14.7	4.8	0.24	1.5	-1.9	0.1	2.1	16.6	0.0	12.7
	17:00	14.3	4.8	0.24	1.7	-1.4	-0.6	2.9	0.0	0.0	0.0
	18:00	13.4	4.8	0.25	1.8	-1.4	-0.4	10.8	86.7	0.0	0.0
	19:00	13.4	4.9	0.29	3.0	-1.4	0.0	0.0	91.7	0.0	0.0
	20:00	12.9	4.7	0.22	1.5	-1.6	3.6	0.0	0.0	0.0	0.0
	21:00	12.8	5.0	0.29	3.7	-1.5	0.9	0.0	0.0	0.0	0.0
	22:00	12.5	4.8	0.25	2.3	-1.4	-0.1	7.5	0.0	0.0	0.0
	23:00	12.0	4.7	0.26	2.8	-1.6	0.4	0.0	0.0	0.0	0.0
	0:00	12.5	4.6	0.23	1.9	-1.6	0.2	0.0	0.0	0.0	0.0
Min		10.9	4.6	0.2	0.4	-1.9	-0.6	0.0	0.0	0.0	0.0
Max		18.6	8.5	0.6	8.0	0.2	3.6	273.7	91.7	0.0	24.1
Average		13.3	5.4	0.2	1.9	-1.5	0.1	13.3	8.2	0.0	1.5

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
24/08/2018	1:00	12.5	4.4	0.21	ZS	-1.8	-0.1	0.0	0.0	0.0	0.0
	2:00	13.2	4.5	0.21	0.6	ZS	ZS	920.8	0.0	0.0	0.0
	3:00	10.5	4.3	0.22	0.8	-1.4	0.9	0.0	0.0	0.0	0.0
	4:00	10.6	4.2	0.22	0.8	-1.7	0.7	0.0	0.0	0.0	0.0
	5:00	9.9	4.1	0.21	1.1	-1.6	1.4	0.0	0.0	0.0	0.0
	6:00	10.4	4.4	0.30	3.8	-1.4	1.6	0.0	10.0	0.0	0.0
	7:00	20.1	8.1	0.55	8.1	0.0	3.2	359.3	0.1	0.0	0.0
	8:00	14.8	6.1	0.53	7.6	0.1	0.5	0.0	0.0	0.0	0.0
	9:00	11.4	5.0	0.35	4.7	-0.8	0.2	3.3	0.0	0.0	0.0
	10:00	11.0	4.8	0.28	2.8	-1.3	1.3	10.6	312.4	0.0	0.0
	11:00	10.0	4.5	0.26	2.0	-1.4	-0.5	75.5	0.0	0.0	0.0
	12:00	11.2	4.7	0.26	1.6	-1.5	-0.3	5.2	92.1	0.0	0.0
	13:00	13.0	5.5	0.26	1.4	-1.6	-0.4	0.0	0.0	0.0	0.0
	14:00	15.3	6.1	0.29	1.9	-1.7	-0.3	0.0	0.0	0.0	0.0
	15:00	14.7	5.9	0.34	3.5	-1.5	0.1	0.0	0.0	0.0	0.0
	16:00	14.8	5.9	0.35	3.9	-1.2	-0.3	0.0	10.7	0.0	0.0
	17:00	13.1	5.9	0.38	4.8	-1.2	-0.4	0.0	436.3	0.0	0.0
	18:00	12.2	5.7	0.36	5.0	-1.3	0.1	0.0	0.0	0.0	0.0
	19:00	11.2	5.5	0.37	4.9	-1.4	0.1	0.0	0.0	0.0	0.0
	20:00	11.2	5.3	0.34	3.8	-1.2	0.2	0.0	0.0	0.0	0.0
	21:00	12.4	5.5	0.30	2.9	-1.4	0.1	0.0	0.0	0.0	0.0
	22:00	11.5	5.4	0.32	3.1	-1.4	0.2	17.4	0.1	0.0	0.0
	23:00	13.4	6.2	0.31	2.6	-1.4	0.3	0.0	0.0	0.0	0.0
	0:00	13.3	6.1	0.28	ZS	-1.5	0.4	0.0	0.0	0.0	0.0
Min		9.9	4.1	0.2	0.6	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		20.1	8.1	0.5	8.1	0.1	3.2	920.8	436.3	0.0	0.0
Average		12.6	5.3	0.3	3.3	-1.3	0.4	58.0	35.9	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
25/08/2018	1:00	15.1	6.6	0.28	1.1	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	14.9	6.2	0.26	1.0	-1.5	0.4	0.0	0.0	0.0	0.0
	3:00	14.4	6.0	0.25	0.9	-1.6	0.3	9.9	0.0	0.0	0.0
	4:00	12.7	5.7	0.26	1.0	-1.7	0.7	46.0	0.0	0.0	0.0
	5:00	12.6	5.8	0.26	2.3	-1.6	0.7	11.0	0.0	0.0	0.0
	6:00	13.1	5.9	0.30	4.2	-1.2	0.8	361.2	0.0	0.0	0.0
	7:00	12.4	6.0	0.37	5.7	-1.2	0.6	0.0	0.0	0.0	0.0
	8:00	14.2	5.9	0.36	4.7	-1.2	0.8	0.0	0.0	0.0	0.0
	9:00	12.6	5.9	0.34	4.1	-1.4	0.1	0.0	0.0	0.0	0.0
	10:00	12.9	5.8	0.31	2.9	-1.3	0.0	0.0	0.0	0.0	0.0
	11:00	13.9	6.0	0.33	2.7	-1.3	-0.3	0.0	0.0	0.0	0.0
	12:00	13.5	6.0	0.32	2.3	-1.2	-0.5	0.0	0.0	0.0	0.0
	13:00	13.2	6.0	0.30	1.8	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	13.3	6.0	0.31	2.0	-1.6	0.4	0.0	0.0	0.0	0.0
	15:00	14.9	6.0	0.34	3.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	16:00	13.1	6.0	0.34	2.9	-1.5	-0.2	0.0	0.4	0.0	0.0
	17:00	13.7	6.0	0.35	3.2	-1.5	-0.2	412.4	0.0	0.0	0.0
	18:00	13.4	6.0	0.35	4.0	-1.6	0.2	12.2	0.0	0.0	0.0
	19:00	14.1	6.2	0.38	4.0	-1.3	-0.1	0.0	0.0	0.0	0.0
	20:00	13.1	5.9	0.38	3.8	-1.4	0.0	0.0	0.0	0.0	0.0
	21:00	13.5	6.0	0.34	3.7	-1.4	-0.1	13.1	5.7	0.0	0.0
	22:00	12.4	5.8	0.35	4.5	-1.4	0.3	0.0	0.0	0.0	0.0
	23:00	11.9	5.8	0.33	3.4	-1.4	0.3	0.0	10.8	0.0	0.0
	0:00	12.5	6.1	0.33	3.2	-1.6	0.4	0.0	0.3	0.0	0.0
Min		11.9	5.7	0.3	0.9	-1.7	-0.5	0.0	0.0	0.0	0.0
Max		15.1	6.6	0.4	5.7	-1.2	0.8	412.4	10.8	0.0	0.0
Average		13.4	6.0	0.3	3.0	-1.4	0.2	36.1	0.7	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
26/08/2018	1:00	14.2	6.4	0.32	3.2	-1.4	0.3	0.0	0.0	0.0	0.0
	2:00	14.1	6.9	0.31	2.4	-1.4	0.1	0.0	0.0	0.0	0.0
	3:00	14.1	7.0	0.29	1.9	-1.6	0.4	0.0	0.0	0.0	0.0
	4:00	13.9	7.0	0.29	2.1	-1.5	0.3	0.0	1.4	0.0	0.0
	5:00	14.7	7.5	0.30	2.2	-1.4	0.3	0.0	0.0	0.0	0.0
	6:00	15.4	8.0	0.35	5.2	-1.3	1.5	0.0	288.2	0.0	0.0
	7:00	17.7	8.1	0.43	6.3	-0.6	1.2	0.0	0.0	0.0	0.0
	8:00	15.2	7.5	0.39	4.0	-0.9	0.1	0.0	0.0	0.0	0.0
	9:00	13.8	7.0	0.32	2.0	-1.3	-0.2	0.0	0.0	0.0	0.0
	10:00	13.4	6.9	0.32	1.9	-1.4	-0.4	0.0	0.0	0.0	0.0
	11:00	17.0	7.2	0.32	1.4	-1.6	0.3	0.0	0.0	0.0	0.1
	12:00	23.1	8.7	0.35	1.7	-1.4	-0.1	0.2	21.4	0.0	0.0
	13:00	15.2	6.8	0.33	1.5	-1.3	-0.3	11.7	205.3	0.0	0.0
	14:00	19.0	7.4	0.34	1.4	-1.4	-0.3	738.4	0.0	0.0	0.0
	15:00	16.6	6.7	0.31	0.9	-1.7	-0.2	12.3	10.9	0.0	0.0
	16:00	14.5	6.4	0.33	1.6	-1.7	-0.3	0.0	0.9	0.0	0.0
	17:00	17.0	6.8	0.31	1.4	-1.6	0.1	8.5	0.0	0.0	0.0
	18:00	17.2	7.9	0.37	1.4	-1.6	-0.3	12.1	23.0	0.0	0.0
	19:00	17.2	7.4	0.37	1.6	-1.6	-0.3	3.2	0.0	0.0	0.0
	20:00	17.3	7.8	0.37	1.1	-1.5	-0.1	36.0	0.6	0.0	0.0
	21:00	17.4	7.5	0.39	1.6	-1.6	-0.1	0.0	135.0	0.0	0.0
	22:00	17.5	7.4	0.45	1.9	-1.0	-0.5	48.3	0.0	0.0	0.0
	23:00	18.1	7.4	0.45	3.4	-0.9	-0.1	0.0	0.2	0.0	0.0
	0:00	19.0	8.6	0.44	ZS	-0.7	-0.5	12.0	0.0	0.0	0.0
Min		13.4	6.4	0.3	0.9	-1.7	-0.5	0.0	0.0	0.0	0.0
Max		23.1	8.7	0.5	6.3	-0.6	1.5	738.4	288.2	0.0	0.1
Average		16.3	7.3	0.4	2.3	-1.4	0.0	36.8	28.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
27/08/2018	1:00	19.2	6.8	0.43	2.1	ZS	ZS	0.0	0.3	0.0	0.0
	2:00	20.8	8.0	0.33	1.5	-0.7	-0.3	13.0	0.0	0.0	0.0
	3:00	20.8	7.5	0.29	0.7	-1.5	0.4	88.5	0.0	0.0	0.0
	4:00	14.8	6.2	0.30	0.6	-1.4	1.0	0.0	0.0	0.0	0.0
	5:00	12.6	5.5	0.30	1.3	-1.3	0.9	13.1	0.0	0.0	0.0
	6:00	14.2	4.3	0.31	2.0	-1.5	1.4	110.5	0.0	0.0	0.0
	7:00	12.9	4.7	0.41	4.5	-1.1	1.0	0.0	0.3	0.0	0.0
	8:00	13.4	5.0	0.52	5.9	-0.8	0.7	0.0	0.0	0.0	0.0
	9:00	11.8	5.1	0.50	4.9	-0.6	0.3	0.0	664.6	0.0	0.0
	10:00	11.9	5.2	0.44	6.9	0.0	-0.2	0.0	0.0	0.0	0.0
	11:00	11.4	5.5	0.35	7.4	0.4	-0.1	1.4	0.0	0.0	0.0
	12:00	10.8	5.4	0.32	NT	-0.7	-0.2	0.0	0.0	0.0	0.0
	13:00	10.3	4.9	0.31	1.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	12.0	5.0	0.30	1.2	-1.4	-0.3	0.0	0.0	0.0	0.0
	15:00	14.1	5.3	0.30	1.0	-1.5	-0.2	0.0	13.6	0.0	0.0
	16:00	16.2	6.7	0.31	1.1	-1.4	-0.4	0.0	69.1	0.0	0.0
	17:00	21.1	9.1	0.42	1.8	-1.2	-0.6	0.0	0.0	0.0	0.0
	18:00	15.1	6.6	0.35	1.3	-1.3	-0.5	0.0	0.7	0.0	0.0
	19:00	31.4	19.3	0.43	1.7	-1.0	-0.5	0.1	1.3	0.0	0.0
	20:00	25.3	14.9	0.41	2.1	-0.9	-0.7	0.0	46.9	0.0	0.0
	21:00	13.0	6.9	0.30	1.6	-1.1	-0.7	0.0	0.0	0.0	0.0
	22:00	22.4	15.8	0.43	1.6	-1.0	-0.8	13.8	80.4	0.0	0.0
	23:00	15.6	8.9	0.43	2.2	-0.9	-0.6	0.0	0.0	0.0	0.0
	0:00	16.2	9.5	0.29	1.1	-1.2	-0.4	0.0	0.4	0.0	0.0
Min		10.3	4.3	0.3	0.6	-1.5	-0.8	0.0	0.0	0.0	0.0
Max		31.4	19.3	0.5	7.4	0.4	1.4	110.5	664.6	0.0	0.0
Average		16.1	7.6	0.4	2.4	-1.0	0.0	10.0	36.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
28/08/2018	1:00	9.8	4.6	0.26	ZS	-1.8	0.1	0.0	0.1	0.0	0.0
	2:00	10.9	4.8	0.26	0.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	12.3	4.9	0.26	0.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	4:00	12.5	4.9	0.26	0.4	-1.8	-0.1	0.0	0.0	0.0	0.0
	5:00	11.5	4.9	0.25	0.4	-1.7	-0.5	0.0	0.0	0.0	0.0
	6:00	10.9	4.7	0.26	0.5	-1.7	-0.1	0.0	0.2	0.0	0.0
	7:00	15.6	6.7	0.52	3.8	-0.8	1.1	0.0	0.3	0.0	0.0
	8:00	21.6	9.1	0.69	10.0	3.6	1.8	0.0	0.0	0.0	0.0
	9:00	16.4	7.7	0.40	6.7	0.2	-0.2	14.8	0.2	0.0	0.0
	10:00	14.6	5.5	0.28	2.0	-1.2	-0.5	27.6	0.2	0.0	0.0
	11:00	13.5	5.5	0.28	1.1	-1.5	-0.3	1.8	201.8	0.0	0.0
	12:00	12.8	5.5	0.29	0.9	-1.5	-0.5	0.0	0.0	0.0	0.0
	13:00	13.3	5.3	0.28	0.9	-1.5	-0.5	0.0	0.0	0.0	0.0
	14:00	14.4	5.6	0.28	1.2	-1.5	-0.2	0.0	0.0	0.0	0.0
	15:00	18.2	6.1	0.28	1.1	-1.6	-0.4	28.4	0.3	0.0	0.0
	16:00	17.7	6.1	0.28	1.3	-1.7	-0.3	0.0	0.0	0.0	0.0
	17:00	18.8	6.2	0.29	1.5	-1.6	-0.5	0.0	0.0	0.0	0.0
	18:00	17.9	6.3	0.32	2.6	-1.5	-0.3	0.0	0.0	0.0	0.0
	19:00	16.9	6.0	0.32	2.4	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	15.7	5.8	0.29	1.2	-1.6	-0.2	0.0	0.0	0.0	0.0
	21:00	17.2	6.0	0.31	1.6	-1.8	-0.1	0.0	23.4	0.0	0.0
	22:00	16.7	6.2	0.31	1.9	-1.3	-0.2	0.0	200.7	0.0	0.0
	23:00	17.3	6.6	0.31	2.0	-1.7	0.7	0.0	0.0	0.0	0.0
	0:00	17.6	6.9	0.31	ZS	-1.5	0.9	0.0	0.0	0.0	0.0
Min		9.8	4.6	0.3	0.4	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		21.6	9.1	0.7	10.0	3.6	1.8	28.4	201.8	0.0	0.0
Average		15.2	5.9	0.3	2.0	-1.2	0.0	3.0	17.8	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
29/08/2018	1:00	18.5	7.2	0.31	1.6	ZS	ZS	0.0	184.0	0.0	0.0
	2:00	18.8	7.3	0.30	2.1	-1.2	0.5	0.0	0.0	0.0	0.0
	3:00	16.0	6.5	0.29	1.5	-1.4	0.4	0.0	40.9	0.0	0.0
	4:00	14.9	6.1	0.29	1.6	-1.4	0.2	0.0	0.0	0.0	0.0
	5:00	16.4	6.6	0.32	4.1	-1.1	0.9	0.0	0.0	0.0	0.0
	6:00	15.8	7.2	0.40	5.1	-0.7	1.1	0.0	0.0	0.0	0.0
	7:00	19.0	7.7	0.59	7.9	-0.2	1.8	0.0	0.0	0.0	0.0
	8:00	18.1	7.7	0.67	8.0	0.1	0.6	0.0	51.6	0.0	0.0
	9:00	17.3	7.4	0.45	5.2	-0.3	0.1	0.0	0.0	0.0	0.0
	10:00	49.4	26.1	0.44	4.9	3.7	-1.0	0.1	0.0	0.0	0.0
	11:00	28.3	14.3	0.44	4.1	0.8	0.6	0.0	0.0	0.0	0.0
	12:00	19.3	10.2	0.44	2.8	0.8	-0.2	0.0	0.0	0.0	0.0
	13:00	16.7	7.3	0.41	2.8	-0.4	0.1	0.0	9.6	0.0	0.0
	14:00	15.7	6.3	0.41	3.0	-0.7	-0.4	226.8	0.0	0.0	0.0
	15:00	16.0	6.2	0.41	3.2	-1.0	-0.1	7.4	0.3	0.0	0.0
	16:00	15.6	6.3	0.41	3.8	-0.8	-0.4	0.0	306.0	0.0	0.0
	17:00	17.9	6.7	0.45	4.9	-0.9	-0.2	14.3	0.4	0.0	0.0
	18:00	19.3	6.9	0.42	4.4	-0.8	-0.1	13.9	0.2	0.0	0.0
	19:00	17.3	6.9	0.40	3.6	-1.1	-0.2	0.0	0.1	0.0	0.0
	20:00	15.8	7.0	0.34	1.4	-1.2	-0.3	0.0	0.0	0.0	0.0
	21:00	16.7	7.1	0.34	1.2	-1.2	-0.2	0.0	0.4	0.0	0.0
	22:00	15.0	6.7	0.33	1.2	-1.4	-0.1	0.0	0.0	0.0	0.0
	23:00	14.1	6.2	0.33	1.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	0:00	13.6	5.9	0.31	0.7	-1.3	-0.4	0.0	69.4	0.0	0.0
Min		13.6	5.9	0.3	0.7	-1.4	-1.0	0.0	0.0	0.0	0.0
Max		49.4	26.1	0.7	8.0	3.7	1.8	226.8	306.0	0.0	0.0
Average		18.6	8.1	0.4	3.3	-0.6	0.1	10.9	27.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
30/08/2018	1:00	12.6	5.9	0.32	1.4	-1.5	0.2	0.0	0.0	0.0	0.0
	2:00	11.9	5.6	0.31	1.0	-1.5	0.1	0.0	0.5	0.0	0.0
	3:00	12.4	5.6	0.32	1.6	-1.6	0.4	0.0	498.2	0.0	0.0
	4:00	12.7	5.8	0.33	2.3	-1.5	0.3	0.0	0.0	0.0	0.0
	5:00	12.1	5.7	0.33	2.5	-1.5	0.5	0.0	0.0	0.0	0.0
	6:00	12.7	5.8	0.37	3.7	-1.3	0.3	0.0	0.0	0.0	0.0
	7:00	14.2	5.9	0.44	6.0	-1.0	0.5	2.2	0.7	0.0	0.0
	8:00	13.8	5.9	0.54	7.4	-0.7	0.3	0.0	0.0	0.0	0.0
	9:00	12.5	5.6	0.45	5.2	-0.8	-0.1	0.0	0.0	0.0	0.0
	10:00	13.8	7.0	0.36	2.6	-1.3	-0.1	128.9	0.0	0.0	0.0
	11:00	13.1	5.4	0.33	1.5	-1.3	0.8	0.0	0.0	0.0	0.0
	12:00	11.7	5.1	0.36	1.8	-1.5	-0.2	0.0	0.0	0.0	0.0
	13:00	12.7	5.0	0.34	1.9	-1.6	0.0	0.0	0.0	0.0	0.0
	14:00	12.7	4.9	0.33	1.1	-1.6	-0.2	0.0	0.0	0.0	0.0
	15:00	14.3	5.0	0.34	1.3	-1.7	-0.2	3.7	0.0	0.0	0.0
	16:00	11.6	5.1	0.32	1.0	-1.7	-0.2	15.7	0.0	0.0	0.0
	17:00	13.7	5.0	0.34	1.6	-1.7	-0.2	0.0	0.0	0.0	0.0
	18:00	14.1	5.2	0.35	1.7	-1.7	-0.3	15.0	8.5	0.0	0.0
	19:00	14.6	5.1	0.35	1.3	-1.6	-0.5	0.0	0.0	0.0	0.0
	20:00	13.2	4.9	0.33	0.9	-1.6	-0.5	0.0	3.2	0.0	0.0
	21:00	11.6	4.8	0.34	1.0	-1.8	-0.2	148.8	0.0	0.0	0.0
	22:00	12.1	4.8	0.33	1.1	-1.6	-0.4	0.0	0.0	0.0	0.0
	23:00	11.2	4.6	0.34	0.8	-1.8	-0.3	9.6	0.0	0.0	0.0
	0:00	10.5	4.5	0.35	0.8	-1.8	-0.1	0.0	0.0	0.0	0.0
Min		10.5	4.5	0.3	0.8	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		14.6	7.0	0.5	7.4	-0.7	0.8	148.8	498.2	0.0	0.0
Average		12.7	5.3	0.4	2.1	-1.5	0.0	13.5	21.3	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
31/08/2018	1:00	10.7	4.8	0.38	ZS	-2.0	0.0	14.9	0.0	0.0	0.0
	2:00	11.6	4.9	0.34	0.3	ZS	ZS	0.2	0.0	0.0	0.0
	3:00	12.8	5.2	0.35	0.2	-1.4	-0.3	0.3	216.1	0.0	0.0
	4:00	15.8	5.6	0.34	0.2	-1.6	-0.4	0.0	0.1	0.0	0.0
	5:00	13.5	5.4	0.35	0.2	-1.7	-0.3	3.4	0.0	0.0	0.0
	6:00	13.7	5.4	0.35	0.2	-1.7	-0.1	0.0	0.0	0.0	0.0
	7:00	15.2	5.4	0.35	0.7	-1.4	-0.4	0.0	0.0	0.0	0.0
	8:00	16.6	5.8	0.35	0.8	-1.3	-0.7	170.1	0.0	0.0	0.0
	9:00	15.2	5.5	0.37	0.8	-1.5	-0.3	0.0	0.0	0.0	0.0
	10:00	14.7	5.7	0.35	0.7	-1.6	-0.2	IO	IO	IO	IO
	11:00	16.6	6.1	0.36	0.6	-1.6	-0.3	IO	IO	IO	IO
	12:00	13.6	5.3	0.37	1.8	-1.7	-0.2	IO	IO	IO	IO
	13:00	10.4	3.8	0.48	5.2	-0.8	0.6	IO	IO	IO	IO
	14:00	9.3	3.6	0.49	6.0	-0.8	0.3	IO	IO	IO	IO
	15:00	9.4	4.0	0.55	9.0	-0.3	0.1	IO	IO	IO	IO
	16:00	12.8	4.9	0.45	10.3	2.8	0.2	IO	IO	IO	IO
	17:00	16.3	6.6	0.42	3.6	-1.1	-0.1	IO	IO	IO	IO
	18:00	32.9	18.3	0.61	3.7	-0.7	-0.4	IO	IO	IO	IO
	19:00	24.9	11.7	0.55	2.3	-0.8	-0.6	IO	IO	IO	IO
	20:00	21.5	9.0	0.46	2.3	-1.3	-0.1	IO	IO	IO	IO
	21:00	22.8	8.8	0.43	1.5	-1.4	-0.2	IO	IO	IO	IO
	22:00	24.5	9.7	0.37	1.5	-1.6	-0.1	IO	IO	IO	IO
	23:00	24.0	8.8	0.38	2.0	-1.4	0.4	IO	IO	IO	IO
	0:00	22.1	8.0	0.36	ZS	-1.6	-0.2	IO	IO	IO	IO
Min		9.3	3.6	0.3	0.2	-2.0	-0.7	ID	ID	ID	ID
Max		32.9	18.3	0.6	10.3	2.8	0.6	ID	ID	ID	ID
Average		16.7	6.8	0.4	2.4	-1.1	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
01/09/2018	1:00	21.0	7.7	0.35	0.6	ZS	ZS	IO	IO	IO	IO
	2:00	20.3	7.4	0.34	0.4	-1.5	-0.2	IO	IO	IO	IO
	3:00	21.1	7.6	0.34	0.3	-1.5	-0.3	IO	IO	IO	IO
	4:00	20.2	7.5	0.35	0.6	-1.7	0.7	IO	IO	IO	IO
	5:00	22.3	7.8	0.34	0.2	-1.7	0.0	IO	IO	IO	IO
	6:00	22.3	8.1	0.41	4.3	-1.0	0.6	IO	IO	IO	IO
	7:00	22.4	8.4	0.49	9.3	0.7	1.2	IO	IO	IO	IO
	8:00	17.8	7.2	0.58	6.5	-0.2	1.0	IO	IO	IO	IO
	9:00	18.9	7.0	0.56	6.2	-0.4	0.2	IO	IO	IO	IO
	10:00	20.0	7.5	0.45	3.3	-0.9	-0.1	IO	IO	IO	IO
	11:00	16.0	6.3	0.36	0.9	-1.4	-0.3	IO	IO	IO	IO
	12:00	16.4	6.5	0.37	1.0	-1.5	-0.4	IO	IO	IO	IO
	13:00	15.8	6.6	0.36	0.9	-1.7	-0.3	IO	IO	IO	IO
	14:00	16.7	6.5	0.37	1.0	-1.7	-0.3	IO	IO	IO	IO
	15:00	15.7	6.4	0.37	0.7	-1.7	-0.4	IO	IO	IO	IO
	16:00	15.7	6.7	0.38	1.4	-1.6	-0.5	IO	IO	IO	IO
	17:00	18.0	6.8	0.38	1.3	-1.6	-0.3	IO	IO	IO	IO
	18:00	17.1	6.6	0.38	1.1	-1.3	-0.6	IO	IO	IO	IO
	19:00	20.3	9.0	0.46	1.1	-1.4	-0.4	IO	IO	IO	IO
	20:00	16.4	6.2	0.39	0.8	-1.9	-0.2	IO	IO	IO	IO
	21:00	17.1	6.1	0.42	1.3	-1.6	-0.1	IO	IO	IO	IO
	22:00	14.8	5.8	0.45	1.4	-1.5	-0.2	IO	IO	IO	IO
	23:00	UM	UM	0.44	2.0	-1.5	0.0	IO	IO	IO	IO
	0:00	UM	UM	0.43	3.0	-1.4	1.0	IO	IO	IO	IO
Min		14.8	5.8	0.3	0.2	-1.9	-0.6	ID	ID	ID	ID
Max		22.4	9.0	0.6	9.3	0.7	1.2	ID	ID	ID	ID
Average		18.5	7.1	0.4	2.1	-1.3	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
02/09/2018	1:00	UM	UM	0.40	3.2	-1.2	2.0	IO	IO	IO	IO
	2:00	UM	UM	0.42	3.4	-1.4	1.7	IO	IO	IO	IO
	3:00	UM	UM	0.39	2.3	-1.4	1.0	IO	IO	IO	IO
	4:00	UM	UM	0.42	3.7	-1.3	1.9	IO	IO	IO	IO
	5:00	UM	UM	0.41	2.5	-1.3	1.3	IO	IO	IO	IO
	6:00	UM	UM	0.43	4.4	-1.0	2.2	IO	IO	IO	IO
	7:00	UM	UM	0.50	7.5	1.9	2.1	IO	IO	IO	IO
	8:00	UM	UM	0.49	4.8	-0.6	1.0	IO	IO	IO	IO
	9:00	UM	UM	0.50	3.8	-0.8	0.6	IO	IO	IO	IO
	10:00	UM	UM	0.51	4.6	-0.9	0.9	IO	IO	IO	IO
	11:00	UM	UM	0.52	4.9	-0.8	0.4	IO	IO	IO	IO
	12:00	UM	UM	0.46	3.8	-0.9	0.2	IO	IO	IO	IO
	13:00	UM	UM	0.44	2.1	-1.2	0.0	IO	IO	IO	IO
	14:00	UM	UM	0.42	1.4	-1.3	-0.6	IO	IO	IO	IO
	15:00	UM	UM	0.41	1.2	-1.2	-0.3	IO	IO	IO	IO
	16:00	UM	UM	0.44	0.9	-1.5	-0.2	IO	IO	IO	IO
	17:00	UM	UM	0.52	1.5	-1.2	-0.5	IO	IO	IO	IO
	18:00	UM	UM	0.89	3.7	-0.5	-0.8	IO	IO	IO	IO
	19:00	UM	UM	0.66	2.3	-0.4	-0.6	IO	IO	IO	IO
	20:00	UM	UM	0.60	2.3	-0.8	-0.5	IO	IO	IO	IO
	21:00	UM	UM	0.80	3.1	-0.2	-0.4	IO	IO	IO	IO
	22:00	UM	UM	1.03	5.4	0.8	0.6	IO	IO	IO	IO
	23:00	UM	UM	PO	PO	PO	PO	IO	IO	IO	IO
	0:00	21.0	9.0	PO	8.1	1.4	3.2	IO	IO	IO	IO
Min		ID	ID	0.4	0.9	-1.5	-0.8	ID	ID	ID	ID
Max		ID	ID	1.0	8.1	1.9	3.2	ID	ID	ID	ID
Average		ID	ID	0.5	3.5	-0.7	0.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
03/09/2018	1:00	15.7	6.7	PO	9.9	WP	WP	0.0	0.0	0.0	0.0
	2:00	14.1	6.3	0.58	3.4	-0.4	2.1	0.0	0.0	0.0	0.0
	3:00	14.0	6.5	0.56	1.7	-0.8	8.1	0.0	0.0	0.0	0.0
	4:00	15.0	6.1	0.53	9.4	-0.9	3.0	0.0	0.0	0.0	0.0
	5:00	17.3	7.7	0.49	5.4	-0.8	0.3	0.0	0.0	0.0	0.0
	6:00	15.7	7.0	0.48	0.8	-1.6	0.8	325.8	0.0	0.0	0.0
	7:00	12.7	5.9	0.75	8.5	-0.7	7.7	0.0	0.2	0.0	0.0
	8:00	15.9	6.9	1.10	12.5	0.5	6.0	0.0	0.5	0.0	0.0
	9:00	11.9	5.6	0.70	7.2	0.0	7.1	113.8	0.1	0.0	0.0
	10:00	11.1	5.4	0.58	5.4	-1.0	2.2	0.0	284.5	0.0	0.0
	11:00	8.7	4.0	0.49	1.9	-1.5	0.2	13.9	0.0	0.0	0.0
	12:00	10.5	4.8	0.49	2.2	-1.5	0.3	0.0	0.0	0.0	0.0
	13:00	10.1	4.7	0.48	1.1	-1.7	-0.1	272.5	0.0	0.0	0.0
	14:00	13.2	5.6	0.48	1.6	-1.7	-0.1	0.0	0.0	0.0	0.0
	15:00	12.4	5.8	0.48	1.8	-1.5	-0.5	0.0	0.0	0.0	0.0
	16:00	13.5	5.6	0.51	2.0	-1.5	-0.2	0.0	0.0	0.0	0.0
	17:00	15.1	7.7	0.54	3.5	-1.5	-0.3	221.8	0.0	0.0	0.0
	18:00	27.8	15.4	0.80	4.8	-0.7	-0.3	0.0	0.0	0.0	0.0
	19:00	28.4	15.2	0.83	2.8	-0.4	-0.8	0.0	0.0	0.0	0.0
	20:00	14.6	6.6	0.52	1.6	-1.0	-0.5	0.0	0.3	0.0	0.0
	21:00	13.0	6.4	0.51	2.4	-1.6	1.2	0.0	0.0	0.0	0.0
	22:00	13.3	6.3	0.51	2.2	-1.5	1.4	0.0	0.2	0.0	0.0
	23:00	15.3	6.6	0.57	6.3	-1.3	2.0	0.0	0.0	0.0	0.0
	0:00	24.4	9.6	0.90	13.7	0.3	3.9	185.5	139.9	0.0	0.0
Min		8.7	4.0	0.5	0.8	-1.7	-0.8	0.0	0.0	0.0	0.0
Max		28.4	15.4	1.1	13.7	0.5	8.1	325.8	284.5	0.0	0.0
Average		15.1	7.0	0.6	4.7	-1.0	1.9	47.2	17.7	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
04/09/2018	1:00	24.6	10.6	0.74	ZS	0.6	2.7	62.5	0.0	0.0	0.0
	2:00	25.9	11.7	0.71	11.2	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	20.8	8.5	0.59	9.2	2.0	1.0	0.0	0.0	0.0	0.0
	4:00	19.4	7.8	0.58	8.3	1.6	1.0	0.1	184.8	0.0	0.0
	5:00	16.8	7.2	0.57	8.7	0.7	0.8	0.0	0.0	0.0	0.0
	6:00	17.0	7.0	0.67	8.5	-0.1	1.3	0.0	0.0	0.0	0.0
	7:00	17.3	7.7	0.91	8.5	3.0	1.3	0.0	0.1	0.0	0.0
	8:00	20.8	6.8	0.76	6.7	2.9	0.3	0.0	0.0	0.0	0.0
	9:00	17.9	6.6	0.64	7.1	1.0	0.1	0.0	0.0	0.0	0.0
	10:00	17.9	6.7	0.54	7.0	0.5	0.0	268.4	0.0	0.0	0.0
	11:00	16.5	7.5	0.54	6.6	0.1	-0.2	0.0	0.0	0.0	0.0
	12:00	13.2	6.4	0.50	1.7	-1.3	-0.1	84.0	0.0	0.0	0.0
	13:00	12.7	5.7	0.50	1.3	-1.6	-0.2	0.0	0.0	0.0	0.0
	14:00	15.3	5.8	0.51	1.3	-1.4	-0.4	8.7	88.1	0.0	0.0
	15:00	13.3	5.5	0.51	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	16:00	12.5	4.9	0.51	1.3	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	12.7	5.4	0.54	1.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	18:00	13.8	6.2	0.55	1.6	-1.4	-0.3	143.7	0.3	0.0	0.0
	19:00	13.4	6.5	0.52	1.0	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	12.9	5.4	0.51	1.0	-1.6	-0.3	2.6	0.0	0.0	0.0
	21:00	15.4	5.6	0.49	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	22:00	17.2	5.8	0.49	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	23:00	20.5	6.5	0.50	1.3	-1.8	0.1	0.0	0.2	0.0	0.0
	0:00	21.3	7.7	0.50	ZS	-1.6	0.2	0.0	0.0	0.0	0.0
Min		12.5	4.9	0.5	1.0	-1.8	-0.4	0.0	0.0	0.0	0.0
Max		25.9	11.7	0.9	11.2	3.0	2.7	268.4	184.8	0.0	0.0
Average		17.1	6.9	0.6	4.4	-0.3	0.2	23.7	11.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
05/09/2018	1:00	23.4	8.4	0.48	0.5	ZS	ZS	131.6	0.0	0.0	0.0
	2:00	26.2	9.1	0.48	0.5	-1.7	1.1	0.0	0.0	0.0	0.0
	3:00	26.7	9.4	0.47	0.4	-1.5	1.4	181.1	0.0	0.0	0.0
	4:00	23.9	8.8	0.48	0.4	-1.6	0.2	0.0	115.0	0.0	0.0
	5:00	27.0	9.2	0.47	0.4	-1.6	0.1	0.0	0.0	0.0	0.0
	6:00	28.8	9.7	0.66	6.1	-0.5	2.8	0.0	0.0	0.0	0.0
	7:00	30.2	10.5	0.66	6.5	0.5	3.4	0.0	0.0	0.0	0.0
	8:00	22.6	8.8	0.78	7.8	-0.6	4.3	0.0	0.0	0.0	0.0
	9:00	28.1	10.9	0.66	4.2	-0.7	1.2	0.0	0.1	0.0	0.0
	10:00	20.0	7.5	0.51	1.1	-1.4	0.9	0.0	0.0	0.0	0.0
	11:00	14.9	5.6	0.64	5.7	-1.0	1.4	0.0	0.0	0.0	0.0
	12:00	10.7	4.5	0.51	1.8	-1.4	-0.5	0.0	0.0	0.0	0.0
	13:00	12.5	5.1	0.52	2.1	-1.3	-0.2	0.0	0.0	0.0	0.0
	14:00	23.3	8.8	0.52	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	15:00	20.7	8.2	0.53	1.3	-1.6	0.0	0.0	0.8	0.0	0.0
	16:00	15.1	5.9	0.65	4.7	-1.3	-0.2	0.0	0.0	0.0	0.0
	17:00	27.2	12.0	0.63	3.7	-1.0	-0.6	0.0	0.0	0.0	0.0
	18:00	42.5	21.9	0.66	2.4	-0.9	-0.6	0.0	0.0	0.0	0.0
	19:00	28.0	9.8	0.62	4.2	-1.4	0.3	0.0	0.0	0.0	0.0
	20:00	35.3	11.3	1.00	11.2	1.3	1.7	0.0	0.1	0.0	0.0
	21:00	33.5	11.6	1.06	10.7	7.2	1.2	0.0	0.1	0.0	0.0
	22:00	49.0	13.9	1.35	8.4	3.5	4.4	0.1	1.4	0.0	0.1
	23:00	34.0	10.5	0.91	7.3	1.8	1.9	0.0	0.8	0.0	0.0
	0:00	34.1	11.4	0.93	8.2	2.4	2.2	0.0	0.5	0.0	0.0
Min		10.7	4.5	0.5	0.4	-1.7	-0.6	0.0	0.0	0.0	0.0
Max		49.0	21.9	1.4	11.2	7.2	4.4	181.1	115.0	0.0	0.1
Average		26.6	9.7	0.7	4.2	-0.2	1.1	13.0	5.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
06/09/2018	1:00	33.2	11.2	0.81	7.3	2.7	3.2	0.0	0.5	0.0	0.0
	2:00	29.1	9.4	0.63	6.6	2.7	1.4	0.0	0.0	0.0	0.0
	3:00	25.7	8.3	0.55	4.5	-0.5	0.2	0.0	0.0	0.0	0.0
	4:00	23.8	7.4	0.54	3.8	-0.8	0.4	0.0	0.0	0.0	0.0
	5:00	22.0	7.6	0.57	6.5	2.0	0.4	0.0	0.0	0.0	0.0
	6:00	23.7	7.0	0.66	5.5	0.2	2.2	16.4	0.0	0.0	0.0
	7:00	17.6	6.0	0.70	5.7	0.4	0.8	0.0	0.0	0.0	0.0
	8:00	16.4	5.5	0.84	5.1	-0.3	0.4	0.0	0.0	0.0	0.0
	9:00	26.1	8.0	0.80	8.2	2.6	1.0	0.0	0.0	0.0	0.0
	10:00	30.0	10.6	0.65	6.8	0.4	0.0	0.0	0.3	0.0	0.0
	11:00	24.5	7.9	0.56	5.3	-0.2	-0.2	121.9	1.2	0.0	0.0
	12:00	17.1	6.5	0.53	2.1	-1.2	0.1	0.0	0.0	0.0	0.0
	13:00	14.6	5.8	0.56	ZA	-1.0	-0.2	0.0	0.0	0.0	0.0
	14:00	14.6	6.0	0.55	ZA	-1.4	-0.1	0.0	0.0	0.0	0.0
	15:00	14.8	5.9	0.55	ZA	-1.3	-0.4	0.0	119.6	0.0	0.0
	16:00	15.0	6.1	0.55	ZA	-1.5	-0.3	0.0	0.0	0.0	0.0
	17:00	14.8	5.8	0.56	ZA	-1.6	-0.1	0.0	0.0	0.0	0.0
	18:00	13.1	5.5	0.56	1.6	-1.3	-0.3	0.0	0.0	0.0	0.0
	19:00	14.1	5.4	0.53	0.9	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	12.2	5.4	0.52	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	21:00	12.9	5.6	0.52	0.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	22:00	15.2	6.1	0.55	1.0	-1.5	0.3	0.0	16.2	0.0	0.0
	23:00	16.0	6.2	0.56	1.2	-1.5	0.3	0.0	0.0	0.0	0.0
	0:00	16.3	6.1	0.53	0.7	-1.7	0.5	0.0	0.0	0.0	0.0
Min		12.2	5.4	0.5	0.3	-1.7	-0.4	0.0	0.0	0.0	0.0
Max		33.2	11.2	0.8	8.2	2.7	3.2	121.9	119.6	0.0	0.0
Average		19.3	6.9	0.6	3.9	-0.4	0.4	5.8	5.7	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
07/09/2018	1:00	13.0	5.7	0.54	ZS	-1.8	0.8	0.0	0.0	0.0	0.0
	2:00	14.7	6.2	0.57	2.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	18.9	7.0	0.61	3.7	-0.2	3.0	0.8	0.0	0.0	0.0
	4:00	17.4	7.0	0.60	4.1	-0.6	3.5	0.0	0.0	0.0	0.0
	5:00	14.9	6.5	0.58	4.4	-0.5	1.5	0.0	0.0	0.0	0.0
	6:00	19.3	7.5	0.73	5.4	-0.1	6.1	0.0	613.2	0.0	0.0
	7:00	26.2	8.7	1.03	8.4	1.6	7.6	0.0	578.3	0.0	0.0
	8:00	21.4	8.0	0.92	7.6	0.9	1.8	0.0	0.1	0.0	0.0
	9:00	14.3	6.0	0.73	4.7	-0.2	-0.4	0.0	0.0	0.0	0.0
	10:00	12.9	5.6	0.60	2.4	-1.1	0.1	0.0	0.0	0.0	0.0
	11:00	12.9	5.5	0.56	1.3	-1.3	0.0	0.0	0.0	0.0	0.1
	12:00	15.1	5.5	0.55	0.9	-1.4	-0.2	150.7	0.0	0.0	0.0
	13:00	14.1	5.3	0.57	1.1	-1.5	-0.3	0.0	0.0	0.0	0.0
	14:00	13.2	5.1	0.55	0.5	-1.6	-0.3	0.0	0.0	0.0	0.0
	15:00	14.2	5.1	0.56	0.8	-1.4	-0.5	0.0	0.0	0.0	0.0
	16:00	13.2	5.3	0.63	2.2	-1.3	-0.4	0.0	77.6	0.0	0.0
	17:00	12.4	5.1	0.63	2.5	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	12.6	5.1	0.58	1.7	-1.5	-0.2	0.1	0.0	0.0	0.0
	19:00	13.3	4.9	0.55	0.7	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	11.7	5.0	0.56	0.9	-1.6	-0.1	0.0	0.0	0.0	0.0
	21:00	11.2	4.7	0.54	0.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	22:00	10.0	4.6	0.55	0.1	-1.8	0.1	0.0	0.0	0.0	0.0
	23:00	10.9	4.5	0.56	0.4	-1.7	-0.1	0.0	0.0	0.0	0.0
	0:00	12.5	4.9	0.56	ZS	-1.7	0.1	0.0	0.0	0.0	0.0
Min		10.0	4.5	0.5	0.1	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		26.2	8.7	1.0	8.4	1.6	7.6	150.7	613.2	0.0	0.1
Average		14.6	5.8	0.6	2.6	-1.0	0.9	6.3	52.9	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
08/09/2018	1:00	13.8	5.0	0.55	0.3	ZS	ZS	16.7	0.0	0.0	0.0
	2:00	13.3	4.6	0.54	0.2	-1.3	0.4	0.0	0.0	0.0	0.0
	3:00	11.0	4.3	0.55	0.9	-1.6	0.5	0.0	0.0	0.0	0.0
	4:00	11.3	4.7	0.57	2.8	-1.2	0.7	0.0	0.0	0.0	0.0
	5:00	13.2	5.1	0.62	4.6	-1.3	3.0	0.0	0.0	0.0	0.0
	6:00	18.9	6.9	0.90	8.9	0.4	9.5	0.0	0.0	0.0	0.0
	7:00	22.4	7.5	0.90	9.9	1.2	5.4	0.0	0.2	0.0	0.0
	8:00	15.3	5.8	0.70	5.5	0.0	0.3	0.0	15.3	0.0	0.0
	9:00	12.2	4.8	0.62	2.2	-1.3	0.3	0.0	0.0	0.0	0.0
	10:00	11.9	4.8	0.61	1.9	-1.2	0.1	166.2	0.0	0.0	0.0
	11:00	12.0	4.6	0.56	0.6	-1.5	-0.3	192.1	0.0	0.0	0.0
	12:00	13.2	4.9	0.60	1.4	-1.5	-0.1	0.0	0.2	0.0	0.0
	13:00	14.0	5.4	0.61	2.2	-1.3	-0.2	0.0	0.0	0.0	0.0
	14:00	14.8	4.7	0.56	0.3	-1.5	-0.6	0.0	0.0	0.0	0.0
	15:00	15.8	4.7	0.56	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	16:00	12.9	4.7	0.57	0.2	-1.9	-0.2	0.0	0.0	0.0	0.0
	17:00	13.4	4.7	0.57	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	18:00	13.9	6.1	0.63	0.7	-1.5	-0.3	17.2	0.0	0.0	0.0
	19:00	14.1	5.9	0.63	0.6	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	15.0	6.7	0.64	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	21:00	18.8	9.3	0.76	0.9	-1.0	-0.6	0.1	0.0	0.0	0.0
	22:00	14.9	6.1	0.67	0.8	-1.4	-0.4	0.0	159.4	0.0	0.0
	23:00	12.8	5.2	0.60	0.4	-1.5	-0.6	0.0	0.0	0.0	0.0
	0:00	14.4	5.2	0.67	0.4	-1.4	-0.5	0.0	0.0	0.0	0.0
Min		11.0	4.3	0.5	0.2	-1.9	-0.6	0.0	0.0	0.0	0.0
Max		22.4	9.3	0.9	9.9	1.2	9.5	192.1	159.4	0.0	0.0
Average		14.3	5.5	0.6	2.0	-1.2	0.7	16.3	7.3	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
09/09/2018	1:00	16.2	5.3	0.63	0.6	-1.5	-0.3	0.0	0.0	0.0	0.0
	2:00	12.8	4.7	0.60	1.2	-1.5	0.0	0.0	0.0	0.0	0.0
	3:00	15.1	4.7	0.60	0.8	-1.6	0.1	18.0	0.0	0.0	0.0
	4:00	13.1	4.6	0.58	0.8	-1.7	0.2	0.0	0.0	0.0	0.0
	5:00	13.2	4.9	0.55	0.0	-1.7	-0.3	0.0	0.0	0.0	0.0
	6:00	12.7	4.7	0.56	0.0	-1.6	-0.3	0.0	0.0	0.0	0.0
	7:00	10.9	4.5	0.57	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	8:00	11.2	4.5	0.57	0.4	-1.6	-0.4	0.7	0.0	0.0	0.0
	9:00	11.3	4.3	0.57	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	10:00	11.6	4.6	0.59	0.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	11:00	10.5	4.4	0.59	0.6	-1.7	-0.2	0.2	0.0	0.0	0.0
	12:00	11.6	4.8	0.63	1.5	-1.4	0.1	0.0	0.0	0.0	0.0
	13:00	12.3	4.2	0.59	0.4	-1.6	-0.6	0.0	0.0	0.0	0.0
	14:00	11.3	4.3	0.59	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	15:00	14.3	4.3	0.59	0.3	-1.8	-0.3	0.0	0.0	0.0	0.0
	16:00	12.4	4.2	0.64	0.4	-1.6	-0.3	0.0	0.1	0.0	0.0
	17:00	13.3	5.0	0.63	0.8	-1.3	-0.4	0.0	0.1	0.0	0.0
	18:00	12.8	5.2	0.76	1.6	-1.5	-0.2	0.0	0.5	0.0	0.0
	19:00	14.0	5.9	0.96	1.8	-0.2	-0.3	0.1	1.9	0.0	0.9
	20:00	14.3	5.6	1.05	2.3	0.2	-0.2	0.0	1.3	0.0	0.3
	21:00	14.9	5.2	1.08	3.5	0.8	-0.1	1.1	1.7	0.0	0.4
	22:00	13.4	5.1	1.06	5.0	0.9	0.8	0.1	1.8	0.0	0.8
	23:00	37.4	16.9	1.36	9.1	1.4	4.0	8.5	0.9	0.0	0.0
	0:00	26.6	11.6	1.16	ZS	1.4	2.9	0.1	2.0	0.0	0.0
Min		10.5	4.2	0.6	0.0	-1.8	-0.6	0.0	0.0	0.0	0.0
Max		37.4	16.9	1.4	9.1	1.4	4.0	18.0	2.0	0.0	0.9
Average		14.5	5.6	0.7	1.4	-1.0	0.1	1.2	0.4	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
10/09/2018	1:00	31.4	15.3	1.20	8.9	ZS	ZS	0.3	0.9	0.0	0.2
	2:00	29.1	14.2	1.08	8.6	0.8	4.0	0.2	0.1	0.0	0.0
	3:00	32.8	17.7	1.02	7.8	0.6	3.5	0.1	0.0	0.0	0.0
	4:00	27.7	14.5	0.91	6.3	3.3	2.2	0.1	0.0	0.0	0.0
	5:00	20.6	10.2	0.74	5.5	1.7	0.5	0.0	0.0	0.0	0.0
	6:00	23.4	9.9	0.78	4.7	0.5	1.6	0.0	0.0	0.0	0.0
	7:00	22.6	9.1	0.92	5.1	3.3	1.7	0.0	0.0	0.0	0.0
	8:00	20.9	7.3	1.04	6.1	1.7	0.3	0.0	117.0	0.0	0.0
	9:00	19.7	6.3	0.91	7.5	1.2	0.2	0.0	0.0	0.0	0.0
	10:00	20.3	6.0	0.75	7.2	0.7	-0.1	0.0	0.1	0.0	0.0
	11:00	14.9	5.7	0.70	3.2	-0.6	-0.1	13.0	109.7	0.0	0.0
	12:00	15.2	5.5	0.68	1.4	-1.0	-0.2	0.0	0.0	0.0	0.0
	13:00	16.3	5.3	0.66	1.5	-1.1	-0.5	0.0	0.0	0.0	0.0
	14:00	15.2	5.3	0.65	0.9	-1.2	-0.3	0.0	0.0	0.0	0.0
	15:00	16.3	5.5	0.65	0.5	-1.5	-0.4	120.7	0.0	0.0	0.0
	16:00	19.5	6.3	0.68	0.8	-1.7	-0.1	0.0	0.0	0.0	0.0
	17:00	19.3	6.4	0.72	0.8	-1.3	-0.5	0.0	0.0	0.0	0.0
	18:00	18.7	6.2	0.69	0.5	-1.4	-0.7	0.0	0.0	0.0	0.0
	19:00	19.0	7.9	0.74	0.7	-1.4	-0.5	0.0	0.0	0.0	0.0
	20:00	36.4	21.2	0.88	0.9	-1.0	-0.7	0.0	0.0	0.0	0.0
	21:00	20.3	8.0	0.74	0.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	22:00	18.0	6.4	0.65	0.2	-1.6	-0.2	0.0	0.0	0.0	0.0
	23:00	18.3	6.7	0.63	0.2	-1.9	-0.1	96.2	0.0	0.0	0.0
	0:00	21.6	7.6	0.62	0.2	-1.7	-0.4	205.4	0.7	0.0	0.0
Min		14.9	5.3	0.6	0.2	-1.9	-0.7	0.0	0.0	0.0	0.0
Max		36.4	21.2	1.2	8.9	3.3	4.0	205.4	117.0	0.0	0.2
Average		21.6	8.9	0.8	3.3	-0.2	0.4	18.2	9.5	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
11/09/2018	1:00	21.1	7.3	0.64	ZS	-1.6	-0.5	0.0	0.0	0.0	0.0
	2:00	24.7	7.9	0.62	0.0	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	28.4	9.1	0.62	-0.1	-1.2	0.0	0.0	0.0	0.0	0.0
	4:00	30.4	9.8	0.63	0.1	-1.6	-0.2	0.0	0.0	0.0	0.0
	5:00	30.4	10.0	0.64	0.9	-1.7	0.3	0.0	0.0	0.0	0.0
	6:00	24.5	8.0	0.70	3.4	-1.4	0.9	26.9	0.1	0.0	0.0
	7:00	30.2	11.3	0.63	0.1	-1.5	0.2	0.0	0.0	0.0	0.0
	8:00	26.3	8.8	0.85	5.5	-1.2	0.2	0.0	0.0	0.0	0.0
	9:00	37.1	12.3	0.82	3.4	-0.9	0.0	0.0	0.0	0.0	0.0
	10:00	20.4	8.0	0.72	4.7	-0.5	0.2	0.0	0.0	0.0	0.0
	11:00	24.3	9.5	0.72	2.9	-1.2	-0.1	0.0	137.5	0.0	0.0
	12:00	17.0	7.0	NT	3.9	-1.1	1.6	0.0	114.8	0.0	0.0
	13:00	13.1	5.6	NT	5.8	-0.8	0.3	0.0	0.0	0.0	0.0
	14:00	17.9	6.6	NT	4.2	-0.9	0.3	0.0	0.0	0.0	0.0
	15:00	15.7	6.0	NT	4.0	-0.5	-0.1	0.0	0.0	0.0	0.0
	16:00	13.6	5.0	1.06	1.2	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	28.6	13.7	1.25	2.0	-1.2	-0.1	0.0	0.0	0.0	0.0
	18:00	26.8	12.3	1.26	1.8	-0.6	-0.4	0.1	0.0	0.0	0.0
	19:00	25.3	11.3	1.07	1.0	-0.7	-0.5	0.0	0.0	0.0	0.0
	20:00	25.6	11.8	0.90	0.8	-1.1	-0.5	0.0	0.0	0.0	0.0
	21:00	42.7	24.1	0.77	0.9	-0.7	-0.9	0.0	0.0	0.0	0.0
	22:00	24.0	8.6	0.47	0.5	-1.1	-0.4	0.0	0.1	0.0	0.0
	23:00	24.9	8.4	0.43	0.6	-1.7	0.0	0.0	0.0	0.0	0.0
	0:00	20.5	7.1	0.31	ZS	-1.8	-0.2	0.0	0.0	0.0	0.0
Min		13.1	5.0	0.3	-0.1	-1.8	-0.9	0.0	0.0	0.0	0.0
Max		42.7	24.1	1.3	5.8	-0.5	1.6	26.9	137.5	0.0	0.0
Average		24.7	9.6	0.8	2.2	-1.1	0.0	1.1	10.5	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
12/09/2018	1:00	16.8	6.5	0.32	1.5	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	14.4	5.0	0.34	2.9	-1.1	2.6	0.0	0.0	0.0	0.0
	3:00	14.5	6.1	0.32	8.1	0.4	2.4	0.0	0.0	0.0	0.0
	4:00	11.7	4.8	0.30	7.8	0.3	0.4	0.0	0.0	0.0	0.0
	5:00	14.3	4.0	0.30	4.5	-0.8	0.1	0.0	0.0	0.0	0.0
	6:00	13.9	3.7	0.34	9.5	-0.3	1.4	0.0	0.0	0.0	0.0
	7:00	15.9	4.2	0.51	9.7	1.6	1.9	0.0	0.0	0.0	0.0
	8:00	10.3	3.1	0.54	8.3	1.7	0.0	0.0	0.0	0.0	0.0
	9:00	13.6	4.1	0.64	11.0	1.0	0.1	20.6	0.0	0.0	0.0
	10:00	11.3	4.2	0.46	12.4	2.4	0.3	0.0	0.0	0.0	0.0
	11:00	8.8	3.3	0.34	3.7	-0.4	-0.3	0.0	0.0	0.0	0.0
	12:00	11.0	3.7	0.35	7.0	0.1	-0.1	0.0	0.0	0.0	0.0
	13:00	11.0	4.1	0.33	3.2	-0.6	-0.3	0.0	0.0	0.0	0.0
	14:00	12.2	4.3	0.31	1.0	-1.4	-0.4	0.0	0.0	0.0	0.0
	15:00	11.1	4.0	0.32	1.0	-1.4	0.1	0.0	0.0	0.0	0.0
	16:00	13.5	5.4	0.36	1.1	-1.3	-0.3	0.0	0.0	0.0	0.0
	17:00	13.2	5.5	0.37	1.3	-1.3	-0.2	0.0	0.0	0.0	0.0
	18:00	13.1	4.6	0.34	1.0	-1.5	-0.1	0.0	0.0	0.0	0.0
	19:00	15.2	4.7	0.32	0.6	-1.7	-0.1	137.3	0.0	0.0	0.0
	20:00	14.3	4.8	0.31	0.9	-1.6	0.7	0.0	0.0	0.0	0.0
	21:00	12.8	4.7	0.35	2.4	-1.3	0.6	0.0	0.0	0.0	0.0
	22:00	10.8	4.1	0.38	3.4	-1.3	0.7	0.0	0.0	0.0	0.0
	23:00	10.8	4.1	0.37	3.5	-1.5	0.9	0.0	0.0	0.0	0.0
	0:00	10.2	4.4	0.38	3.1	-1.6	0.5	125.9	0.0	0.0	0.0
Min		8.8	3.1	0.3	0.6	-1.7	-0.4	0.0	0.0	0.0	0.0
Max		16.8	6.5	0.6	12.4	2.4	2.6	137.3	0.0	0.0	0.0
Average		12.7	4.5	0.4	4.5	-0.5	0.5	11.8	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
13/09/2018	1:00	11.8	5.1	0.35	3.2	-1.4	0.5	0.0	0.0	0.0	0.0
	2:00	11.2	5.3	0.34	3.2	-1.2	0.7	0.0	0.0	0.0	0.0
	3:00	12.6	5.8	0.35	2.9	-1.1	0.7	0.8	0.0	0.0	0.0
	4:00	16.0	6.1	0.37	3.2	-0.9	1.4	0.0	0.0	0.0	0.0
	5:00	16.8	5.9	0.37	3.9	-0.9	0.9	0.7	129.5	0.0	0.0
	6:00	11.5	5.0	0.34	2.2	-1.0	2.4	0.0	0.1	0.0	0.0
	7:00	6.9	3.4	0.39	2.7	-1.3	2.1	0.0	0.0	0.0	0.0
	8:00	10.0	3.7	0.66	9.5	0.5	1.4	0.0	0.0	0.0	0.0
	9:00	13.1	5.7	0.68	10.2	-0.1	1.8	0.0	0.0	0.0	0.0
	10:00	11.1	5.0	0.51	8.9	0.2	1.1	0.1	0.1	0.0	0.0
	11:00	9.2	4.1	0.41	9.0	1.6	0.0	0.0	0.0	0.0	0.0
	12:00	9.3	3.7	0.41	7.6	2.4	-0.4	0.0	0.0	0.0	0.0
	13:00	9.4	3.9	0.38	6.9	3.8	0.1	0.0	0.0	0.0	0.0
	14:00	11.7	4.5	0.36	2.0	-1.2	-0.1	0.0	0.2	0.0	0.0
	15:00	14.5	6.7	0.40	6.9	0.8	-0.3	0.0	10.9	0.0	0.0
	16:00	48.7	31.8	0.53	3.3	-0.7	-0.4	0.0	0.0	0.0	0.0
	17:00	18.1	10.7	0.51	1.9	-1.2	-0.1	1.6	12.2	0.0	0.0
	18:00	19.3	11.4	0.48	2.3	-0.9	-0.2	1.3	0.0	0.0	0.0
	19:00	14.1	6.7	0.39	2.4	-0.9	-0.3	6.4	0.0	0.0	0.0
	20:00	12.5	5.6	0.51	1.8	-1.2	-0.2	0.0	0.0	0.0	0.0
	21:00	12.2	5.8	0.40	0.7	-1.5	-0.1	0.0	0.0	0.0	0.0
	22:00	16.7	7.9	0.41	2.3	-1.5	1.5	0.0	0.0	0.0	0.0
	23:00	23.5	9.1	0.54	9.6	0.1	1.4	0.0	0.0	0.0	0.0
	0:00	27.0	9.0	0.68	9.6	0.4	3.2	0.0	0.0	0.0	0.0
Min		6.9	3.4	0.3	0.7	-1.5	-0.4	0.0	0.0	0.0	0.0
Max		48.7	31.8	0.7	10.2	3.8	3.2	6.4	129.5	0.0	0.0
Average		15.3	7.2	0.4	4.8	-0.3	0.7	0.5	6.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
14/09/2018	1:00	33.6	9.9	0.60	ZS	4.9	2.3	0.0	0.1	0.1	0.0
	2:00	22.8	7.0	0.48	9.6	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	25.5	7.6	0.47	8.1	2.4	2.7	0.0	0.0	0.0	0.0
	4:00	26.5	7.9	0.49	7.4	2.8	3.3	0.0	0.0	0.0	0.0
	5:00	24.5	8.1	0.50	6.8	3.3	5.4	0.0	0.0	0.0	0.0
	6:00	27.6	9.5	0.68	6.6	2.4	6.2	0.0	0.1	0.0	0.0
	7:00	33.5	12.7	0.94	8.7	4.3	3.7	0.0	0.4	0.0	0.0
	8:00	28.6	11.1	0.81	9.8	2.3	1.7	3.4	0.1	0.0	0.0
	9:00	29.6	11.4	0.68	7.3	0.5	0.8	0.0	0.0	0.0	0.0
	10:00	28.5	11.9	0.50	4.7	-0.2	-0.2	0.0	0.0	0.0	0.0
	11:00	24.8	11.0	0.41	3.0	-0.8	0.4	0.0	0.0	0.0	0.0
	12:00	23.8	10.1	0.41	2.8	-0.6	-0.4	0.0	0.0	0.0	0.0
	13:00	23.3	10.2	0.43	4.1	-0.7	-0.2	0.0	0.0	0.0	0.0
	14:00	22.2	9.7	0.43	3.7	-0.9	0.2	0.0	0.0	0.0	0.0
	15:00	21.8	9.1	0.43	4.4	-0.9	0.1	0.0	0.0	0.0	0.0
	16:00	20.8	8.6	0.50	5.9	-0.8	-0.1	0.0	0.0	0.0	0.0
	17:00	18.6	8.3	0.48	4.5	-0.9	-0.2	0.0	0.0	0.0	0.0
	18:00	19.0	8.2	0.50	4.5	-1.1	0.3	0.0	0.0	0.0	0.0
	19:00	18.4	8.5	0.45	3.6	-1.2	0.5	0.0	0.0	0.0	0.0
	20:00	21.2	8.5	0.36	1.5	-1.5	1.4	0.0	0.0	0.0	0.0
	21:00	20.7	8.4	0.35	1.4	-1.5	2.3	0.0	0.0	0.0	0.0
	22:00	18.5	8.2	0.37	1.7	-1.5	3.4	0.0	0.0	0.0	0.0
	23:00	20.0	8.2	0.35	0.9	-1.5	1.4	0.0	0.0	0.0	0.0
	0:00	18.6	8.1	0.33	ZS	-1.8	1.3	0.0	0.0	0.0	0.0
Min		18.4	7.0	0.3	0.9	-1.8	-0.4	0.0	0.0	0.0	0.0
Max		33.6	12.7	0.9	9.8	4.9	6.2	3.4	0.4	0.1	0.0
Average		23.8	9.3	0.5	5.0	0.3	1.6	0.1	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
15/09/2018	1:00	17.6	8.3	0.35	0.7	ZS	ZS	0.0	23.6	0.0	0.0
	2:00	18.3	8.4	0.36	1.8	-1.3	1.8	39.6	0.0	0.0	0.0
	3:00	18.6	8.6	0.34	2.3	-1.3	0.8	0.0	0.0	0.0	0.0
	4:00	17.8	8.4	0.34	1.9	-1.5	0.8	0.0	0.0	0.0	0.0
	5:00	18.1	8.3	0.34	1.3	-1.5	0.4	0.0	0.0	0.0	0.0
	6:00	17.9	8.3	0.39	2.5	-1.3	0.5	0.0	0.0	0.0	0.0
	7:00	23.5	9.5	0.55	6.6	-0.8	0.9	0.0	0.0	0.0	0.0
	8:00	20.7	8.9	0.49	4.1	-0.7	0.3	0.0	38.1	0.0	0.0
	9:00	18.7	8.0	0.45	3.8	-0.9	0.5	0.0	0.0	0.0	0.0
	10:00	17.7	7.7	0.44	2.7	-0.9	0.6	0.0	1134.6	0.0	0.0
	11:00	18.2	7.9	0.42	2.6	-1.1	0.1	0.0	0.0	0.0	0.0
	12:00	19.2	7.8	0.40	2.3	-1.3	-0.2	0.0	0.3	0.0	0.0
	13:00	17.5	7.3	0.39	1.6	-1.2	3.3	0.0	0.1	0.0	0.0
	14:00	15.0	6.8	0.38	1.2	-1.4	0.0	0.0	0.0	0.0	0.0
	15:00	15.3	6.8	0.39	1.3	-1.3	-0.3	0.0	0.0	0.0	0.0
	16:00	15.2	6.8	0.38	1.6	-1.4	-0.3	0.0	0.1	0.0	0.0
	17:00	15.7	7.1	0.38	1.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	18:00	20.0	8.0	0.40	1.2	-1.7	0.0	0.0	0.0	0.0	0.0
	19:00	20.4	7.9	0.40	0.6	-1.5	-0.5	0.0	0.0	0.0	0.0
	20:00	23.3	7.9	0.44	0.7	-1.6	-0.1	0.0	0.0	0.0	0.0
	21:00	20.6	7.5	0.43	2.1	-1.7	0.1	0.0	0.0	0.0	0.0
	22:00	19.8	8.2	0.58	7.5	-1.0	1.1	0.0	0.0	0.0	0.0
	23:00	16.5	7.4	0.47	4.1	-1.0	0.5	0.0	0.1	0.0	0.0
	0:00	15.8	7.2	0.41	1.5	-1.5	0.2	38.3	0.0	0.0	0.0
Min		15.0	6.8	0.3	0.6	-1.7	-0.5	0.0	0.0	0.0	0.0
Max		23.5	9.5	0.6	7.5	-0.7	3.3	39.6	1134.6	0.0	0.0
Average		18.4	7.9	0.4	2.4	-1.3	0.4	3.2	49.9	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
16/09/2018	1:00	15.1	6.4	0.37	0.6	-1.5	-0.2	0.0	0.0	0.0	0.0
	2:00	12.1	6.1	0.37	1.2	-1.5	0.5	126.8	0.0	0.0	0.0
	3:00	13.3	6.4	0.40	2.4	-1.4	0.4	0.0	0.0	0.0	0.0
	4:00	14.9	7.0	0.44	4.3	-1.0	1.1	0.0	0.0	0.0	0.0
	5:00	16.0	7.4	0.49	5.8	-0.5	3.6	0.0	0.0	0.0	0.0
	6:00	14.0	6.7	0.44	4.6	-0.7	1.4	0.0	0.0	0.0	0.0
	7:00	16.5	6.7	0.56	6.5	-0.4	1.9	0.0	0.1	0.0	0.0
	8:00	13.2	5.4	0.46	3.5	-0.8	-0.1	0.0	0.0	0.0	0.0
	9:00	11.3	4.3	0.39	1.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	10:00	11.3	4.0	0.39	0.9	-1.5	-0.3	0.0	0.0	0.0	0.0
	11:00	9.3	3.9	0.39	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	12:00	13.0	4.0	0.38	0.9	-1.7	-0.3	0.0	344.2	0.0	0.0
	13:00	11.1	4.1	0.38	0.7	-1.8	-0.3	0.0	0.0	0.0	0.0
	14:00	10.7	4.1	0.40	0.8	-1.6	0.8	0.0	0.0	0.0	0.0
	15:00	10.5	3.9	0.41	0.8	-1.7	0.9	0.0	0.0	0.0	0.0
	16:00	9.5	3.9	0.43	1.0	-1.6	0.2	0.0	0.0	0.0	0.0
	17:00	10.8	4.4	0.60	2.2	-0.8	-0.3	0.0	0.9	0.0	0.2
	18:00	14.7	6.7	0.45	1.3	-1.3	-0.1	0.0	0.0	0.0	0.0
	19:00	15.3	5.1	0.67	2.0	-1.0	-0.1	0.0	1.0	0.0	0.3
	20:00	14.5	4.9	0.54	1.0	-1.3	-0.4	0.9	0.2	0.0	0.0
	21:00	15.1	5.0	0.60	1.5	-1.2	-0.5	0.0	0.1	0.0	0.0
	22:00	12.9	5.0	0.50	1.5	-1.7	-0.1	0.0	0.0	0.0	0.0
	23:00	13.9	4.5	ZS	ZS	-1.5	-0.2	0.0	0.1	0.0	0.0
	0:00	12.6	4.2	0.54	ZS	-1.2	-0.3	0.0	0.0	0.0	0.0
Min		9.3	3.9	0.4	0.5	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		16.5	7.4	0.7	6.5	-0.4	3.6	126.8	344.2	0.0	0.3
Average		13.0	5.2	0.5	2.1	-1.3	0.3	5.3	14.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
17/09/2018	1:00	13.1	4.2	0.57	2.9	ZS	ZS	0.0	0.2	0.0	0.0
	2:00	10.1	3.4	0.33	0.4	-1.2	-0.2	0.0	0.0	0.0	0.0
	3:00	9.3	3.4	0.30	0.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	4:00	9.2	3.6	0.30	-0.2	-1.6	-0.4	0.0	0.3	0.0	0.1
	5:00	9.0	3.8	0.30	-0.1	-1.7	0.0	0.0	0.0	0.0	0.0
	6:00	11.2	4.6	0.43	4.4	-1.5	0.9	0.0	0.0	0.0	0.0
	7:00	19.5	7.1	0.60	7.3	-0.2	2.9	0.0	0.0	0.0	0.0
	8:00	20.4	6.2	0.44	4.2	-0.5	0.1	0.0	0.0	0.0	0.0
	9:00	21.1	6.6	0.46	6.0	-0.5	-0.3	0.0	51.9	0.0	0.0
	10:00	13.9	6.2	0.40	2.4	-1.0	0.1	0.0	0.0	0.0	0.0
	11:00	12.8	5.9	0.35	0.3	-1.4	-0.3	48.7	0.0	0.0	0.0
	12:00	14.1	6.5	0.37	1.0	-1.7	-0.2	0.0	0.0	0.0	0.0
	13:00	15.4	6.8	0.37	1.0	-1.8	0.1	0.0	0.0	0.0	0.0
	14:00	15.7	7.0	0.38	1.5	-1.5	-0.3	0.0	0.0	0.0	0.0
	15:00	15.7	6.9	0.36	0.4	-1.7	-0.3	0.0	0.0	0.0	0.0
	16:00	20.3	11.1	0.48	1.3	-1.5	-0.3	238.0	0.0	0.0	0.0
	17:00	22.5	10.8	0.43	1.1	-1.5	-0.2	0.0	0.0	0.0	0.0
	18:00	16.0	7.0	0.48	6.9	-0.3	-0.1	171.2	0.0	0.0	0.0
	19:00	14.4	6.9	0.58	13.7	3.0	0.3	0.0	0.0	0.0	0.0
	20:00	13.6	6.6	0.52	11.6	0.6	1.3	0.0	0.0	0.0	0.0
	21:00	13.0	7.1	0.64	13.1	1.0	4.0	0.0	0.0	0.0	0.0
	22:00	13.0	7.0	0.67	15.0	1.7	2.4	0.0	0.0	0.0	0.0
	23:00	20.4	10.9	0.68	13.8	1.3	3.9	0.0	0.0	0.0	0.0
	0:00	14.2	7.9	0.37	6.1	-0.3	1.9	0.0	0.0	0.0	0.0
Min		9.0	3.4	0.3	-0.2	-1.8	-0.4	0.0	0.0	0.0	0.0
Max		22.5	11.1	0.7	15.0	3.0	4.0	238.0	51.9	0.0	0.1
Average		14.9	6.6	0.4	4.8	-0.6	0.7	19.1	2.2	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
18/09/2018	1:00	13.3	7.2	0.39	ZS	-0.5	2.2	0.9	0.0	0.0	0.0
	2:00	13.6	6.7	0.38	4.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	16.3	7.4	0.42	11.4	4.5	1.6	0.0	0.0	0.0	0.0
	4:00	15.6	7.3	0.41	9.8	2.1	0.5	0.0	0.0	0.0	0.0
	5:00	15.2	6.7	0.41	6.7	1.7	0.6	0.0	0.0	0.0	0.0
	6:00	17.2	6.7	0.49	8.7	3.4	0.5	204.8	0.0	0.0	0.0
	7:00	16.2	6.6	0.54	8.1	1.9	0.1	0.0	0.0	0.0	0.0
	8:00	17.0	6.4	0.55	5.5	1.0	0.1	0.0	0.0	0.0	0.0
	9:00	17.8	6.2	0.50	2.5	-0.9	-0.2	0.2	0.0	0.0	0.0
	10:00	13.8	5.9	0.41	1.8	-1.3	-0.2	0.0	0.0	0.0	0.0
	11:00	11.8	5.4	0.40	1.0	-1.2	-0.4	0.6	0.0	0.0	0.0
	12:00	9.6	4.6	0.37	1.2	-1.5	-0.2	4.3	80.2	0.0	0.0
	13:00	8.3	4.3	0.38	1.0	-1.2	-0.5	0.0	0.0	0.0	0.0
	14:00	18.1	5.9	0.43	1.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	15:00	28.5	18.2	0.54	2.5	-0.7	-0.7	0.0	0.0	0.0	0.0
	16:00	22.6	12.8	0.48	2.1	-0.9	-0.3	0.0	0.0	0.0	0.0
	17:00	15.5	7.6	0.49	1.8	-1.1	-0.5	2.2	0.0	0.0	0.0
	18:00	11.3	4.4	0.42	1.4	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	8.9	3.6	0.41	0.4	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	8.9	3.7	0.40	0.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	21:00	8.8	3.9	0.41	0.3	-1.7	-0.1	0.0	0.0	0.0	0.0
	22:00	8.3	3.8	0.39	0.3	-1.6	-0.5	0.0	96.3	0.0	0.0
	23:00	8.4	3.9	0.39	0.4	-1.6	-0.3	0.0	0.0	0.0	0.0
	0:00	8.5	4.3	0.37	ZS	-1.7	-0.2	0.0	0.0	0.0	0.0
Min		8.3	3.6	0.4	0.3	-1.7	-0.7	0.0	0.0	0.0	0.0
Max		28.5	18.2	0.6	11.4	4.5	2.2	204.8	96.3	0.0	0.0
Average		13.9	6.4	0.4	3.3	-0.3	0.0	8.9	7.4	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
19/09/2018	1:00	10.3	4.6	0.39	-0.1	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	12.1	4.7	0.29	-0.3	-1.4	0.2	0.0	0.0	0.0	0.0
	3:00	10.8	4.5	0.30	0.6	-1.4	0.3	0.0	0.0	0.0	0.0
	4:00	12.8	5.2	0.33	1.6	-1.3	0.3	1.6	0.0	0.0	0.0
	5:00	13.1	5.3	0.34	2.4	-1.4	0.7	0.0	3.3	0.0	0.0
	6:00	17.9	6.1	0.44	5.2	-0.9	1.2	0.0	0.0	0.0	0.0
	7:00	24.9	7.9	0.68	7.9	0.0	3.3	0.0	0.0	0.0	0.0
	8:00	24.8	8.1	0.75	7.8	0.5	1.1	0.0	0.0	0.0	0.0
	9:00	24.5	6.6	0.39	2.9	-0.7	-0.2	265.1	0.0	0.0	0.0
	10:00	17.6	6.0	0.32	0.7	-1.5	0.0	0.0	0.0	0.0	0.0
	11:00	15.7	5.9	0.33	0.6	-1.6	0.0	0.0	0.0	0.0	0.0
	12:00	14.9	5.4	0.35	0.7	-1.5	0.2	0.0	0.0	0.0	0.0
	13:00	14.7	5.1	0.34	0.3	-1.6	0.1	0.0	0.0	0.0	0.0
	14:00	8.5	3.8	0.38	1.8	-1.7	0.0	0.0	0.0	0.0	0.0
	15:00	10.2	4.4	0.35	0.9	-1.6	-0.2	0.0	0.0	0.0	0.0
	16:00	11.5	4.4	0.35	1.0	-1.5	-0.4	0.0	0.0	0.0	0.0
	17:00	11.3	4.6	0.42	2.9	-1.5	-0.3	8.0	0.0	0.0	0.0
	18:00	16.9	6.4	0.62	8.8	-0.8	0.1	0.0	0.0	0.0	0.0
	19:00	16.4	6.0	0.49	6.4	-0.9	0.2	1.0	0.0	0.0	0.0
	20:00	16.2	6.2	0.51	5.7	-1.1	0.5	0.2	0.0	0.0	0.0
	21:00	15.3	6.1	0.45	4.9	-1.4	0.5	0.0	0.0	0.0	0.0
	22:00	14.6	6.0	0.41	3.9	-1.4	0.5	30.5	0.0	0.0	0.0
	23:00	16.7	6.5	0.39	3.3	-1.2	0.3	0.0	0.0	0.0	0.0
	0:00	29.8	11.6	0.35	1.3	-1.7	0.4	0.0	0.0	0.0	0.0
Min		8.5	3.8	0.3	-0.3	-1.7	-0.4	0.0	0.0	0.0	0.0
Max		29.8	11.6	0.7	8.8	0.5	3.3	265.1	3.3	0.0	0.0
Average		15.9	5.9	0.4	3.0	-1.2	0.4	12.8	0.1	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
20/09/2018	1:00	31.1	12.1	0.34	1.7	-1.5	0.7	0.0	0.0	0.0	0.0
	2:00	28.4	10.9	0.33	1.0	-1.4	0.6	0.0	0.0	0.0	0.0
	3:00	28.6	11.1	0.34	1.3	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	34.8	13.1	0.36	2.3	-1.3	1.2	0.0	0.0	0.0	0.0
	5:00	31.5	11.1	0.39	6.0	-0.6	4.3	0.0	0.0	0.0	0.0
	6:00	29.6	10.7	0.50	10.5	4.4	1.9	0.0	0.0	0.0	0.0
	7:00	31.7	11.3	0.67	9.9	3.5	1.6	0.0	0.0	0.0	0.0
	8:00	33.7	12.0	0.74	8.7	2.0	1.1	0.0	0.0	0.0	0.0
	9:00	38.4	13.5	0.60	6.5	0.6	1.1	0.0	0.0	0.0	0.0
	10:00	35.4	13.0	0.49	4.1	-0.6	0.0	0.0	0.0	0.0	0.0
	11:00	33.1	12.5	0.43	3.9	-0.9	-0.3	0.0	0.0	0.0	0.0
	12:00	33.0	12.0	0.40	2.5	-1.5	-0.2	0.0	0.0	0.0	0.0
	13:00	33.9	12.5	0.41	2.2	-1.3	0.5	0.0	0.0	0.0	0.0
	14:00	31.9	11.6	0.41	1.8	-1.3	-0.1	0.0	0.0	0.0	0.0
	15:00	30.3	11.0	0.41	2.2	-1.5	-0.1	216.0	0.0	0.0	0.0
	16:00	30.0	11.0	0.45	3.3	-1.5	-0.3	0.4	0.0	0.0	0.0
	17:00	29.1	10.6	0.45	2.8	-1.6	0.0	0.0	0.0	0.0	0.0
	18:00	29.0	10.7	0.38	1.3	-1.7	-0.1	0.0	0.0	0.0	0.0
	19:00	26.3	10.2	0.41	0.9	-1.8	0.0	0.0	0.0	0.0	0.0
	20:00	20.3	7.8	0.37	0.5	-1.4	-0.3	0.0	24.7	0.0	0.0
	21:00	21.2	8.4	0.40	0.3	-1.7	-0.2	0.3	0.0	0.0	0.0
	22:00	20.6	8.0	0.39	0.3	-1.6	-0.3	1.5	0.0	0.0	0.0
	23:00	26.6	10.3	0.37	0.1	-1.6	-0.4	0.0	0.0	0.0	0.0
	0:00	23.1	9.1	0.29	0.2	-1.6	-0.5	0.0	0.0	0.0	0.0
Min		20.3	7.8	0.3	0.1	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		38.4	13.5	0.7	10.5	4.4	4.3	216.0	24.7	0.0	0.0
Average		29.6	11.0	0.4	3.1	-0.7	0.4	9.1	1.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
21/09/2018	1:00	26.5	10.2	0.29	ZS	-2.0	0.1	0.0	0.0	0.0	0.0
	2:00	30.0	10.8	0.29	-0.3	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	16.8	6.2	0.29	-0.4	-1.4	-0.1	0.0	0.0	0.0	0.0
	4:00	10.3	4.1	0.30	-0.3	-1.6	0.1	206.0	0.0	0.0	0.0
	5:00	12.0	4.8	0.31	0.6	-1.7	0.1	0.0	0.0	0.0	0.0
	6:00	11.2	4.5	0.39	3.8	-1.4	0.9	0.0	0.0	0.0	0.0
	7:00	13.9	5.5	0.46	5.7	-1.1	0.6	0.0	0.0	0.0	0.0
	8:00	15.0	5.8	0.62	7.4	-1.0	0.1	0.9	0.0	0.0	0.0
	9:00	14.0	6.1	0.55	6.1	-1.0	0.3	15.3	0.0	0.0	0.0
	10:00	16.2	6.3	0.45	4.9	-1.0	0.4	0.0	0.0	0.0	0.0
	11:00	15.2	6.1	0.36	1.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	12:00	14.7	6.6	0.46	4.1	-1.2	0.2	0.0	0.0	0.0	0.0
	13:00	17.8	7.9	0.49	5.2	-0.7	0.0	0.0	0.0	0.0	0.0
	14:00	18.0	8.3	0.49	4.9	-0.8	-0.3	0.0	0.0	0.1	0.0
	15:00	19.0	8.0	0.44	3.7	-1.0	-0.3	0.0	0.0	0.0	0.0
	16:00	20.8	8.1	0.46	4.0	-1.3	-0.3	1.0	0.0	0.0	0.0
	17:00	20.7	8.8	0.53	6.2	-0.9	-0.2	0.0	0.0	0.0	0.0
	18:00	20.5	9.2	0.67	9.9	-0.7	0.2	0.0	0.0	0.0	0.0
	19:00	20.3	9.1	0.71	10.7	-0.6	0.2	0.0	0.0	0.0	0.0
	20:00	UM	UM	0.73	11.6	-0.7	0.8	1.0	0.0	0.0	0.0
	21:00	UM	UM	0.64	9.3	-0.6	0.6	0.0	0.0	0.0	0.0
	22:00	UM	UM	0.46	4.4	-1.1	0.2	0.0	0.0	0.0	0.0
	23:00	UM	UM	0.38	1.0	-1.7	-0.2	250.1	0.0	0.0	0.0
	0:00	UM	UM	0.39	ZS	-1.8	0.0	0.0	0.0	0.0	0.0
Min		10.3	4.1	0.3	-0.4	-2.0	-0.3	0.0	0.0	0.0	0.0
Max		30.0	10.8	0.7	11.6	-0.6	0.9	250.1	0.0	0.1	0.0
Average		17.5	7.2	0.5	4.7	-1.2	0.1	19.8	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
22/09/2018	1:00	UM	UM	0.40	1.7	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	UM	UM	0.33	1.5	-1.2	0.4	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.34	1.1	-1.4	0.4	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.32	1.4	-1.5	0.1	0.0	0.0	0.0	0.0
	5:00	UM	UM	0.34	3.9	-1.4	0.8	0.0	0.0	0.0	0.0
	6:00	UM	UM	0.41	3.6	-1.2	0.8	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.52	6.3	-0.6	1.0	0.0	0.0	0.0	0.0
	8:00	UM	UM	0.47	4.2	-1.0	0.3	0.0	0.0	0.0	0.0
	9:00	UM	UM	0.49	3.0	-0.7	-0.2	0.0	0.0	0.0	0.0
	10:00	UM	UM	0.45	3.1	-0.6	-0.1	0.0	0.0	0.0	0.0
	11:00	UM	UM	0.46	3.0	-0.8	-0.2	0.0	0.0	0.0	0.0
	12:00	UM	UM	0.42	1.5	-1.0	-0.4	15.4	0.0	0.0	0.0
	13:00	UM	UM	0.42	1.8	-1.4	-0.1	0.0	0.0	0.0	0.0
	14:00	UM	UM	0.42	2.0	-1.2	-0.5	0.0	0.0	0.0	0.0
	15:00	UM	UM	0.44	3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	16:00	UM	UM	0.41	2.3	-1.4	-0.3	0.0	0.0	0.0	0.0
	17:00	UM	UM	0.43	2.7	-1.3	-0.4	0.0	0.0	0.0	0.0
	18:00	UM	UM	0.44	3.5	-1.5	-0.1	0.0	0.0	0.0	0.0
	19:00	UM	UM	0.49	5.5	-1.2	0.3	0.0	0.0	0.0	0.0
	20:00	UM	UM	0.45	4.3	-1.4	0.3	0.0	0.0	0.0	0.0
	21:00	UM	UM	0.43	1.5	-1.7	-0.1	20.2	0.0	0.0	0.0
	22:00	UM	UM	0.42	1.7	-1.6	2.3	291.4	0.0	0.0	0.0
	23:00	UM	UM	0.40	3.1	-1.7	0.8	0.8	0.0	0.0	0.0
	0:00	UM	UM	0.35	1.6	-1.6	0.2	30.4	0.0	0.0	0.0
Min		ID	ID	0.3	1.1	-1.7	-0.5	0.0	0.0	0.0	0.0
Max		ID	ID	0.5	6.3	-0.6	2.3	291.4	0.0	0.0	0.0
Average		ID	ID	0.4	2.8	-1.2	0.2	14.9	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
23/09/2018	1:00	UM	UM	0.31	1.9	-1.4	0.5	0.0	0.0	0.0	0.0
	2:00	UM	UM	0.31	1.4	-1.5	0.3	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.31	1.6	-1.4	0.1	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.30	1.0	-1.7	0.1	1.0	0.0	0.0	0.0
	5:00	UM	UM	0.29	1.2	-1.9	0.2	15.1	0.0	0.0	0.0
	6:00	UM	UM	0.31	2.3	-1.7	0.6	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.38	3.8	-1.3	0.4	0.0	0.0	0.0	0.0
	8:00	UM	UM	0.36	2.6	-1.5	0.0	36.3	0.0	0.0	0.0
	9:00	UM	UM	0.34	1.9	-1.8	0.0	0.0	0.0	0.0	0.0
	10:00	UM	UM	0.34	1.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	11:00	UM	UM	0.31	1.1	-1.6	-0.3	0.0	0.2	0.0	0.0
	12:00	UM	UM	0.30	0.7	-1.8	-0.1	0.0	0.0	0.0	0.0
	13:00	UM	UM	0.31	0.6	-1.8	-0.5	0.0	0.0	0.0	0.0
	14:00	UM	UM	0.32	0.7	-1.8	-0.3	0.8	0.0	0.0	0.0
	15:00	UM	UM	0.32	0.6	-1.9	-0.4	0.8	0.0	0.0	0.0
	16:00	UM	UM	0.34	1.2	-1.7	-0.3	0.0	0.0	0.0	0.0
	17:00	UM	UM	0.38	1.3	-1.4	-0.5	0.0	0.0	0.0	0.0
	18:00	UM	UM	0.45	1.6	-1.4	-0.1	0.0	0.2	0.0	0.0
	19:00	UM	UM	0.70	1.8	-0.1	-0.3	11.1	1.4	0.0	0.3
	20:00	UM	UM	0.66	3.6	0.2	-0.1	0.0	0.9	0.0	0.2
	21:00	UM	UM	0.51	3.9	-0.8	0.4	0.0	0.3	0.0	0.0
	22:00	UM	UM	0.58	3.5	-0.6	0.2	306.3	0.8	0.0	0.2
	23:00	UM	UM	0.47	3.6	-0.9	0.4	0.0	0.1	0.0	0.0
	0:00	UM	UM	0.46	ZS	-1.1	0.3	0.0	0.0	0.0	0.0
Min		ID	ID	0.3	0.6	-1.9	-0.5	0.0	0.0	0.0	0.0
Max		ID	ID	0.7	3.9	0.2	0.6	306.3	1.4	0.0	0.3
Average		ID	ID	0.4	1.9	-1.3	0.0	15.5	0.2	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
24/09/2018	1:00	UM	UM	0.42	3.1	ZS	ZS	82.5	0.1	0.0	0.0
	2:00	UM	UM	0.33	1.6	-1.2	0.4	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.31	1.0	-1.5	0.4	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.32	0.8	-1.6	0.2	257.1	0.0	0.0	0.0
	5:00	UM	UM	0.32	1.4	-1.2	0.1	0.0	0.0	0.0	0.0
	6:00	UM	UM	0.43	7.4	-1.0	1.8	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.62	10.3	-0.1	1.5	0.0	0.0	0.0	0.0
	8:00	UM	UM	0.52	5.4	-0.7	0.2	0.0	0.0	0.0	0.0
	9:00	UM	UM	0.50	4.8	-0.9	0.2	0.0	0.0	0.0	0.0
	10:00	UM	UM	0.47	3.6	-1.2	0.1	0.0	0.4	0.0	0.0
	11:00	15.9	6.5	0.41	2.6	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	16.7	6.1	0.37	1.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	13:00	16.5	5.9	0.35	0.6	-1.6	-0.2	0.0	0.0	0.0	0.0
	14:00	UM	UM	0.36	0.9	-1.5	-0.4	0.0	0.0	0.0	0.0
	15:00	UM	UM	0.33	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	16:00	UM	UM	0.36	1.2	-1.6	-0.4	1.0	0.0	0.0	7.5
	17:00	UM	UM	0.36	0.4	-1.6	-0.5	0.0	0.0	0.0	0.0
	18:00	UM	UM	0.38	0.9	-1.7	-0.5	0.0	0.0	0.0	0.0
	19:00	UM	UM	0.35	0.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	20:00	UM	UM	0.34	0.1	-1.8	-0.3	0.0	0.0	0.0	0.0
	21:00	UM	UM	0.34	0.2	-1.6	-0.6	0.0	0.0	0.0	17.0
	22:00	UM	UM	0.33	0.1	-2.0	0.2	0.0	0.0	0.0	0.0
	23:00	UM	UM	ZS	0.2	-1.5	-0.3	0.0	0.0	0.0	0.0
	0:00	UM	UM	0.34	0.1	-1.8	-0.3	0.0	0.0	0.0	0.0
Min		ID	ID	0.3	0.1	-2.0	-0.6	0.0	0.0	0.0	0.0
Max		ID	ID	0.6	10.3	-0.1	1.8	257.1	0.4	0.0	17.0
Average		ID	ID	0.4	2.0	-1.4	0.0	14.2	0.0	0.0	1.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
25/09/2018	1:00	UM	UM	0.36	ZS	-1.8	-0.4	0.0	0.0	0.0	7.7
	2:00	UM	UM	0.36	0.1	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.35	0.0	-1.5	-0.1	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.35	0.1	-1.7	-0.2	0.0	0.0	0.0	0.0
	5:00	UM	UM	0.31	-0.3	-1.8	0.0	0.0	0.0	0.0	0.1
	6:00	UM	UM	0.31	-0.2	-1.7	-0.1	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.45	5.0	-0.8	0.3	0.0	0.1	0.0	0.0
	8:00	UM	UM	0.66	9.3	1.7	0.5	0.0	0.0	0.0	0.0
	9:00	UM	UM	0.48	3.8	-0.8	-0.1	0.0	0.0	0.0	0.0
	10:00	14.7	5.5	0.38	0.7	-1.4	-0.3	0.0	0.0	0.0	0.0
	11:00	12.3	4.2	0.38	0.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	12:00	8.1	2.5	0.39	0.4	-1.7	-0.3	0.0	0.0	0.0	0.0
	13:00	6.3	2.2	0.38	0.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	14:00	8.4	2.4	0.38	0.4	-1.5	-0.4	23.6	0.0	0.0	0.0
	15:00	20.7	9.3	0.44	0.9	-1.2	-0.6	0.0	0.0	0.0	0.0
	16:00	16.7	5.2	0.43	1.2	-1.1	-0.4	54.2	0.0	0.0	0.0
	17:00	16.3	7.3	0.45	1.9	-1.3	-0.5	0.0	0.0	0.0	0.0
	18:00	11.0	3.4	0.41	1.6	-1.5	-0.4	0.0	0.0	0.0	0.0
	19:00	9.2	3.0	0.38	1.0	-1.4	-0.4	0.0	0.0	0.0	0.0
	20:00	8.8	3.2	0.43	1.9	-1.5	0.0	0.0	0.1	0.1	0.1
	21:00	7.7	3.1	0.53	5.3	-1.2	0.7	0.0	0.0	0.0	0.1
	22:00	7.7	2.8	0.40	1.9	-1.3	-0.2	0.0	0.0	0.0	0.0
	23:00	7.2	2.6	0.41	1.2	-1.6	0.4	12.4	0.0	0.0	0.0
	0:00	6.4	2.4	0.41	ZS	-1.4	0.4	0.0	0.0	0.0	0.0
Min		ID	ID	0.3	-0.3	-1.8	-0.6	0.0	0.0	0.0	0.0
Max		ID	ID	0.7	9.3	1.7	0.7	54.2	0.1	0.1	7.7
Average		ID	ID	0.4	1.7	-1.3	-0.1	3.8	0.0	0.0	0.3

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
26/09/2018	1:00	6.6	2.5	0.37	0.2	ZS	ZS	262.0	0.0	0.0	0.0
	2:00	10.2	4.3	0.37	2.2	-1.2	1.6	0.0	0.0	0.0	0.0
	3:00	15.8	6.6	0.40	3.6	-1.0	1.7	0.1	0.0	0.0	0.0
	4:00	13.7	6.3	0.39	5.0	-0.5	9.5	0.0	0.0	0.0	2.4
	5:00	14.9	6.7	0.43	7.4	0.0	7.2	0.0	0.0	0.0	0.0
	6:00	14.7	5.4	0.45	6.0	1.4	0.7	0.2	0.0	0.0	0.0
	7:00	18.7	7.3	0.64	6.6	5.5	1.1	0.0	0.0	0.0	0.0
	8:00	11.8	4.8	0.68	8.9	2.5	0.5	0.0	0.0	0.0	0.0
	9:00	16.2	5.4	0.66	11.7	3.3	0.0	0.0	0.0	0.0	0.0
	10:00	13.9	4.9	0.42	10.9	2.9	0.1	0.0	0.0	0.0	0.0
	11:00	16.2	5.7	0.50	8.7	1.8	-0.3	0.0	0.0	0.0	0.0
	12:00	15.9	5.9	0.39	3.1	-0.4	-0.2	0.0	0.0	0.0	0.0
	13:00	16.5	6.1	0.36	3.6	-0.3	-0.4	0.0	0.0	0.0	0.0
	14:00	19.1	6.9	0.34	1.6	-1.0	-0.7	0.0	0.0	0.0	0.0
	15:00	23.0	5.5	0.33	0.8	-1.5	-0.6	0.0	0.0	0.0	0.0
	16:00	18.7	5.7	0.34	0.8	-1.4	-0.4	0.0	0.0	0.0	0.0
	17:00	17.8	5.6	0.34	0.9	-1.7	-0.3	0.0	0.0	0.0	0.0
	18:00	16.7	5.4	0.34	0.9	-1.6	-0.2	311.4	0.0	0.0	0.0
	19:00	14.2	4.9	0.33	0.5	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	14.8	5.2	0.35	0.4	-1.6	-0.4	0.0	0.0	0.0	0.0
	21:00	11.0	4.1	0.34	0.7	-1.6	-0.4	0.0	0.0	0.0	0.0
	22:00	9.4	3.6	0.39	4.1	-1.4	0.7	318.4	0.0	0.0	0.0
	23:00	11.3	4.1	0.44	6.1	-0.9	1.3	0.0	0.0	0.0	0.0
	0:00	10.0	3.9	0.37	3.2	-1.3	0.6	0.0	0.0	0.0	0.0
Min		6.6	2.5	0.3	0.2	-1.7	-0.7	0.0	0.0	0.0	0.0
Max		23.0	7.3	0.7	11.7	5.5	9.5	318.4	0.0	0.0	2.4
Average		14.6	5.3	0.4	4.1	-0.1	0.9	37.2	0.0	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
27/09/2018	1:00	9.1	4.5	0.34	1.0	-1.5	0.5	0.0	0.0	0.0	0.0
	2:00	8.9	4.3	0.34	1.5	-1.5	0.4	171.9	0.0	0.0	0.0
	3:00	10.1	4.4	0.33	1.1	-1.6	0.2	0.0	0.0	0.0	0.0
	4:00	12.8	5.3	0.34	1.3	-1.6	0.2	0.0	0.0	0.0	0.0
	5:00	13.5	5.9	0.36	2.1	-1.5	0.2	0.0	0.0	0.0	0.0
	6:00	17.6	7.3	0.38	3.3	-1.4	0.4	0.0	0.0	0.0	0.0
	7:00	22.5	9.7	0.49	4.0	-1.1	0.7	68.4	0.0	0.0	0.0
	8:00	28.7	10.9	0.54	5.0	-0.8	0.1	10.8	0.0	0.0	0.0
	9:00	30.3	11.2	0.49	4.6	-1.1	0.5	0.0	0.0	0.0	0.0
	10:00	27.7	10.8	0.43	3.1	-1.0	-0.2	0.0	0.0	0.0	0.0
	11:00	25.2	10.2	0.40	3.1	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	24.0	10.5	0.42	2.9	-1.1	-0.2	0.0	0.0	0.0	0.0
	13:00	24.7	11.0	0.46	3.6	-1.0	-0.1	0.0	0.0	0.0	0.0
	14:00	24.4	9.9	0.46	3.6	-1.1	-0.1	0.0	0.0	0.0	0.0
	15:00	21.9	9.8	0.45	3.7	-1.2	-0.3	0.0	0.0	0.0	0.0
	16:00	19.6	9.6	0.51	5.3	-1.1	-0.3	0.0	0.0	0.0	0.0
	17:00	20.7	9.8	0.59	6.9	-0.9	-0.1	0.0	0.0	0.0	0.7
	18:00	20.8	9.8	0.61	7.8	-1.0	0.1	0.0	0.0	0.0	0.0
	19:00	19.9	9.7	0.55	5.6	-0.9	0.0	312.5	0.0	0.0	0.0
	20:00	21.2	10.2	0.51	5.2	-1.0	0.1	0.0	0.0	0.0	0.0
	21:00	21.4	10.3	0.49	4.8	-1.3	0.5	0.0	0.0	0.0	0.0
	22:00	24.4	10.2	0.44	3.4	-1.2	0.2	2.0	0.0	0.0	0.0
	23:00	18.3	9.8	0.42	2.3	-1.6	0.5	0.0	0.0	0.0	0.0
	0:00	18.4	9.7	0.33	1.6	-1.7	0.4	0.0	0.0	0.0	0.0
Min		8.9	4.3	0.3	1.0	-1.7	-0.3	0.0	0.0	0.0	0.0
Max		30.3	11.2	0.6	7.8	-0.8	0.7	312.5	0.0	0.0	0.7
Average		20.3	8.9	0.4	3.6	-1.2	0.2	23.6	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
28/09/2018	1:00	17.5	9.3	0.33	ZS	-1.7	0.3	14.5	0.0	0.0	0.0
	2:00	17.9	9.1	0.33	0.8	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	17.6	8.9	0.34	0.8	-1.3	0.3	0.0	0.0	0.0	0.0
	4:00	17.8	9.1	0.32	0.6	-1.6	0.1	0.1	0.0	0.0	0.0
	5:00	18.1	8.6	0.33	0.9	-1.8	0.3	0.0	0.0	0.0	0.0
	6:00	21.6	9.0	0.37	2.5	-1.3	0.2	0.0	0.0	0.0	0.0
	7:00	25.6	9.1	0.51	5.3	-1.0	0.6	0.0	0.0	0.0	0.0
	8:00	23.6	8.8	0.58	6.5	-0.6	0.3	0.0	0.0	0.0	0.0
	9:00	22.4	8.6	0.53	5.1	-1.0	0.1	0.0	0.0	0.0	0.0
	10:00	21.4	8.1	0.44	3.5	-1.1	-0.3	0.0	0.0	0.0	0.0
	11:00	19.3	7.6	0.41	2.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	12:00	20.3	7.6	0.40	1.8	-1.4	-0.3	0.0	0.0	0.0	0.0
	13:00	20.2	7.6	0.43	2.4	-1.5	-0.2	0.0	0.0	0.0	0.0
	14:00	21.9	7.8	0.43	2.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	15:00	21.5	7.6	0.45	2.9	-1.1	-0.5	0.0	0.0	0.0	0.0
	16:00	21.0	8.0	0.48	3.5	-1.2	-0.2	0.0	0.0	0.0	0.0
	17:00	20.8	8.0	0.49	4.2	-1.1	-0.3	0.9	0.0	0.1	0.0
	18:00	23.2	8.2	0.54	5.3	-1.1	0.1	0.0	0.0	0.0	0.0
	19:00	20.7	7.9	0.45	3.7	-1.2	0.1	0.0	0.0	0.0	0.0
	20:00	22.2	8.1	0.36	1.2	-1.5	-0.2	0.0	0.0	0.0	0.0
	21:00	21.9	8.2	0.35	1.0	-1.7	-0.1	0.0	0.0	0.0	0.0
	22:00	22.7	8.0	0.36	1.3	-1.5	1.2	0.0	0.0	0.0	0.0
	23:00	19.8	7.7	0.37	1.5	-1.6	0.2	0.0	0.0	0.0	0.0
	0:00	19.7	8.0	0.38	ZS	-1.5	0.0	0.0	0.0	0.0	0.0
Min		17.5	7.6	0.3	0.6	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		25.6	9.3	0.6	6.5	-0.6	1.2	14.5	0.0	0.1	0.0
Average		20.8	8.3	0.4	2.7	-1.3	0.1	0.6	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
29/09/2018	1:00	18.9	7.8	0.36	0.8	ZS	ZS	0.0	0.1	0.0	0.0
	2:00	19.5	7.9	0.29	0.8	-1.6	0.3	0.0	0.1	0.0	0.2
	3:00	19.6	7.8	0.28	0.2	-1.8	0.2	0.0	0.1	0.2	0.2
	4:00	20.9	8.2	0.31	1.6	-1.8	0.2	0.0	0.7	0.0	0.0
	5:00	19.6	7.9	0.30	1.2	-1.6	0.0	0.0	0.0	0.1	0.0
	6:00	19.0	7.5	0.36	3.4	-1.6	0.4	0.1	0.1	0.0	0.1
	7:00	18.1	7.2	0.41	4.9	-1.3	0.3	0.0	0.1	0.0	0.2
	8:00	15.7	6.5	0.41	3.7	-1.2	-0.3	0.0	6.9	0.0	0.3
	9:00	16.0	6.0	0.38	2.9	-1.5	-0.1	0.0	0.1	0.0	0.0
	10:00	17.6	6.3	0.41	3.6	-1.2	-0.1	0.0	0.0	0.0	0.0
	11:00	18.5	6.8	0.42	3.9	-1.4	0.2	0.0	0.0	0.0	0.0
	12:00	16.7	7.1	0.39	2.4	-1.5	0.0	0.0	0.0	0.0	0.0
	13:00	16.9	7.1	0.37	1.8	-1.7	-0.1	0.0	7.3	0.0	0.0
	14:00	17.7	7.6	0.40	2.3	-1.6	-0.1	0.0	0.0	0.0	0.0
	15:00	17.6	7.7	0.41	2.4	-1.4	-0.4	0.0	0.0	0.0	0.0
	16:00	18.5	8.0	0.41	2.9	-1.6	-0.1	0.0	0.0	0.0	0.0
	17:00	17.9	7.8	0.41	3.8	-1.2	-0.1	0.0	0.0	0.0	0.0
	18:00	21.5	8.9	0.41	2.8	-1.3	-0.1	0.0	0.0	0.0	0.0
	19:00	24.6	9.3	0.40	2.0	-1.3	-0.1	0.0	0.0	0.0	0.0
	20:00	21.4	8.7	0.38	2.3	-1.4	-0.1	0.0	0.0	0.0	0.0
	21:00	21.0	8.3	0.35	1.5	-1.6	0.1	0.0	0.0	0.0	0.1
	22:00	18.2	8.3	0.37	1.7	-1.6	0.2	0.0	0.5	0.0	0.0
	23:00	17.7	8.1	0.41	1.8	-1.7	0.3	0.1	0.1	0.0	0.5
	0:00	17.2	7.9	0.36	2.0	-1.4	-0.1	23.5	0.0	0.0	0.0
Min		15.7	6.0	0.3	0.2	-1.8	-0.4	0.0	0.0	0.0	0.0
Max		24.6	9.3	0.4	4.9	-1.2	0.4	23.5	7.3	0.2	0.5
Average		18.8	7.7	0.4	2.4	-1.5	0.0	1.0	0.7	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
30/09/2018	1:00	17.3	8.0	0.36	2.3	-1.3	0.1	0.0	0.0	0.0	0.0
	2:00	16.6	8.0	0.33	1.0	-1.6	0.1	0.0	0.0	0.0	0.0
	3:00	16.8	7.8	0.34	1.1	-1.6	0.1	0.0	0.0	0.0	0.0
	4:00	16.1	7.9	0.34	1.7	-1.6	0.1	0.0	0.0	0.1	0.0
	5:00	17.4	8.0	0.34	1.3	-1.5	0.1	0.0	0.1	0.0	0.0
	6:00	18.7	8.5	0.37	2.0	-1.4	0.2	0.0	0.0	0.0	0.0
	7:00	23.2	9.6	0.41	3.5	-1.1	0.0	0.0	0.0	0.0	0.0
	8:00	22.5	8.9	0.41	3.4	-1.3	0.0	0.0	0.0	0.0	0.0
	9:00	20.0	8.2	0.39	2.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	10:00	18.1	7.7	0.36	1.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	11:00	17.7	7.4	0.35	0.8	-1.6	-0.1	0.0	0.0	0.0	0.0
	12:00	17.0	6.8	0.35	0.9	-1.6	-0.5	0.0	0.0	0.0	0.0
	13:00	15.3	6.6	0.36	1.0	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	16.8	7.0	0.37	1.0	-1.6	0.2	293.6	0.0	0.0	0.0
	15:00	18.2	7.0	0.37	1.2	-1.8	0.0	0.0	0.0	0.0	0.0
	16:00	16.9	6.6	0.38	1.5	-1.5	-0.2	1.2	0.0	0.0	0.0
	17:00	15.7	7.0	0.40	2.1	-1.7	0.1	0.0	0.0	0.0	0.0
	18:00	16.6	6.7	0.44	2.8	-1.4	-0.2	0.0	0.0	0.0	0.0
	19:00	16.1	7.1	0.54	4.7	-1.1	0.1	0.0	0.0	0.0	0.0
	20:00	15.6	6.7	0.55	4.3	-1.0	0.2	0.0	0.0	0.0	0.0
	21:00	14.0	6.4	0.61	2.6	-0.8	0.2	0.0	9.2	0.0	0.0
	22:00	16.1	7.5	0.64	2.7	-0.7	0.2	0.1	0.7	0.0	0.0
	23:00	14.4	6.5	0.83	2.8	-0.1	-0.1	0.1	1.6	0.0	0.4
	0:00	19.7	8.3	0.87	ZS	1.0	-0.5	0.3	2.0	0.0	0.7
Min		14.0	6.4	0.3	0.8	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		23.2	9.6	0.9	4.7	1.0	0.2	293.6	9.2	0.1	0.7
Average		17.4	7.5	0.4	2.1	-1.2	0.0	12.3	0.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
01/10/2018	1:00	17.7	6.4	0.84	2.6	ZS	ZS	0.1	1.0	11.1	0.6
	2:00	14.7	6.0	0.40	0.4	-1.0	0.0	0.0	0.0	0.0	0.0
	3:00	12.7	5.8	0.31	0.5	-1.3	0.4	0.0	0.0	0.0	0.0
	4:00	12.8	6.1	0.30	1.4	-1.2	0.4	0.0	0.0	0.0	0.0
	5:00	12.8	6.0	0.31	1.6	-1.3	0.5	0.0	0.0	0.0	0.0
	6:00	13.4	6.0	0.40	5.0	-1.1	0.5	10.8	0.0	0.0	0.0
	7:00	15.8	6.8	0.54	7.7	-0.6	0.2	0.0	0.0	0.0	0.0
	8:00	15.0	6.2	0.57	7.3	-0.6	0.0	0.0	0.0	0.0	0.0
	9:00	15.7	6.2	0.47	5.1	-0.9	-0.4	0.0	0.0	0.0	0.0
	10:00	16.1	5.9	0.33	1.4	-1.4	-0.2	0.0	0.0	0.0	0.0
	11:00	14.4	5.8	0.33	1.2	-1.4	-0.6	0.0	0.0	0.0	0.0
	12:00	12.9	5.7	0.33	0.9	-1.6	-0.3	0.0	0.0	0.0	0.0
	13:00	12.3	5.6	0.35	1.4	-1.6	-0.2	0.0	0.0	0.0	0.0
	14:00	14.1	5.6	0.36	1.5	-1.4	0.3	0.0	0.0	0.0	0.0
	15:00	13.5	5.6	0.39	2.1	-1.5	-0.3	0.0	0.0	0.0	0.0
	16:00	13.0	5.5	0.41	2.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	13.4	5.6	0.39	2.2	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	14.0	5.6	0.42	3.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	12.7	5.6	0.36	1.4	-1.6	-0.3	0.0	0.0	0.0	0.0
	20:00	11.8	5.4	0.32	0.3	-1.8	0.0	0.0	0.0	0.0	0.0
	21:00	12.3	5.1	0.33	0.6	-1.7	-0.4	0.0	0.0	0.0	0.0
	22:00	11.9	5.0	0.34	0.9	-1.7	-0.5	0.0	0.0	0.0	0.0
	23:00	11.8	5.1	0.34	0.7	-1.9	0.0	0.0	0.0	0.0	0.0
	0:00	10.3	5.0	0.34	0.4	-1.8	0.0	38.4	0.0	0.0	0.0
Min		10.3	5.0	0.3	0.3	-1.9	-0.6	0.0	0.0	0.0	0.0
Max		17.7	6.8	0.8	7.7	-0.6	0.5	38.4	1.0	11.1	0.6
Average		13.5	5.7	0.4	2.2	-1.4	-0.1	2.1	0.0	0.5	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
02/10/2018	1:00	9.8	4.8	0.32	ZS	-1.6	-0.3	0.0	0.0	0.0	0.0
	2:00	10.7	5.2	0.33	0.7	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	10.3	4.9	0.34	1.3	-1.5	0.6	0.0	0.1	0.0	0.0
	4:00	10.0	4.8	0.34	1.6	-1.7	0.5	0.0	0.0	0.0	0.0
	5:00	12.1	5.8	0.39	4.6	-1.4	1.3	0.0	0.0	0.0	0.0
	6:00	20.6	9.7	0.57	9.1	-0.4	3.9	0.0	0.0	0.0	0.0
	7:00	20.0	8.0	0.74	9.2	0.3	3.0	0.0	0.0	0.0	0.0
	8:00	20.5	7.1	0.59	7.0	-0.5	0.3	0.0	0.0	0.0	0.0
	9:00	22.5	6.3	0.42	2.7	-1.3	-0.2	0.0	0.0	0.0	0.0
	10:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	11:00	13.8	5.6	0.59	0.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	12:00	15.7	5.8	0.55	NT	-1.2	-0.3	0.0	0.0	0.0	0.0
	13:00	15.4	5.3	0.50	NT	-0.8	-0.1	0.0	0.0	0.0	0.0
	14:00	21.9	5.7	0.48	0.6	NT	NT	0.0	0.0	0.0	0.0
	15:00	18.6	6.3	0.47	0.4	NT	NT	0.0	0.0	0.0	0.0
	16:00	21.9	6.7	NT	0.3	-1.2	0.0	0.0	0.0	0.0	0.0
	17:00	NT	NT	0.44	0.8	-1.3	0.0	0.0	0.0	0.0	0.0
	18:00	20.8	6.6	0.42	0.5	-1.3	0.0	0.0	0.0	0.0	0.0
	19:00	17.8	6.4	0.42	0.6	-1.3	0.0	0.0	0.0	0.0	0.0
	20:00	18.7	6.8	0.45	1.7	-1.3	0.2	0.0	0.0	0.0	0.0
	21:00	20.9	7.5	0.44	1.4	-1.2	0.3	7.0	0.0	0.0	0.0
	22:00	17.7	6.9	0.40	0.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	23:00	18.3	6.7	0.39	0.1	-1.4	0.2	0.0	0.0	0.0	0.0
	0:00	17.0	6.9	0.38	ZS	-1.3	0.1	250.7	0.0	0.0	0.0
Min		9.8	4.8	0.3	0.1	-1.7	-0.4	0.0	0.0	0.0	0.0
Max		22.5	9.7	0.7	9.2	0.3	3.9	250.7	0.1	0.0	0.0
Average		17.0	6.3	0.5	2.3	-1.2	0.4	10.7	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
03/10/2018	1:00	17.4	7.2	0.38	0.3	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	17.4	7.0	0.27	-0.2	-1.2	0.4	0.0	0.0	0.0	0.0
	3:00	17.3	6.9	0.28	0.1	-1.4	0.3	0.0	0.0	0.0	0.0
	4:00	16.2	7.0	0.30	1.0	-1.6	0.5	245.6	0.0	0.0	0.0
	5:00	16.0	7.0	0.30	1.5	-1.3	0.3	0.0	0.0	0.0	0.0
	6:00	17.4	7.7	0.35	3.2	-1.4	0.7	0.0	0.0	0.0	0.0
	7:00	21.9	8.5	0.46	4.9	-1.1	0.3	0.0	0.0	0.0	0.0
	8:00	23.7	8.8	0.54	5.7	-0.7	0.2	0.9	0.0	0.0	0.0
	9:00	24.1	8.9	0.53	4.8	-0.7	0.0	48.7	44.6	31.6	137.1
	10:00	23.3	8.7	0.45	4.3	-0.9	0.0	22.8	14.6	15.2	53.0
	11:00	21.2	9.1	0.39	3.2	-1.1	0.1	5.2	4.6	4.6	15.8
	12:00	18.9	8.3	0.35	1.6	-1.3	-0.2	0.9	0.8	0.8	2.9
	13:00	20.1	8.1	0.37	2.1	-1.4	0.1	0.0	0.0	0.0	0.0
	14:00	21.1	8.3	0.37	2.6	-1.2	-0.1	0.0	0.0	0.0	0.0
	15:00	21.3	8.7	0.39	2.7	-1.1	0.1	0.0	0.0	0.0	0.0
	16:00	23.2	10.1	0.46	4.3	-0.8	0.1	0.0	0.0	0.0	0.0
	17:00	21.7	11.0	0.51	6.3	-0.5	-0.1	0.0	0.0	0.0	0.0
	18:00	19.8	9.1	0.55	8.5	-0.8	0.4	0.0	0.0	0.0	0.0
	19:00	19.0	9.1	0.52	8.1	-0.8	0.4	0.0	0.0	0.0	0.0
	20:00	20.5	9.1	0.48	7.6	-0.6	0.5	0.0	0.0	0.0	0.0
	21:00	18.0	8.7	0.42	4.5	-0.8	0.4	0.0	0.0	0.0	0.0
	22:00	17.9	8.6	0.35	2.5	-1.1	0.4	0.0	0.0	0.0	0.0
	23:00	18.5	8.8	0.33	1.8	-1.3	0.4	0.0	0.0	0.0	0.0
	0:00	18.8	8.9	0.31	0.7	-1.4	0.4	0.0	0.0	0.0	0.0
Min		16.0	6.9	0.3	-0.2	-1.6	-0.2	0.0	0.0	0.0	0.0
Max		24.1	11.0	0.5	8.5	-0.5	0.7	245.6	44.6	31.6	137.1
Average		19.8	8.5	0.4	3.4	-1.0	0.2	13.5	2.7	2.2	8.7

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
15/10/2018	1:00	18.7	8.5	0.46	0.7	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	14.3	7.3	0.44	0.4	-0.7	0.2	0.0	0.0	0.0	0.0
	3:00	13.3	5.6	0.36	-0.2	-1.0	0.4	0.0	0.0	0.0	0.0
	4:00	11.9	5.6	0.35	0.6	-1.2	0.2	0.0	0.0	0.0	0.0
	5:00	20.2	10.8	0.41	1.4	-0.9	0.4	0.0	0.0	0.0	0.0
	6:00	21.5	9.7	0.41	2.3	-0.7	0.5	0.0	0.0	0.0	0.0
	7:00	19.8	8.3	0.36	0.7	-0.6	0.0	0.0	0.0	0.0	0.0
	8:00	22.7	11.6	0.41	0.6	-0.7	0.1	0.0	0.0	0.0	0.0
	9:00	19.7	8.2	0.40	0.9	-0.6	-0.1	0.0	0.0	0.0	0.0
	10:00	16.5	5.0	0.36	-0.5	-0.9	-0.1	0.0	0.0	0.0	0.0
	11:00	9.8	2.3	0.30	-0.3	-1.1	-0.2	0.0	0.0	0.0	0.0
	12:00	7.5	2.5	0.32	-0.7	-1.1	-0.4	0.0	0.0	0.0	0.0
	13:00	11.8	3.9	0.33	-0.6	-0.9	-0.4	0.0	0.0	0.0	0.0
	14:00	12.4	3.6	0.33	-0.8	-0.9	-0.4	0.0	0.0	0.0	0.0
	15:00	12.1	3.2	0.33	-0.7	-1.2	-0.2	0.0	0.0	0.0	0.0
	16:00	9.7	2.3	0.32	-1.2	-1.0	-0.4	0.0	0.0	0.0	0.0
	17:00	10.6	2.4	0.33	-1.3	-1.0	-0.5	0.0	0.0	0.0	0.0
	18:00	11.9	4.3	0.38	-0.4	-1.3	0.0	0.0	0.0	0.0	0.0
	19:00	12.9	6.0	0.41	0.1	-1.2	0.0	0.0	0.0	0.0	0.0
	20:00	14.9	7.6	0.42	0.2	-1.0	0.2	0.0	0.0	0.0	0.0
	21:00	15.0	6.7	0.41	0.6	-1.1	0.0	0.0	0.0	0.0	0.0
	22:00	17.3	6.2	0.41	1.5	-1.0	0.2	0.0	0.0	0.0	0.0
	23:00	11.4	3.9	0.40	0.5	-1.1	0.7	0.0	0.0	0.0	0.0
	0:00	9.8	3.1	0.35	-0.1	-1.1	0.6	0.0	0.0	0.0	0.0
Min		7.5	2.3	0.3	-1.3	-1.3	-0.5	0.0	0.0	0.0	0.0
Max		22.7	11.6	0.5	2.3	-0.6	0.7	0.0	0.0	0.0	0.0
Average		14.4	5.8	0.4	0.2	-1.0	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
16/10/2018	1:00	14.9	7.7	0.45	ZS	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	17.0	8.0	0.46	-0.9	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	20.2	11.4	0.51	-1.1	-0.6	1.7	0.0	0.0	0.0	0.0
	4:00	18.1	8.2	0.45	-1.0	-0.9	1.1	0.0	0.0	0.0	0.0
	5:00	24.4	11.1	0.53	-1.3	-0.6	1.0	0.0	0.0	0.0	0.0
	6:00	26.4	10.6	0.54	-0.8	-0.3	1.0	0.0	0.0	0.0	0.0
	7:00	20.3	8.7	0.46	-1.2	-0.6	1.7	0.0	0.0	0.0	0.0
	8:00	18.8	3.8	0.43	-3.3	-0.6	0.1	0.0	0.0	0.0	0.0
	9:00	14.8	2.9	0.40	-2.8	-0.9	-0.2	0.0	0.0	0.0	0.0
	10:00	12.8	2.6	0.36	-3.1	-0.9	-0.4	0.0	0.0	0.0	0.0
	11:00	9.6	2.2	0.35	-3.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	12:00	11.4	2.4	0.33	-3.2	-1.2	-0.3	0.0	0.0	0.0	0.0
	13:00	12.8	4.5	0.34	-3.0	-1.2	-0.4	0.0	0.0	0.0	0.0
	14:00	14.3	4.5	0.35	-3.0	-1.1	-0.2	0.0	0.0	0.0	0.0
	15:00	14.0	3.2	0.34	-3.1	-1.0	-0.5	0.0	0.0	0.0	0.0
	16:00	22.7	5.1	0.35	-3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	17:00	11.4	3.1	0.36	-3.5	-1.3	-0.3	0.0	0.0	0.0	0.0
	18:00	11.6	3.3	0.37	-3.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	19:00	8.5	2.8	0.37	-3.0	-1.2	-0.5	0.0	0.0	0.0	0.0
	20:00	7.5	2.6	0.36	-3.5	-1.4	-0.2	0.0	0.0	0.0	0.0
	21:00	7.2	2.4	0.36	-3.3	-1.3	0.0	0.0	0.0	0.0	0.0
	22:00	7.4	2.3	0.35	-3.5	-1.2	-0.4	0.0	0.0	0.0	0.0
	23:00	7.1	2.5	0.35	-3.2	-1.5	-0.3	0.0	0.0	0.0	0.0
	0:00	8.9	3.0	0.35	ZS	ZS	ZS	0.0	0.0	0.0	0.0
Min		7.1	2.2	0.3	-3.6	-1.5	-0.5	0.0	0.0	0.0	0.0
Max		26.4	11.4	0.5	-0.8	-0.3	1.7	0.0	0.0	0.0	0.0
Average		14.3	4.9	0.4	-2.6	-1.0	0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
17/10/2018	1:00	10.3	3.4	0.34	-2.6	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	9.2	3.9	0.35	-2.8	-1.1	0.1	0.0	0.0	0.0	0.0
	3:00	12.3	5.0	0.40	-2.2	-1.1	0.5	0.0	0.0	0.0	0.0
	4:00	12.8	4.8	0.36	-3.0	-1.1	0.4	0.0	0.0	0.0	0.0
	5:00	23.1	5.5	0.36	-1.2	-1.4	0.6	0.0	0.0	0.0	0.0
	6:00	33.4	6.9	0.42	-0.1	-1.0	0.2	0.0	0.0	0.0	0.0
	7:00	15.2	6.4	0.42	-1.9	-1.0	0.5	0.0	0.0	0.0	0.0
	8:00	29.7	7.2	0.44	-1.9	-0.8	-0.2	0.0	0.0	0.0	0.0
	9:00	40.1	6.8	0.42	-2.6	-1.1	0.0	0.0	0.0	0.0	0.0
	10:00	54.9	6.7	0.36	-3.5	-1.0	-0.1	0.0	0.0	0.0	0.0
	11:00	89.7	9.1	0.36	-3.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	12:00	48.3	8.0	0.37	-3.4	-1.0	-0.2	0.0	0.0	0.0	0.0
	13:00	43.7	8.4	0.38	-2.5	-0.9	-0.5	0.0	0.0	0.0	0.0
	14:00	54.6	6.7	0.37	-3.1	-1.2	0.0	0.0	0.0	0.0	0.0
	15:00	28.2	6.2	0.38	-3.2	-1.1	-0.2	0.0	0.0	0.0	0.0
	16:00	41.1	6.1	0.37	-3.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	17:00	17.8	4.2	0.37	-3.2	-1.2	-0.4	0.0	0.0	0.0	0.0
	18:00	14.6	4.2	0.38	-2.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	15.0	5.1	0.39	-3.6	-1.5	0.0	0.0	0.0	0.0	0.0
	20:00	16.0	5.1	0.39	-3.2	-1.4	-0.3	0.0	0.0	0.0	0.0
	21:00	16.4	5.0	0.38	-3.1	-1.2	-0.3	0.0	0.0	0.0	0.0
	22:00	13.8	5.1	0.37	-3.0	-1.5	-0.1	0.0	0.0	0.0	0.0
	23:00	14.3	5.0	0.37	-3.3	-1.7	0.1	0.0	0.0	0.0	0.0
	0:00	14.1	5.1	0.37	-3.2	-1.3	-0.2	0.0	0.0	0.0	0.0
Min		9.2	3.4	0.3	-3.6	-1.7	-0.5	0.0	0.0	0.0	0.0
Max		89.7	9.1	0.4	-0.1	-0.8	0.6	0.0	0.0	0.0	0.0
Average		27.9	5.8	0.4	-2.8	-1.2	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
18/10/2018	1:00	13.2	5.4	0.37	-3.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	2:00	15.3	5.8	0.41	-2.2	-1.0	0.0	0.0	0.0	0.0	0.0
	3:00	12.7	5.6	0.38	-3.2	-1.6	0.2	0.0	0.0	0.0	0.0
	4:00	13.8	5.8	0.37	-3.1	-1.5	-0.1	0.0	0.0	0.0	0.0
	5:00	14.4	5.7	0.37	-3.2	-1.5	0.0	0.0	0.0	0.0	0.0
	6:00	28.6	7.0	0.42	-1.5	-1.2	-0.1	0.0	0.0	0.0	0.0
	7:00	32.3	7.4	0.44	-2.5	-1.3	0.1	0.0	0.0	0.0	0.0
	8:00	39.3	7.4	0.44	-3.0	-1.4	0.0	0.0	0.0	0.0	0.0
	9:00	49.7	7.7	0.44	-2.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	10:00	57.0	8.4	0.42	-3.5	-1.0	-0.4	0.0	0.0	0.0	0.0
	11:00	PO	PO	0.46	PO	PO	PO	PO	PO	PO	PO
	12:00	110.7	12.3	1.04	-3.3	-1.4	-0.1	0.0	0.0	0.0	0.0
	13:00	73.2	10.4	1.05	-3.3	-1.2	-0.5	0.0	0.0	0.0	0.0
	14:00	45.7	7.8	0.80	-3.3	-1.2	-0.2	0.0	0.0	0.0	0.0
	15:00	28.5	6.7	0.58	-3.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	16:00	22.8	6.3	0.45	-3.6	-1.5	0.0	0.0	0.0	0.0	0.0
	17:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	18:00	14.7	5.9	0.56	-3.4	-1.1	-0.5	0.0	0.0	0.0	0.0
	19:00	14.4	5.0	0.54	-3.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	20:00	13.1	4.8	0.49	-3.3	-1.3	-0.4	0.0	0.0	0.0	0.0
	21:00	13.9	5.1	0.50	-3.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	22:00	15.3	4.5	0.47	-3.6	-1.5	-0.1	0.0	0.0	0.0	0.0
	23:00	17.0	4.4	ZS	-2.8	-1.4	-0.2	0.0	0.0	0.0	0.0
	0:00	17.2	4.3	ZS	-2.3	-1.4	-0.2	0.0	0.0	0.0	0.0
Min		12.7	4.3	0.4	-3.6	-1.6	-0.5	0.0	0.0	0.0	0.0
Max		110.7	12.3	1.0	-1.5	-1.0	0.2	0.0	0.0	0.0	0.0
Average		30.1	6.5	0.5	-3.1	-1.3	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
19/10/2018	1:00	18.5	4.6	0.45	ZS	-1.5	0.1	0.0	0.0	0.0	0.0
	2:00	11.6	4.6	0.45	-2.1	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	12.9	5.1	0.48	-2.5	-1.1	0.4	0.0	0.0	0.0	0.0
	4:00	14.0	5.5	0.48	-2.3	-1.1	0.3	0.0	0.0	0.0	0.0
	5:00	15.3	5.7	0.43	-2.9	-1.7	0.1	0.0	0.0	0.0	0.0
	6:00	19.7	6.6	0.46	-2.3	-1.6	0.1	0.0	0.0	0.0	0.0
	7:00	21.0	6.7	0.46	-3.1	-1.6	0.2	0.0	0.0	0.0	0.0
	8:00	37.8	7.6	0.47	-2.8	-1.6	-0.3	0.0	0.0	0.0	0.0
	9:00	34.2	7.9	0.47	-3.5	-1.5	-0.2	0.0	0.0	0.0	0.0
	10:00	46.9	8.6	0.44	-3.8	-1.7	0.0	0.0	0.0	0.0	0.0
	11:00	35.2	12.0	0.50	-2.5	-1.4	-0.2	0.0	0.0	0.0	0.0
	12:00	26.4	10.6	0.49	-3.2	-1.0	-0.3	0.0	0.0	0.0	0.0
	13:00	24.6	9.8	0.42	-3.0	-1.4	0.1	0.0	0.3	0.0	0.0
	14:00	19.1	8.5	0.44	-1.6	-1.2	-0.3	0.0	0.3	0.0	0.0
	15:00	23.6	10.7	0.47	-0.9	-1.1	-0.1	0.0	0.0	0.0	0.0
	16:00	19.6	8.9	0.38	-2.9	-1.4	0.1	0.0	0.9	0.0	0.0
	17:00	20.2	8.9	0.40	-2.3	-1.3	-0.2	0.0	1.8	0.0	0.0
	18:00	20.5	8.9	0.43	-1.2	-1.1	-0.2	0.0	1.9	0.0	0.0
	19:00	18.1	7.7	0.42	-2.0	-1.4	0.0	0.0	1.5	0.0	0.0
	20:00	17.4	7.1	0.37	-2.6	-1.3	-0.2	0.0	2.3	0.0	0.0
	21:00	17.6	7.3	0.36	-2.6	-1.5	0.1	0.0	1.8	0.0	0.0
	22:00	16.5	7.1	0.34	-2.5	-1.4	-0.1	0.0	2.0	0.0	0.0
	23:00	16.5	7.1	0.35	-1.9	-1.3	-0.4	0.0	0.6	0.0	0.0
	0:00	16.6	7.0	0.35	ZS	-1.6	0.0	0.0	1.7	0.0	0.0
Min		11.6	4.6	0.3	-3.8	-1.7	-0.4	0.0	0.0	0.0	0.0
Max		46.9	12.0	0.5	-0.9	-1.0	0.4	0.0	2.3	0.0	0.0
Average		21.8	7.7	0.4	-2.5	-1.4	-0.1	0.0	0.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
20/10/2018	1:00	16.4	6.9	0.36	-1.2	ZS	ZS	0.0	1.6	0.0	0.0
	2:00	16.5	7.0	0.35	-1.0	-1.3	0.0	0.0	1.5	0.0	0.0
	3:00	15.7	6.6	0.35	-0.7	-1.4	0.5	0.0	1.9	0.0	0.0
	4:00	16.2	6.7	0.34	0.1	-1.6	0.9	0.0	2.4	0.0	0.0
	5:00	17.2	6.5	0.34	0.5	-1.4	0.6	0.0	1.4	0.0	0.0
	6:00	19.8	6.7	0.35	0.5	-1.3	0.5	0.0	2.1	0.0	0.0
	7:00	20.0	7.4	0.39	-0.8	-1.2	0.1	0.0	2.2	0.0	0.0
	8:00	18.4	6.9	0.37	-2.0	-1.2	0.1	0.0	1.7	0.0	0.0
	9:00	19.0	7.2	0.38	-1.7	-1.2	0.1	0.0	1.1	0.0	0.0
	10:00	18.3	6.6	0.36	-2.8	-1.1	-0.2	0.0	1.4	0.0	0.0
	11:00	17.1	6.1	0.34	-3.2	-1.3	0.0	0.0	0.6	0.0	0.0
	12:00	14.7	6.3	0.34	-2.6	-1.1	-0.4	0.0	0.8	0.0	0.0
	13:00	21.7	8.3	0.37	-3.0	-1.1	-0.2	0.0	1.5	0.0	0.0
	14:00	18.7	8.0	0.35	-2.9	-1.0	-0.3	0.0	1.7	0.0	0.0
	15:00	18.3	8.5	0.36	-2.5	-1.2	0.1	0.0	0.8	0.0	0.0
	16:00	14.3	5.7	0.36	-2.0	-1.4	-0.2	0.0	1.1	0.0	0.0
	17:00	19.5	7.3	0.38	-1.1	-1.3	-0.3	0.0	1.5	0.0	0.0
	18:00	30.1	16.9	0.48	-0.3	-1.1	0.0	0.0	2.0	0.0	0.0
	19:00	47.7	28.2	0.53	1.2	-1.0	0.3	0.0	1.9	0.0	0.0
	20:00	33.9	18.4	0.50	0.7	-1.0	0.5	0.0	1.7	0.0	0.0
	21:00	38.7	19.6	0.51	0.9	-0.8	1.1	0.0	1.4	0.0	0.0
	22:00	25.7	13.1	0.49	-0.4	-0.8	0.5	0.0	1.9	0.0	0.0
	23:00	23.5	10.8	0.47	0.0	-0.9	0.2	0.0	1.9	0.0	0.0
	0:00	23.7	11.0	0.45	0.4	-0.7	0.4	0.0	1.4	0.0	0.0
Min		14.3	5.7	0.3	-3.2	-1.6	-0.4	0.0	0.6	0.0	0.0
Max		47.7	28.2	0.5	1.2	-0.7	1.1	0.0	2.4	0.0	0.0
Average		21.9	9.8	0.4	-1.0	-1.1	0.2	0.0	1.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
21/10/2018	1:00	24.1	9.3	0.43	-0.1	-0.9	1.2	0.0	1.1	0.0	0.0
	2:00	24.5	9.1	0.42	0.0	-0.8	1.0	0.0	1.5	0.0	0.0
	3:00	22.0	9.0	0.39	-0.1	-1.0	1.2	0.0	1.9	0.0	0.0
	4:00	23.4	8.8	0.44	-0.3	-1.0	0.9	0.0	1.4	0.0	0.0
	5:00	23.4	10.8	0.61	0.3	-0.9	0.9	0.0	1.9	0.0	0.0
	6:00	22.9	11.7	0.67	0.1	-0.6	0.8	0.0	1.1	0.0	0.0
	7:00	19.8	9.2	0.56	-1.2	-0.7	0.6	0.0	1.1	0.0	0.0
	8:00	19.8	9.0	0.48	-1.4	-0.8	0.5	0.0	1.7	0.0	0.0
	9:00	21.1	7.6	0.37	-3.3	-1.1	0.2	0.0	1.4	0.0	0.0
	10:00	20.4	7.8	0.36	-3.1	-1.2	0.2	0.0	1.6	0.0	0.0
	11:00	20.1	8.6	0.37	-3.5	-1.1	0.1	0.0	1.1	0.0	0.0
	12:00	20.2	8.4	0.37	-3.4	-1.0	-0.1	0.0	0.5	0.0	0.0
	13:00	20.2	8.4	0.36	-3.4	-1.1	-0.3	0.0	0.2	0.0	0.0
	14:00	20.2	8.5	0.36	-3.4	-1.1	-0.3	0.0	1.4	0.0	0.0
	15:00	19.0	8.1	0.34	-3.6	-1.2	-0.1	0.0	0.6	0.0	0.0
	16:00	18.0	7.4	0.34	-3.8	-1.2	-0.5	0.0	0.3	0.0	0.0
	17:00	16.9	7.0	0.35	-3.6	-1.1	-0.3	0.0	0.0	0.0	0.0
	18:00	20.1	7.5	0.35	-3.0	-1.3	-0.4	0.0	0.0	0.0	0.0
	19:00	18.8	7.9	0.37	-3.7	-1.3	-0.3	0.0	0.0	0.0	1.8
	20:00	19.2	8.1	0.36	-3.5	-1.5	-0.1	0.0	0.0	0.0	5.6
	21:00	19.3	7.5	0.35	-2.8	-1.4	-0.1	0.0	2.1	0.0	0.0
	22:00	17.1	7.3	0.34	-3.3	-1.5	-0.2	0.0	3.1	0.0	0.0
	23:00	16.6	7.5	0.34	-3.3	-1.6	0.0	0.0	3.0	0.0	0.0
	0:00	16.8	7.3	0.33	ZS	-1.6	-0.2	0.0	3.2	0.0	0.0
Min		16.6	7.0	0.3	-3.8	-1.6	-0.5	0.0	0.0	0.0	0.0
Max		24.5	11.7	0.7	0.3	-0.6	1.2	0.0	3.2	0.0	5.6
Average		20.2	8.4	0.4	-2.3	-1.1	0.2	0.0	1.3	0.0	0.3

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
22/10/2018	1:00	15.9	7.0	0.33	-0.7	ZS	ZS	0.0	3.2	0.0	0.0
	2:00	14.8	6.5	0.33	-0.7	-1.2	0.2	0.0	3.3	0.0	0.0
	3:00	17.3	6.9	0.34	0.0	-1.3	-0.2	0.0	3.1	0.0	0.0
	4:00	15.2	6.4	0.33	-0.5	-1.3	-0.1	0.0	3.3	0.0	0.0
	5:00	16.1	6.2	0.33	-0.5	-1.4	0.0	0.0	3.2	0.0	0.0
	6:00	16.0	6.6	0.35	-0.2	-1.4	-0.2	0.0	3.3	0.0	0.0
	7:00	16.2	6.2	0.36	-0.7	-1.3	-0.2	0.0	3.4	0.0	0.0
	8:00	19.8	6.4	0.39	-0.7	-1.2	-0.4	0.0	3.4	0.0	0.0
	9:00	14.4	6.1	0.45	-0.4	-1.0	-0.2	0.0	3.5	0.0	0.0
	10:00	14.9	6.3	0.37	-0.7	-1.3	0.1	0.0	3.4	0.0	0.0
	11:00	16.5	6.4	0.36	-0.7	-1.1	-0.3	0.0	3.6	0.0	0.0
	12:00	15.0	6.1	0.36	-1.0	-1.3	-0.1	0.0	3.7	0.0	0.0
	13:00	15.3	6.0	0.37	-0.7	-1.2	0.0	0.0	3.9	0.0	0.0
	14:00	15.4	5.9	0.36	-0.6	-1.3	0.0	0.0	3.8	0.0	0.0
	15:00	15.6	5.7	0.36	-0.8	-1.3	-0.4	0.0	4.0	0.0	0.0
	16:00	15.3	5.9	0.36	-1.2	-1.3	-0.4	0.0	4.0	0.0	0.0
	17:00	15.6	5.6	0.36	-0.2	-1.4	-0.4	0.0	4.1	0.0	0.0
	18:00	14.6	5.3	0.37	-0.3	-1.3	-0.4	0.0	4.2	0.0	0.0
	19:00	16.7	5.9	0.42	1.3	-1.1	-0.2	0.0	4.3	0.0	0.0
	20:00	32.6	16.2	0.47	2.2	-0.9	0.1	0.0	4.2	0.0	0.0
	21:00	14.1	5.3	0.40	-0.2	-1.1	0.1	0.0	4.5	0.0	0.0
	22:00	11.8	5.1	0.35	-0.1	-1.1	-0.1	0.0	4.5	0.0	0.0
	23:00	12.6	5.5	0.35	-0.4	-1.4	0.0	0.0	4.8	0.0	0.0
	0:00	11.4	5.0	0.34	-0.4	-1.3	0.1	0.0	4.5	0.0	0.5
Min		11.4	5.0	0.3	-1.2	-1.4	-0.4	0.0	3.1	0.0	0.0
Max		32.6	16.2	0.5	2.2	-0.9	0.2	0.0	4.8	0.0	0.5
Average		16.0	6.4	0.4	-0.3	-1.2	-0.1	0.0	3.8	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
23/10/2018	1:00	10.6	4.7	0.34	ZS	-1.4	-0.1	0.0	4.6	0.0	2.3
	2:00	11.3	4.7	0.34	-1.9	ZS	ZS	0.0	4.7	0.0	4.2
	3:00	12.3	4.7	0.34	-1.7	-1.0	-0.1	0.0	4.7	0.0	2.3
	4:00	11.5	4.7	0.34	-1.3	-1.5	0.2	0.0	4.7	0.0	1.7
	5:00	14.4	5.7	0.38	1.4	-1.2	0.4	0.0	4.8	0.0	1.1
	6:00	14.7	5.9	0.42	1.8	-1.1	0.8	0.0	4.8	0.0	0.5
	7:00	14.3	5.2	0.39	-1.0	-1.3	0.6	0.0	4.9	0.0	1.7
	8:00	16.8	5.1	0.36	-2.9	-1.1	-0.4	0.0	4.8	0.0	0.6
	9:00	19.6	5.2	0.38	-2.9	-1.1	-0.5	0.0	4.8	0.0	0.0
	10:00	19.9	5.4	0.37	-2.3	-1.3	-0.2	0.0	4.6	0.0	1.7
	11:00	20.3	5.6	0.36	-2.8	-1.3	-0.3	0.0	4.4	0.0	0.6
	12:00	17.6	6.4	0.37	-2.3	-1.1	-0.4	0.0	4.5	0.0	0.0
	13:00	16.4	5.8	0.36	-2.2	-1.3	-0.3	0.0	4.4	0.0	0.0
	14:00	16.6	5.3	0.36	-2.6	-1.3	-0.3	0.0	4.5	0.0	0.0
	15:00	14.1	5.2	0.34	-2.3	-1.6	-0.2	0.0	4.7	0.0	0.0
	16:00	13.0	4.9	0.36	-2.6	-1.3	-0.4	0.0	4.3	0.0	0.0
	17:00	13.0	4.5	0.36	-2.5	-1.3	-0.4	0.0	4.8	0.0	0.0
	18:00	13.9	4.7	0.37	-2.8	-1.4	-0.3	0.0	4.8	0.0	0.0
	19:00	12.2	4.9	0.39	-2.2	-1.3	-0.2	0.0	4.9	0.0	0.0
	20:00	12.2	4.9	0.43	-2.3	-1.1	-0.2	0.0	5.0	0.0	0.0
	21:00	12.1	4.9	0.39	-1.8	-1.5	0.1	0.0	5.0	0.0	0.0
	22:00	11.4	4.8	0.37	-2.6	-1.4	-0.1	0.0	5.0	0.0	0.0
	23:00	12.0	4.8	0.39	-2.3	-1.5	-0.3	0.0	5.1	0.0	0.0
	0:00	12.1	5.2	0.39	ZS	-1.6	-0.1	0.0	5.1	0.0	0.0
Min		10.6	4.5	0.3	-2.9	-1.6	-0.5	0.0	4.3	0.0	0.0
Max		20.3	6.4	0.4	1.8	-1.0	0.8	0.0	5.1	0.0	4.2
Average		14.3	5.1	0.4	-1.9	-1.3	-0.1	0.0	4.7	0.0	0.7

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
24/10/2018	1:00	11.4	4.8	0.36	-2.1	ZS	ZS	0.0	5.2	0.0	0.0
	2:00	11.5	4.9	0.35	-2.2	-1.2	0.0	0.0	5.3	0.0	0.0
	3:00	12.4	4.8	0.35	-2.0	-1.5	-0.2	0.0	5.2	0.0	0.0
	4:00	12.2	4.9	0.35	-1.7	-1.5	-0.1	0.0	5.1	0.0	0.0
	5:00	13.3	4.9	0.35	-1.9	-1.4	0.0	0.0	5.1	0.0	0.0
	6:00	17.4	6.2	0.41	0.6	-1.2	0.4	0.0	5.1	0.0	0.0
	7:00	18.2	6.1	0.45	-1.2	-0.9	0.3	0.0	4.9	0.0	0.0
	8:00	22.0	5.2	0.39	-2.1	-1.0	-0.3	0.0	4.9	0.0	0.0
	9:00	24.3	5.3	0.38	-2.8	-1.2	-0.3	0.0	5.1	0.0	0.0
	10:00	21.3	5.5	0.38	-2.5	-1.1	-0.3	0.0	5.0	0.0	0.0
	11:00	35.1	6.5	0.38	-2.4	-1.2	-0.2	0.0	5.1	0.0	0.0
	12:00	22.4	6.4	0.37	-2.8	-1.2	-0.3	0.0	4.9	0.0	0.0
	13:00	20.3	6.2	0.39	-2.9	-1.1	-0.1	0.0	5.1	0.0	0.0
	14:00	21.4	6.2	0.37	-2.7	-1.1	-0.1	0.0	5.3	0.0	0.0
	15:00	17.2	5.5	0.36	-2.4	-1.2	-0.5	0.0	5.2	0.0	0.0
	16:00	16.4	6.6	0.38	-2.7	-1.3	-0.2	0.0	5.1	0.0	0.0
	17:00	18.0	7.9	0.40	-1.5	-1.1	-0.3	0.0	5.3	0.0	0.0
	18:00	18.2	9.1	0.42	-2.1	-1.2	-0.1	0.0	5.4	0.0	0.0
	19:00	15.5	6.3	0.43	-2.5	-1.2	-0.2	0.0	5.3	0.0	0.0
	20:00	12.8	5.4	0.41	-2.3	-1.3	-0.5	0.0	5.4	0.0	0.0
	21:00	14.2	5.7	0.39	-1.8	-1.5	0.0	0.0	5.3	0.0	0.0
	22:00	13.0	5.8	0.40	-2.0	-1.6	0.0	0.0	5.2	0.0	0.0
	23:00	13.9	5.8	0.40	-2.4	-1.3	-0.4	0.0	5.5	0.0	0.0
	0:00	13.1	5.7	0.38	-2.4	-1.4	-0.4	0.0	5.3	0.0	0.0
Min		11.4	4.8	0.3	-2.9	-1.6	-0.5	0.0	4.9	0.0	0.0
Max		35.1	9.1	0.5	0.6	-0.9	0.4	0.0	5.5	0.0	0.0
Average		17.3	5.9	0.4	-2.1	-1.3	-0.2	0.0	5.2	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
25/10/2018	1:00	12.6	5.7	0.37	-1.8	-1.5	0.0	0.0	5.4	0.0	0.0
	2:00	12.8	5.6	0.37	-2.3	-1.5	-0.1	0.0	5.4	0.0	0.0
	3:00	12.9	5.9	0.39	-2.0	-1.4	-0.1	0.0	5.4	0.0	0.0
	4:00	17.3	7.4	0.48	-1.3	-1.0	0.0	0.0	5.2	0.0	0.0
	5:00	15.9	6.7	0.39	-1.4	-1.3	0.1	0.0	5.4	0.0	0.0
	6:00	14.2	6.4	0.40	-1.3	-1.5	0.1	0.0	5.4	0.0	0.0
	7:00	17.6	6.8	0.42	-1.8	-1.3	0.0	0.0	5.5	0.0	0.0
	8:00	31.6	7.3	0.42	-2.2	-1.1	-0.3	0.0	5.6	0.0	0.0
	9:00	36.9	8.1	0.42	-1.8	-1.3	-0.2	0.0	5.3	0.0	0.0
	10:00	32.4	9.0	0.42	-1.6	-1.2	-0.3	0.0	5.3	0.0	0.0
	11:00	38.0	8.8	0.40	-2.5	-1.1	-0.4	0.0	5.2	0.0	0.0
	12:00	35.2	7.4	0.40	-2.4	-1.3	-0.3	0.0	5.2	0.0	0.0
	13:00	29.6	7.3	0.39	-2.4	-1.2	-0.3	0.0	5.1	0.0	0.0
	14:00	26.9	6.4	0.38	-2.7	-1.4	-0.5	0.0	5.2	0.0	0.0
	15:00	22.1	6.0	0.39	-2.3	-1.5	-0.3	0.0	5.5	0.0	0.0
	16:00	18.6	5.3	0.38	-2.7	-1.5	-0.3	0.0	5.5	0.0	0.0
	17:00	12.9	5.1	0.39	-2.6	-1.4	-0.3	0.0	5.4	0.0	0.0
	18:00	11.8	4.7	0.43	-2.4	-1.4	-0.4	0.0	5.3	0.0	0.0
	19:00	14.9	5.3	0.48	-2.2	-1.1	-0.3	0.0	5.4	0.0	0.0
	20:00	10.0	4.6	0.42	-2.0	-1.6	0.1	0.0	5.4	0.0	0.0
	21:00	10.7	4.7	0.41	-2.2	-1.5	0.0	0.0	5.4	0.0	0.0
	22:00	10.0	4.7	0.41	-2.6	-1.5	-0.1	0.0	5.4	0.0	0.0
	23:00	9.7	4.4	0.40	-2.9	-1.6	-0.1	0.0	5.2	0.0	0.0
	0:00	9.4	4.4	0.39	-2.7	-1.4	-0.3	0.0	5.3	0.0	0.0
Min		9.4	4.4	0.4	-2.9	-1.6	-0.5	0.0	5.1	0.0	0.0
Max		38.0	9.0	0.5	-1.3	-1.0	0.1	0.0	5.6	0.0	0.0
Average		19.3	6.2	0.4	-2.2	-1.4	-0.2	0.0	5.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
26/10/2018	1:00	9.3	4.1	0.39	ZS	-1.2	-0.3	0.0	5.3	0.0	0.0
	2:00	9.9	4.2	0.39	-0.6	ZS	ZS	0.0	5.3	0.0	0.0
	3:00	9.5	4.1	0.39	-0.8	-1.2	-0.2	0.0	5.2	0.0	0.0
	4:00	9.4	4.0	0.38	-1.0	-1.3	-0.3	0.0	5.5	0.0	0.0
	5:00	9.6	3.9	0.38	-1.0	-1.4	-0.2	0.0	5.4	0.0	0.0
	6:00	12.2	4.0	0.40	-0.4	-1.2	-0.1	0.0	5.4	0.0	0.0
	7:00	10.2	3.7	0.41	-0.6	-1.4	-0.3	0.0	5.6	0.0	0.0
	8:00	13.6	3.6	0.41	-1.1	-1.5	0.0	0.0	5.6	0.0	0.0
	9:00	13.4	3.5	0.41	-0.8	-1.3	-0.4	0.0	5.6	0.0	0.0
	10:00	12.2	3.3	0.40	-1.0	-1.2	-0.6	0.0	5.4	0.0	0.0
	11:00	13.1	3.4	0.41	-0.6	-1.2	-0.3	0.0	5.6	0.0	0.0
	12:00	16.8	3.5	0.39	-0.8	-1.5	-0.2	0.0	5.5	0.0	0.0
	13:00	14.0	3.3	0.40	-1.2	-1.3	-0.2	0.0	5.4	0.0	0.0
	14:00	25.0	4.1	0.40	-1.1	-1.4	-0.5	0.0	5.4	0.0	0.0
	15:00	29.1	4.2	0.41	-1.1	-1.4	-0.4	0.0	5.3	0.0	0.0
	16:00	24.9	4.4	0.39	-1.3	-1.5	-0.2	0.0	5.3	0.0	0.0
	17:00	12.1	3.5	0.39	-1.0	-1.5	-0.3	0.0	5.3	0.0	0.0
	18:00	11.8	3.8	0.42	0.0	-1.5	-0.3	0.0	5.4	0.0	0.0
	19:00	9.9	3.9	0.44	0.1	-1.5	-0.3	0.0	5.6	0.0	0.0
	20:00	10.6	4.1	0.41	-0.7	-1.4	-0.1	0.0	5.7	0.0	0.0
	21:00	10.4	4.1	0.41	-0.9	-1.4	-0.2	0.0	5.5	0.0	0.0
	22:00	12.1	4.5	0.40	-0.9	-1.5	-0.1	0.0	5.3	0.0	0.0
	23:00	11.3	4.2	0.39	-0.9	-1.4	-0.1	0.0	5.3	0.0	0.0
	0:00	11.9	4.0	0.39	ZS	-1.8	-0.2	0.0	5.2	0.0	0.0
Min		9.3	3.3	0.4	-1.3	-1.8	-0.6	0.0	5.2	0.0	0.0
Max		29.1	4.5	0.4	0.1	-1.2	0.0	0.0	5.7	0.0	0.0
Average		13.4	3.9	0.4	-0.8	-1.4	-0.2	0.0	5.4	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
27/10/2018	1:00	12.9	5.2	0.43	BO	ZS	ZS	0.0	5.2	0.0	0.0
	2:00	16.0	7.0	0.57	BO	-1.7	0.6	0.0	5.2	0.0	0.0
	3:00	16.6	7.9	0.70	BO	-1.6	0.6	0.0	5.4	0.0	0.0
	4:00	15.3	5.8	0.49	BO	-1.7	0.3	0.0	5.5	0.0	0.0
	5:00	10.7	3.6	0.40	BO	-1.6	0.1	0.0	5.5	0.0	0.0
	6:00	12.0	3.9	0.42	BO	-1.8	0.2	0.0	5.5	0.0	0.0
	7:00	16.5	4.3	0.43	BO	-1.7	-0.1	0.0	5.4	0.0	0.0
	8:00	13.2	4.1	0.41	BO	-1.7	-0.3	0.0	5.6	0.0	0.0
	9:00	17.2	4.0	0.40	BO	-1.6	-0.3	0.0	5.5	0.0	0.0
	10:00	14.2	4.2	0.39	BO	-1.5	-0.5	0.0	5.5	0.0	0.0
	11:00	16.9	4.0	0.40	BO	-1.6	-0.3	0.0	5.2	0.0	0.0
	12:00	16.5	4.6	0.39	BO	-1.5	-0.4	0.0	5.1	0.0	0.0
	13:00	13.5	4.1	0.39	BO	-1.7	-0.3	0.0	5.1	0.0	0.0
	14:00	13.1	4.4	0.39	BO	-1.6	-0.3	0.0	5.1	0.0	0.0
	15:00	11.3	3.9	0.39	BO	-1.5	-0.3	0.0	5.5	0.0	0.0
	16:00	10.3	3.7	0.39	BO	-1.5	-0.3	0.0	5.3	0.0	0.0
	17:00	11.3	3.6	0.39	BO	-1.6	-0.5	0.0	5.4	0.0	0.0
	18:00	12.5	4.1	0.44	BO	-1.5	-0.3	0.0	5.2	0.0	0.0
	19:00	12.1	4.7	0.47	BO	-1.5	-0.2	0.0	5.3	0.0	0.0
	20:00	11.3	4.4	0.46	BO	-1.3	-0.1	0.0	5.3	0.0	0.0
	21:00	11.8	4.3	0.45	BO	-1.3	-0.4	0.0	5.2	0.0	0.0
	22:00	10.4	4.1	0.42	BO	-1.5	0.0	0.0	5.3	0.0	0.0
	23:00	10.6	4.0	0.43	BO	-1.5	-0.2	0.0	5.1	0.0	0.0
	0:00	9.8	3.9	0.42	BO	-1.5	-0.2	0.0	5.2	0.0	0.0
Min		9.8	3.6	0.4	ID	-1.8	-0.5	0.0	5.1	0.0	0.0
Max		17.2	7.9	0.7	ID	-1.3	0.6	0.0	5.6	0.0	0.0
Average		13.2	4.5	0.4	ID	-1.6	-0.1	0.0	5.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
28/10/2018	1:00	9.2	3.6	0.42	BO	-1.5	-0.3	0.0	5.2	0.0	0.0
	2:00	8.4	3.6	0.41	4.1	-1.6	0.0	0.0	5.1	0.0	0.0
	3:00	9.5	3.7	0.40	4.0	-1.6	-0.2	0.0	5.0	0.0	0.0
	4:00	10.2	3.7	0.41	3.7	-1.5	-0.4	0.0	5.3	0.0	0.0
	5:00	10.0	3.9	0.41	3.4	-1.6	0.2	0.0	5.3	0.0	0.0
	6:00	10.6	3.9	0.43	3.5	-1.7	-0.1	0.0	5.3	0.0	0.0
	7:00	12.5	4.0	0.44	3.6	-1.5	-0.3	0.0	5.3	0.0	0.0
	8:00	10.4	3.7	0.41	2.9	-1.6	-0.4	0.0	5.2	0.0	0.0
	9:00	10.8	3.6	0.40	2.8	-1.5	-0.4	0.0	5.2	0.0	0.0
	10:00	12.4	3.7	0.40	2.7	-1.7	-0.1	0.0	5.5	0.0	0.0
	11:00	10.3	3.6	0.40	2.2	-1.7	-0.2	0.0	5.5	0.0	0.0
	12:00	8.9	3.4	0.39	2.1	-1.6	-0.3	0.0	5.7	0.0	0.0
	13:00	14.4	7.2	0.44	2.6	-0.8	-0.6	0.0	5.3	0.0	0.0
	14:00	19.3	10.7	0.46	2.7	-0.7	-0.4	0.0	5.5	0.0	0.0
	15:00	11.8	5.6	0.42	2.3	-1.2	0.0	0.0	5.3	0.0	0.0
	16:00	9.9	4.1	0.42	2.1	-1.4	-0.2	0.0	5.3	0.0	0.0
	17:00	11.1	3.7	0.43	1.7	-1.5	-0.4	0.0	5.4	0.0	0.0
	18:00	12.2	4.2	0.45	2.5	-1.5	-0.2	0.0	5.3	0.0	0.0
	19:00	9.6	3.8	0.47	2.0	-1.6	-0.2	0.0	5.5	0.0	0.0
	20:00	10.2	3.7	0.46	2.2	-1.5	-0.1	0.0	5.3	0.0	0.0
	21:00	8.4	3.4	0.44	2.2	-1.3	0.0	0.0	5.3	0.0	0.0
	22:00	8.4	3.2	0.42	1.6	-1.6	-0.1	0.0	5.5	0.0	0.0
	23:00	7.9	2.8	0.42	1.6	-1.6	-0.1	0.0	5.3	0.0	0.0
	0:00	6.3	2.6	0.42	ZS	-1.7	0.0	0.0	5.3	0.0	0.0
Min		6.3	2.6	0.4	1.6	-1.7	-0.6	0.0	5.0	0.0	0.0
Max		19.3	10.7	0.5	4.1	-0.7	0.2	0.0	5.7	0.0	0.0
Average		10.5	4.1	0.4	2.7	-1.5	-0.2	0.0	5.3	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
29/10/2018	1:00	6.3	2.2	0.43	BO	ZS	ZS	0.0	5.4	0.0	0.0
	2:00	6.6	2.2	0.44	BO	-1.6	0.4	0.0	5.1	0.0	0.0
	3:00	8.1	2.1	0.43	BO	-1.8	0.9	0.0	5.3	0.0	0.0
	4:00	10.4	3.6	0.51	BO	-1.5	0.6	0.0	5.1	0.0	0.0
	5:00	12.4	4.9	0.52	BO	-1.3	1.1	0.0	5.1	0.0	0.0
	6:00	15.6	6.5	0.48	BO	-1.4	0.6	0.0	5.0	0.0	0.0
	7:00	18.5	6.2	0.48	BO	-1.6	0.7	0.0	5.2	0.0	0.0
	8:00	20.9	6.9	0.57	BO	-1.4	0.3	0.0	4.9	0.0	0.0
	9:00	18.5	4.4	0.49	BO	-1.4	-0.3	0.0	5.2	0.0	0.0
	10:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	11:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	12:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	13:00	13.2	3.8	PO	PO	PO	PO	PO	PO	PO	PO
	14:00	23.4	4.6	0.64	BO	-1.4	-0.4	0.0	6.7	0.0	1.1
	15:00	15.6	3.2	0.64	BO	-1.6	0.0	0.0	6.1	0.0	0.0
	16:00	15.7	3.5	0.59	BO	-1.6	-0.5	0.0	6.0	0.0	0.0
	17:00	11.5	3.6	0.59	BO	-1.8	-0.3	0.0	5.5	0.0	0.0
	18:00	10.9	3.6	0.58	BO	-1.7	-0.2	0.0	5.6	0.0	0.0
	19:00	11.9	3.6	0.61	BO	-1.6	0.1	0.0	5.3	0.0	0.0
	20:00	33.1	14.6	0.61	BO	-1.6	0.3	0.0	5.3	0.0	0.0
	21:00	14.3	5.4	0.57	BO	-1.4	-0.1	0.0	5.2	0.0	0.0
	22:00	11.6	3.6	0.53	BO	-1.7	-0.1	0.0	5.2	0.0	0.0
	23:00	10.0	3.7	0.54	BO	-1.6	0.0	0.0	5.0	0.0	0.0
	0:00	10.2	3.8	0.52	BO	-1.6	0.0	0.0	4.9	0.0	0.0
Min		6.3	2.1	0.4	ID	-1.8	-0.5	0.0	4.9	0.0	0.0
Max		33.1	14.6	0.6	ID	-1.3	1.1	0.0	6.7	0.0	1.1
Average		14.2	4.6	0.5	ID	-1.5	0.2	0.0	5.4	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
30/10/2018	1:00	10.0	3.9	0.51	BO	-1.6	0.4	0.0	4.8	0.0	0.0
	2:00	11.0	3.9	0.51	BO	-1.4	0.0	0.0	4.9	0.0	0.0
	3:00	13.6	4.1	0.50	BO	-1.7	0.5	0.0	4.8	0.0	0.0
	4:00	11.9	3.8	0.48	BO	-1.7	0.4	0.0	4.7	0.0	0.0
	5:00	14.5	4.6	0.53	BO	-1.7	0.7	0.0	4.6	0.0	0.0
	6:00	16.2	4.6	0.57	BO	-1.5	0.5	0.0	4.7	0.0	0.0
	7:00	32.6	6.1	0.59	BO	-1.2	0.1	0.0	4.7	0.0	0.0
	8:00	29.1	5.2	0.50	2.5	-1.4	-0.2	0.0	4.7	0.0	0.0
	9:00	32.0	5.4	0.50	2.9	-1.5	-0.3	0.0	4.7	0.0	0.0
	10:00	41.5	5.8	0.51	2.6	-1.5	-0.2	0.0	4.7	0.0	0.0
	11:00	34.7	5.5	0.51	2.9	-1.4	-0.3	0.0	4.6	0.0	0.0
	12:00	48.4	5.6	0.48	1.8	-1.7	0.0	0.0	4.6	0.0	0.0
	13:00	65.3	6.9	0.48	2.7	-1.5	-0.4	0.0	4.5	0.0	0.0
	14:00	21.8	4.9	0.50	1.9	-1.6	-0.1	0.0	4.5	0.0	0.0
	15:00	26.3	4.5	0.48	1.2	-1.6	-0.2	0.0	4.5	0.0	0.0
	16:00	13.6	3.9	0.49	1.5	-1.6	-0.4	0.0	5.6	0.0	0.0
	17:00	14.5	4.2	0.50	1.1	-1.8	-0.2	0.0	4.4	0.0	0.0
	18:00	15.7	4.2	0.51	1.8	-1.7	-0.3	0.0	4.4	0.0	0.0
	19:00	28.8	20.2	0.60	1.9	-0.7	-0.3	0.0	4.3	0.0	0.0
	20:00	48.6	38.3	0.68	2.6	-0.3	0.1	0.0	4.4	0.0	0.0
	21:00	25.4	15.6	0.56	2.0	-1.0	0.0	0.0	4.2	0.0	0.0
	22:00	10.8	4.0	0.48	1.2	-1.6	-0.3	0.0	4.3	0.0	0.0
	23:00	10.2	4.1	0.48	1.2	-1.9	-0.1	0.0	4.4	0.0	0.0
	0:00	10.5	4.2	0.48	ZS	-1.9	-0.2	0.0	4.4	0.0	0.0
Min		10.0	3.8	0.5	ID	-1.9	-0.4	0.0	4.2	0.0	0.0
Max		65.3	38.3	0.7	ID	-0.3	0.7	0.0	5.6	0.0	0.0
Average		24.5	7.2	0.5	ID	-1.5	0.0	0.0	4.6	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
31/10/2018	1:00	11.2	4.2	0.27	1.9	ZS	ZS	0.0	4.5	0.0	0.0
	2:00	10.9	4.3	0.27	1.5	-1.5	-0.2	0.0	4.4	0.0	0.0
	3:00	11.8	4.5	0.27	1.5	-1.6	-0.3	0.0	4.3	0.0	0.0
	4:00	11.9	4.8	0.27	1.6	-1.5	-0.3	0.0	4.3	0.0	0.0
	5:00	13.6	5.2	0.30	2.5	-1.5	-0.1	0.0	4.3	0.0	0.0
	6:00	18.4	5.8	0.37	3.8	-1.1	0.0	0.0	4.2	0.0	0.0
	7:00	18.7	5.9	0.33	1.7	-1.3	-0.3	0.0	4.1	0.0	0.0
	8:00	36.1	7.0	0.32	1.4	-1.3	-0.3	0.0	4.2	0.0	0.0
	9:00	50.3	8.4	0.31	1.1	-1.2	-0.4	0.0	4.0	0.0	0.0
	10:00	96.8	10.8	0.28	1.2	-1.7	-0.1	0.0	4.4	0.0	0.0
	11:00	70.3	9.8	0.28	0.9	-1.6	-0.3	0.0	4.3	0.0	0.0
	12:00	49.7	9.4	0.29	1.3	-1.5	-0.3	0.0	4.2	0.0	0.0
	13:00	27.8	7.5	0.28	0.7	-1.7	-0.4	0.0	4.4	0.0	0.0
	14:00	40.0	8.2	0.28	0.4	-1.7	-0.2	0.0	4.0	0.0	0.0
	15:00	37.3	9.0	0.29	0.7	-1.7	-0.4	0.0	3.8	0.0	0.0
	16:00	21.9	7.5	0.27	0.5	-1.7	-0.6	0.0	3.9	0.0	0.0
	17:00	25.4	7.9	0.29	0.3	-1.7	-0.1	0.0	4.0	0.0	0.0
	18:00	23.3	7.9	0.31	0.8	-1.8	-0.1	0.0	3.7	0.0	0.0
	19:00	20.5	7.7	0.31	1.2	-1.7	-0.3	0.0	3.7	0.0	0.0
	20:00	18.3	7.2	0.30	0.5	-1.8	0.2	0.0	3.6	0.0	0.0
	21:00	18.9	7.2	0.29	0.5	-1.5	-0.3	0.0	3.7	0.0	0.0
	22:00	17.5	7.0	0.28	0.2	-1.7	-0.4	0.0	3.5	0.0	0.0
	23:00	17.3	7.1	0.29	0.5	-2.0	0.0	0.0	1.2	0.0	0.0
	0:00	20.1	7.8	0.28	0.6	-2.0	-0.4	0.0	1.3	0.0	0.0
Min		10.9	4.2	0.3	0.2	-2.0	-0.6	0.0	1.2	0.0	0.0
Max		96.8	10.8	0.4	3.8	-1.1	0.2	0.0	4.5	0.0	0.0
Average		28.7	7.2	0.3	1.1	-1.6	-0.2	0.0	3.8	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
01/11/2018	1:00	21.2	8.3	0.29	0.2	-2.0	-0.3	0.0	1.3	0.0	0.0
	2:00	23.2	9.0	0.29	0.5	-2.0	-0.2	0.0	1.7	0.0	0.0
	3:00	21.1	8.5	0.29	0.5	-2.1	-0.4	0.0	2.0	0.0	0.0
	4:00	20.0	7.9	0.29	1.3	-2.0	0.0	0.0	1.5	0.0	0.0
	5:00	21.7	8.3	0.32	1.7	-1.7	0.0	0.0	2.6	0.0	0.0
	6:00	28.2	9.6	0.33	1.6	-1.7	0.4	0.0	1.7	0.0	0.0
	7:00	30.8	10.3	0.36	1.9	-1.4	-0.1	0.0	2.7	0.0	0.0
	8:00	29.0	10.1	0.38	3.0	-1.2	-0.1	0.0	2.4	0.0	0.0
	9:00	24.9	9.2	0.32	3.8	-0.9	0.0	0.0	2.7	0.0	0.0
	10:00	21.6	7.8	0.31	0.4	-1.6	-0.1	0.0	2.6	0.0	0.0
	11:00	22.6	7.5	0.31	0.7	-1.4	-0.3	0.0	2.6	0.0	0.0
	12:00	23.9	7.6	0.29	0.9	-1.6	-0.2	0.0	2.3	0.0	0.0
	13:00	29.8	7.4	0.28	0.3	-1.3	-0.4	0.0	2.5	0.0	0.0
	14:00	22.2	9.2	0.29	0.2	-1.6	-0.3	0.0	2.6	0.0	0.0
	15:00	28.4	14.6	0.34	0.4	-1.3	-0.6	0.0	2.9	0.0	0.0
	16:00	22.2	11.9	0.33	0.7	-1.1	-0.7	0.0	2.9	0.0	0.0
	17:00	18.4	7.7	0.33	-0.1	-1.4	-0.4	0.0	2.9	0.0	0.0
	18:00	14.0	5.9	0.32	1.2	-1.8	-0.2	0.0	3.0	0.0	0.0
	19:00	18.7	8.1	0.41	2.9	-1.5	0.8	0.0	2.6	0.0	0.0
	20:00	16.4	4.8	0.40	3.6	-1.4	0.2	0.0	2.7	0.0	0.0
	21:00	14.9	4.6	0.40	2.2	-1.5	0.3	0.0	2.9	0.0	0.0
	22:00	13.4	4.2	0.29	0.3	-1.6	0.1	0.0	2.5	0.0	0.0
	23:00	13.0	4.2	0.30	1.1	-1.8	0.1	0.0	3.0	0.0	0.0
	0:00	12.1	4.0	0.27	0.5	-2.1	0.3	0.0	3.1	0.0	0.0
Min		12.1	4.0	0.3	-0.1	-2.1	-0.7	0.0	1.3	0.0	0.0
Max		30.8	14.6	0.4	3.8	-0.9	0.8	0.0	3.1	0.0	0.0
Average		21.3	7.9	0.3	1.2	-1.6	-0.1	0.0	2.5	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
02/11/2018	1:00	11.5	3.6	0.27	ZS	-1.8	0.1	0.0	2.4	0.0	0.0
	2:00	11.9	4.0	0.28	-1.0	ZS	ZS	0.0	2.8	0.0	0.0
	3:00	12.7	4.0	0.27	-2.0	-1.6	0.5	0.0	2.8	0.0	0.0
	4:00	9.9	3.3	0.26	-2.9	-1.7	0.1	0.0	2.8	0.0	0.0
	5:00	12.0	3.7	0.26	-3.2	-1.6	0.4	0.0	2.6	0.0	0.0
	6:00	10.3	3.3	0.28	-2.6	-1.5	0.4	0.0	2.8	0.0	0.0
	7:00	11.9	4.7	0.32	-1.3	-1.7	0.4	0.0	2.9	0.0	0.0
	8:00	12.6	4.7	0.39	-1.7	-1.3	0.2	0.0	2.9	0.0	0.0
	9:00	20.1	4.2	0.36	-3.0	-1.3	-0.1	0.0	2.8	0.0	0.0
	10:00	21.3	4.2	0.30	-3.7	-1.4	-0.5	0.0	2.4	0.0	0.0
	11:00	24.3	4.3	0.29	-3.3	-1.4	-0.3	0.0	2.7	0.0	0.0
	12:00	16.7	4.0	0.30	0.3	-1.5	-0.3	0.0	2.2	0.0	0.0
	13:00	19.5	3.5	0.26	-3.1	-1.6	-0.5	0.0	0.6	0.0	0.0
	14:00	19.5	3.5	0.26	-3.6	-1.4	-0.6	0.0	1.1	0.0	0.0
	15:00	19.5	3.5	0.27	-3.8	-1.5	-0.4	0.0	1.9	0.0	0.0
	16:00	19.5	3.5	0.28	-3.6	-1.5	-0.5	0.0	0.8	0.0	0.0
	17:00	19.5	3.5	0.30	-3.3	-1.6	-0.4	0.0	1.4	0.0	0.0
	18:00	19.5	3.5	0.32	-2.8	-1.7	-0.1	0.0	0.8	0.0	0.0
	19:00	19.5	3.5	0.32	-2.8	-1.7	0.3	0.0	1.6	0.0	0.0
	20:00	19.5	3.5	0.33	-2.0	-1.7	0.3	0.0	0.8	0.0	0.0
	21:00	19.5	3.5	0.31	-3.2	-1.6	0.1	0.0	1.4	0.0	0.0
	22:00	19.5	3.5	0.28	-3.0	-1.5	-0.2	0.0	0.3	0.0	0.0
	23:00	19.5	3.5	0.29	-2.3	-1.5	-0.2	0.0	0.9	0.0	0.0
	0:00	19.5	3.5	0.29	ZS	-1.8	0.2	0.0	0.9	0.0	0.0
Min		9.9	3.3	0.3	-3.8	-1.8	-0.6	0.0	0.3	0.0	0.0
Max		24.3	4.7	0.4	0.3	-1.3	0.5	0.0	2.9	0.0	0.0
Average		17.0	3.7	0.3	-2.6	-1.6	0.0	0.0	1.9	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
03/11/2018	1:00	19.5	3.5	0.29	-1.9	ZS	ZS	0.0	0.6	0.0	0.0
	2:00	19.5	3.5	0.28	-0.9	-1.4	0.5	0.0	0.2	0.0	0.0
	3:00	19.5	3.5	0.29	-1.5	-1.3	0.3	0.0	0.0	0.0	0.0
	4:00	19.5	3.5	0.28	-0.8	-1.6	0.7	0.0	0.0	0.0	0.0
	5:00	19.5	3.5	0.27	-1.8	-1.5	0.4	0.0	0.6	0.0	0.0
	6:00	19.5	3.5	0.32	0.7	-1.3	0.4	0.0	0.8	0.0	0.0
	7:00	19.5	3.5	0.32	-3.8	-1.4	0.1	0.0	0.3	0.0	0.0
	8:00	19.5	3.5	0.29	-3.6	-1.5	-0.4	0.0	0.0	0.0	0.0
	9:00	19.5	3.5	0.27	-3.8	-1.6	-0.2	0.0	0.0	0.0	0.0
	10:00	19.5	3.5	0.27	-4.1	-1.6	-0.3	0.0	0.5	0.0	0.0
	11:00	19.5	3.5	0.26	-4.0	-1.7	-0.2	0.0	0.6	0.0	0.0
	12:00	19.5	3.5	0.26	-3.5	-1.7	-0.5	0.0	0.8	0.0	0.0
	13:00	19.5	3.5	0.25	-3.7	-1.9	-0.2	0.0	0.5	0.0	0.0
	14:00	19.5	3.5	0.26	-3.8	-1.8	-0.4	0.2	2.4	0.4	2.3
	15:00	19.5	3.5	0.27	-3.8	-1.6	-0.4	1.2	1.2	0.6	14.4
	16:00	19.5	3.5	0.26	-4.0	-1.8	-0.3	0.9	1.6	0.4	4.6
	17:00	19.5	3.5	0.31	-2.8	-1.6	-0.5	0.0	1.0	0.0	0.0
	18:00	19.5	3.5	0.35	-2.3	-1.5	-0.2	0.0	0.3	0.0	0.0
	19:00	19.5	3.5	0.33	-2.4	-1.5	-0.4	0.0	0.5	0.0	0.1
	20:00	19.5	3.5	0.34	-2.8	-1.6	-0.1	0.0	0.3	0.0	0.0
	21:00	19.5	3.5	0.33	-2.3	-1.5	-0.1	0.0	0.6	0.0	0.0
	22:00	19.5	3.5	0.29	-3.3	-1.7	-0.1	0.0	0.3	0.0	0.0
	23:00	19.5	3.5	0.31	-2.4	-1.5	0.0	0.0	0.2	0.0	0.0
	0:00	19.5	3.5	0.31	-1.6	-1.5	0.3	0.0	0.0	0.0	0.0
Min		19.5	3.5	0.3	-4.1	-1.9	-0.5	0.0	0.0	0.0	0.0
Max		19.5	3.5	0.3	0.7	-1.3	0.7	1.2	2.4	0.6	14.4
Average		19.5	3.5	0.3	-2.7	-1.6	-0.1	0.1	0.6	0.1	0.9

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
04/11/2018	1:00	19.5	3.5	0.36	-0.5	-1.6	0.2	0.0	0.5	0.0	0.0
	2:00	19.5	3.5	0.33	0.4	-1.2	0.3	0.0	0.3	0.0	0.0
	3:00	19.5	3.5	0.30	-0.6	-1.2	0.4	0.0	0.0	0.0	0.0
	4:00	19.5	3.5	0.30	-1.1	-1.2	0.8	0.0	0.3	0.0	0.0
	5:00	19.5	3.5	0.30	-1.2	-1.1	0.9	0.0	0.2	0.0	0.0
	6:00	19.5	3.5	0.34	-1.8	-1.1	0.1	0.0	0.2	0.0	0.0
	7:00	19.5	3.5	0.33	-2.0	-1.1	0.3	0.0	0.0	0.0	0.0
	8:00	19.5	3.5	0.30	-0.8	-0.9	0.2	0.0	0.4	0.0	0.0
	9:00	19.5	3.5	0.30	2.3	-0.1	0.1	0.0	0.8	0.0	0.0
	10:00	19.5	3.5	0.33	0.3	-0.3	-0.2	0.0	0.6	0.0	0.0
	11:00	19.5	3.5	0.32	-2.1	-0.9	-0.5	0.0	0.8	0.0	0.0
	12:00	19.5	3.5	0.31	-2.9	-1.1	-0.5	0.0	1.6	0.0	0.0
	13:00	19.5	3.5	0.30	-3.7	-1.6	-0.2	0.0	1.2	0.0	0.0
	14:00	19.5	3.5	0.31	-3.6	-1.5	-0.2	0.0	0.6	0.0	0.0
	15:00	19.5	3.5	0.30	-4.0	-1.6	-0.4	0.0	0.9	0.0	0.0
	16:00	19.5	3.5	0.30	-3.4	-1.6	-0.4	0.0	0.6	0.0	0.0
	17:00	19.5	3.5	0.32	-3.8	-1.4	-0.2	0.0	1.4	0.0	0.0
	18:00	19.5	3.5	0.32	-3.0	-1.7	-0.1	0.0	0.7	0.0	0.0
	19:00	19.5	3.5	0.37	-2.3	-1.3	-0.1	0.0	0.6	0.0	0.0
	20:00	19.5	3.5	0.43	-1.0	-1.4	0.0	0.0	0.3	0.0	0.0
	21:00	19.5	3.5	0.59	1.8	-0.9	0.4	0.0	0.3	0.0	0.0
	22:00	19.5	3.5	0.51	2.4	-0.9	0.5	0.0	0.3	0.0	0.0
	23:00	19.5	3.5	0.56	4.2	-0.4	2.5	0.0	0.3	0.0	0.0
	0:00	19.5	3.5	0.43	ZS	-0.6	5.7	0.0	0.0	0.0	0.0
Min		19.5	3.5	0.3	-4.0	-1.7	-0.5	0.0	0.0	0.0	0.0
Max		19.5	3.5	0.6	4.2	-0.1	5.7	0.0	1.6	0.0	0.0
Average		19.5	3.5	0.4	-1.1	-1.1	0.4	0.0	0.5	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
05/11/2018	1:00	19.5	3.5	0.37	2.3	ZS	ZS	0.0	0.3	0.0	0.0
	2:00	19.5	3.5	0.37	2.7	-0.7	1.8	0.0	0.6	0.0	0.0
	3:00	19.5	3.5	0.32	1.2	-1.0	0.5	0.0	0.0	0.0	0.0
	4:00	19.5	3.5	0.29	1.4	-1.1	0.7	0.0	0.3	0.0	0.0
	5:00	19.5	3.5	0.29	1.4	-1.1	0.9	0.0	0.3	0.0	0.0
	6:00	19.5	3.5	0.32	0.7	-0.8	1.2	0.0	0.3	0.0	0.0
	7:00	19.5	3.5	0.31	-1.4	-1.0	5.1	0.0	0.3	0.0	0.0
	8:00	19.5	3.5	0.37	-1.6	-0.8	1.1	0.0	0.6	0.0	0.0
	9:00	18.2	3.6	0.29	-3.4	-1.3	-0.4	0.0	0.8	0.0	0.0
	10:00	11.1	3.6	0.28	-2.8	-1.2	-0.4	0.0	0.8	0.0	0.0
	11:00	10.5	3.6	0.29	-2.1	-1.3	-0.2	0.0	0.3	0.0	0.0
	12:00	12.6	3.7	0.28	-3.0	-1.3	-0.5	0.0	1.3	0.0	0.0
	13:00	10.1	3.7	0.27	-2.8	-1.7	0.0	0.0	0.0	0.0	0.0
	14:00	10.9	3.7	0.26	-2.6	-1.4	-0.4	0.0	0.0	0.0	0.0
	15:00	11.6	3.6	0.26	-2.7	-1.4	-0.4	0.0	0.0	0.0	0.0
	16:00	10.8	3.3	0.29	-1.8	-1.4	-0.2	0.0	0.3	0.0	0.0
	17:00	11.0	4.2	0.28	-2.6	-1.2	-0.6	7.9	0.3	0.0	0.0
	18:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	19:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	20:00	14.1	5.1	0.49	-1.8	-1.3	-0.1	0.0	0.0	0.0	0.0
	21:00	10.2	3.4	0.43	-2.4	-1.5	0.1	0.0	0.0	0.0	0.0
	22:00	12.3	4.9	0.43	-2.0	-1.4	0.0	0.0	0.0	0.0	0.0
	23:00	10.2	4.6	0.39	-1.9	-1.3	0.1	0.0	0.0	0.0	0.0
	0:00	19.8	13.2	0.45	-1.8	-1.1	0.3	0.0	0.0	0.0	0.0
Min		10.1	3.3	0.3	-3.4	-1.7	-0.6	0.0	0.0	0.0	0.0
Max		19.8	13.2	0.5	2.7	-0.7	5.1	7.9	1.3	0.0	0.0
Average		15.0	4.2	0.3	-1.2	-1.2	0.4	0.4	0.3	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
06/11/2018	1:00	16.9	10.3	0.41	ZS	-0.9	0.8	0.0	0.0	0.0	0.0
	2:00	8.1	3.1	0.35	-1.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	8.3	2.8	0.34	-1.5	-1.1	0.1	0.0	0.0	0.0	0.0
	4:00	9.3	3.4	0.33	-1.5	-1.7	0.7	0.0	0.0	0.0	0.0
	5:00	13.8	3.7	0.33	-1.1	-1.5	0.4	0.0	0.0	0.0	0.0
	6:00	14.3	5.7	0.41	0.1	-1.2	2.9	0.0	0.0	0.0	0.0
	7:00	12.1	4.5	0.36	-1.3	-1.2	1.5	0.0	0.0	0.0	0.0
	8:00	17.7	4.7	0.36	-1.9	-1.2	0.1	0.0	0.0	0.0	0.0
	9:00	13.3	4.6	0.34	-2.2	-1.1	-0.4	0.0	0.0	0.0	0.0
	10:00	15.9	5.4	0.37	-2.1	-1.3	-0.3	0.0	0.0	0.0	0.0
	11:00	16.1	6.8	0.37	-2.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	12:00	15.7	7.5	0.37	-1.6	-1.1	-0.2	0.0	0.0	0.0	0.0
	13:00	23.6	11.1	0.39	-2.1	-0.8	-0.3	0.0	0.0	0.0	0.0
	14:00	17.3	9.2	0.36	-2.1	-1.0	-0.4	0.0	0.0	0.0	0.0
	15:00	13.7	6.2	0.34	-2.4	-1.1	-0.3	0.0	0.0	0.0	0.0
	16:00	20.5	11.0	0.39	-2.0	-0.3	-0.2	0.0	0.0	0.0	0.0
	17:00	11.3	3.9	0.34	-2.4	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	10.9	4.1	0.34	-2.4	-1.6	-0.3	0.0	0.0	0.0	0.0
	19:00	11.2	4.3	0.34	-2.3	-1.6	-0.1	0.0	0.0	0.0	0.0
	20:00	11.8	4.4	0.38	-1.6	-1.8	0.0	0.0	0.0	0.0	0.0
	21:00	14.0	5.5	0.42	-2.0	-1.3	-0.3	0.0	0.0	0.0	0.0
	22:00	13.8	5.0	0.36	-1.3	-1.6	0.0	0.0	0.0	0.0	0.0
	23:00	14.3	5.8	0.34	-2.0	-1.4	-0.1	0.0	0.0	0.0	0.0
	0:00	11.0	4.6	0.31	ZS	-1.5	-0.1	0.0	0.0	0.0	0.0
Min		8.1	2.8	0.3	-2.4	-1.8	-0.4	0.0	0.0	0.0	0.0
Max		23.6	11.1	0.4	0.1	-0.3	2.9	0.0	0.0	0.0	0.0
Average		13.9	5.7	0.4	-1.8	-1.2	0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
07/11/2018	1:00	11.7	4.6	0.31	-1.9	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	11.1	4.6	0.27	-2.0	-1.8	-0.1	0.0	0.0	0.0	0.0
	3:00	10.5	4.4	0.27	-2.0	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	11.6	4.5	0.28	-1.5	-1.5	0.1	0.0	0.0	0.0	0.0
	5:00	20.9	5.8	0.31	-0.2	-1.5	1.1	0.0	0.0	0.0	0.0
	6:00	18.9	6.0	0.36	-0.6	-1.5	1.2	0.0	0.3	0.0	0.0
	7:00	25.1	6.8	0.36	-0.3	-1.4	1.1	0.0	0.0	0.0	0.0
	8:00	27.7	5.7	0.32	-0.7	-1.4	0.0	0.1	0.4	0.0	0.0
	9:00	24.3	5.2	0.31	-1.9	-1.6	0.2	0.0	0.0	0.0	0.0
	10:00	27.3	5.1	0.36	-2.2	-1.4	-0.4	0.0	0.3	0.0	0.0
	11:00	25.2	4.9	0.30	-1.7	-1.2	-0.4	0.0	0.0	0.0	0.0
	12:00	28.5	5.1	0.29	-1.9	-1.5	-0.1	0.0	0.3	0.0	0.0
	13:00	20.9	5.3	0.31	-1.5	-1.3	-0.2	0.0	0.0	0.0	0.0
	14:00	27.8	5.2	0.32	-2.0	-1.5	-0.2	0.0	0.0	0.0	0.0
	15:00	22.4	5.9	0.31	-2.3	-1.3	-0.5	0.0	0.0	0.0	0.0
	16:00	14.8	5.5	0.30	-2.2	-1.6	-0.2	0.0	0.4	0.0	0.0
	17:00	11.3	3.6	0.30	-2.2	-1.5	-0.2	0.0	0.7	0.0	0.0
	18:00	10.7	3.4	0.31	-1.9	-1.7	-0.1	0.0	0.7	0.0	0.0
	19:00	9.8	3.5	0.29	-2.0	-1.7	-0.3	0.0	0.0	0.0	0.0
	20:00	9.5	3.5	0.29	-1.8	-1.5	-0.1	0.0	0.0	0.0	0.0
	21:00	13.1	3.8	0.29	-1.8	-1.5	-0.1	0.0	0.0	0.0	0.0
	22:00	9.7	3.6	0.26	-2.2	-1.4	-0.4	0.0	0.3	0.0	0.0
	23:00	10.5	3.9	0.30	-2.2	-1.6	-0.1	0.0	0.0	0.0	0.0
	0:00	11.2	4.0	0.29	-2.3	-1.6	0.0	0.0	0.0	0.0	0.0
Min		9.5	3.4	0.3	-2.3	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		28.5	6.8	0.4	-0.2	-1.2	1.2	0.1	0.7	0.0	0.0
Average		17.3	4.7	0.3	-1.7	-1.5	0.0	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
08/11/2018	1:00	10.0	4.0	0.29	-1.8	-1.8	0.6	0.0	0.0	0.0	0.0
	2:00	9.9	4.3	0.29	-1.9	-1.6	0.1	0.0	0.0	0.0	0.0
	3:00	10.7	4.8	0.33	-1.8	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	13.4	5.7	0.36	-1.4	-1.4	0.5	0.0	0.0	0.0	0.0
	5:00	12.9	5.0	0.33	-1.8	-1.5	0.6	0.0	0.0	0.0	0.0
	6:00	20.2	6.4	0.39	0.3	-1.2	0.6	0.0	0.0	0.0	0.0
	7:00	20.8	5.3	0.36	-1.1	-1.2	0.0	0.0	0.0	0.0	0.0
	8:00	24.9	5.5	0.33	-2.2	-1.3	-0.4	0.0	0.0	0.0	0.0
	9:00	29.8	5.6	0.33	-1.7	-1.4	-0.2	0.0	0.0	0.0	0.0
	10:00	27.2	5.5	0.33	-2.2	-1.2	-0.6	0.0	0.0	0.0	0.0
	11:00	25.6	5.6	0.33	-2.2	-1.5	-0.3	0.0	0.0	0.0	0.0
	12:00	23.2	5.1	0.29	-2.3	-1.3	-0.3	0.0	0.0	0.0	0.0
	13:00	29.5	7.2	0.29	-2.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	14:00	19.2	5.3	0.30	-1.6	-1.4	-0.4	0.0	0.0	0.0	0.0
	15:00	16.2	4.8	0.29	-2.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	16:00	15.0	5.0	0.29	-2.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	17:00	14.7	4.9	0.30	-2.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	18:00	13.8	5.1	0.31	-2.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	19:00	14.1	5.3	0.31	-1.7	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	13.7	5.4	0.30	-2.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	21:00	14.4	5.5	0.29	-2.4	-1.7	0.0	0.0	0.0	0.0	0.0
	22:00	14.6	5.7	0.29	-2.0	-1.6	-0.3	0.0	0.0	0.0	0.0
	23:00	13.2	5.7	0.29	-2.2	-1.7	0.1	0.0	0.0	0.0	0.0
	0:00	13.2	5.5	0.24	ZS	-1.8	-0.3	0.0	0.0	0.0	0.0
Min		9.9	4.0	0.2	-2.6	-1.8	-0.6	0.0	0.0	0.0	0.0
Max		29.8	7.2	0.4	0.3	-1.2	0.6	0.0	0.0	0.0	0.0
Average		17.5	5.3	0.3	-1.9	-1.5	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
09/11/2018	1:00	14.0	5.8	0.25	ZS	-1.9	0.2	0.0	0.0	0.0	0.0
	2:00	16.3	6.8	0.28	-0.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	13.6	5.8	0.25	-1.8	-1.3	0.2	0.0	0.0	0.0	0.0
	4:00	13.1	5.7	0.24	-2.0	-1.6	-0.2	0.0	0.0	0.0	0.0
	5:00	13.1	5.5	0.24	-1.9	-1.6	-0.1	0.0	0.0	0.0	0.0
	6:00	14.0	5.7	0.27	-1.3	-1.8	0.0	0.0	0.0	0.0	0.0
	7:00	19.2	6.0	0.30	-2.3	-1.7	0.3	0.0	0.0	0.0	0.0
	8:00	23.3	6.3	0.30	-2.5	-1.3	-0.3	0.0	0.0	0.0	0.0
	9:00	32.4	7.3	0.30	-2.0	-1.4	-0.2	0.0	0.0	0.0	0.0
	10:00	50.2	7.7	0.28	-2.3	-1.5	-0.1	0.0	0.0	0.0	0.0
	11:00	34.0	6.6	0.28	-2.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	12:00	42.2	8.9	0.30	-0.9	-1.3	-0.2	0.0	0.0	0.0	0.0
	13:00	32.7	8.6	0.32	-2.0	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	27.3	8.2	0.30	-2.3	-1.2	-0.4	0.0	0.0	0.0	0.0
	15:00	18.5	6.5	0.31	-1.9	-1.5	-0.3	0.0	0.0	0.0	0.0
	16:00	16.7	5.5	0.30	-2.2	-1.4	-0.6	0.0	0.0	0.0	0.0
	17:00	15.5	4.8	0.28	-2.4	-1.5	-0.3	0.0	0.0	0.0	0.0
	18:00	11.2	4.6	0.29	-2.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	19:00	12.5	4.3	0.29	-2.5	-1.6	-0.3	0.0	0.0	0.0	0.0
	20:00	13.3	4.2	0.27	-2.6	-1.6	-0.1	0.0	0.0	0.0	0.0
	21:00	12.4	4.1	0.27	-2.3	-1.6	-0.2	0.0	0.0	0.0	0.0
	22:00	11.3	4.2	0.26	-2.4	-1.6	-0.1	0.0	0.0	0.0	0.0
	23:00	11.5	4.3	0.27	-2.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	0:00	10.9	4.4	0.27	ZS	-1.7	-0.3	0.0	0.0	0.0	0.0
Min		10.9	4.1	0.2	-2.6	-1.9	-0.6	0.0	0.0	0.0	0.0
Max		50.2	8.9	0.3	-0.5	-1.2	0.3	0.0	0.0	0.0	0.0
Average		20.0	5.9	0.3	-2.0	-1.5	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
10/11/2018	1:00	10.6	4.3	0.26	BO	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	9.2	4.1	0.25	BO	-1.7	0.0	0.0	0.0	0.0	0.0
	3:00	9.7	4.1	0.25	BO	-1.7	-0.4	0.0	0.0	0.0	0.0
	4:00	10.4	4.4	0.25	BO	-2.0	0.1	0.0	0.0	0.0	0.0
	5:00	12.9	4.8	0.27	BO	-1.9	0.0	0.0	0.0	0.0	0.0
	6:00	17.2	6.6	0.33	BO	-1.9	0.2	0.0	0.0	0.0	0.0
	7:00	21.9	6.7	0.35	BO	-1.2	-0.1	0.0	0.0	0.0	0.0
	8:00	25.9	6.0	0.27	BO	-1.7	0.1	0.0	0.0	0.0	0.0
	9:00	37.0	7.1	0.26	BO	-1.6	-0.2	0.0	0.0	0.0	0.0
	10:00	39.1	7.4	0.25	BO	-1.5	-0.5	0.0	1.4	0.2	0.9
	11:00	28.7	7.7	0.27	BO	-2.0	-0.1	0.2	0.0	0.0	0.0
	12:00	26.7	8.0	0.26	BO	-1.5	-0.5	0.1	0.8	0.0	0.1
	13:00	35.5	9.1	0.26	BO	-1.7	-0.2	0.0	0.3	0.3	0.0
	14:00	23.3	7.4	0.26	BO	-1.6	-0.3	0.0	0.9	0.2	0.3
	15:00	18.9	6.6	0.25	BO	-1.7	-0.3	0.0	0.3	0.0	0.0
	16:00	18.4	6.6	0.27	BO	-1.6	-0.5	0.0	0.3	0.0	0.0
	17:00	18.1	6.8	0.28	BO	-1.8	-0.3	0.0	0.0	0.0	0.1
	18:00	19.3	7.1	0.31	BO	-1.8	-0.5	0.0	0.2	0.0	0.0
	19:00	18.9	7.6	0.36	BO	-1.8	-0.2	0.0	0.1	0.0	0.0
	20:00	16.2	7.2	0.30	BO	-2.0	-0.1	0.0	0.5	0.0	0.0
	21:00	16.2	6.4	0.28	BO	-1.6	-0.1	0.1	0.1	0.0	0.0
	22:00	15.4	6.5	0.28	BO	-1.8	-0.1	0.1	0.2	0.0	0.1
	23:00	15.8	6.4	0.29	BO	-1.8	-0.1	0.0	0.3	0.0	0.0
	0:00	15.7	6.0	0.27	BO	-1.6	-0.1	0.0	0.7	0.2	0.1
Min		9.2	4.1	0.2	ID	-2.0	-0.5	0.0	0.0	0.0	0.0
Max		39.1	9.1	0.4	ID	-1.2	0.2	0.2	1.4	0.3	0.9
Average		20.0	6.4	0.3	ID	-1.7	-0.2	0.0	0.2	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
11/11/2018	1:00	14.6	5.9	0.26	2.9	-1.8	0.0	0.0	0.0	0.0	0.2
	2:00	14.1	6.0	0.26	2.7	-1.8	-0.2	0.0	0.3	0.0	0.0
	3:00	15.5	6.0	0.27	2.5	-1.7	-0.1	0.0	0.0	0.0	0.0
	4:00	15.2	6.4	0.28	2.6	-1.7	0.4	0.0	0.4	0.0	0.0
	5:00	23.3	12.5	0.40	2.1	-1.6	0.7	0.0	0.0	0.0	0.0
	6:00	29.2	13.6	0.40	2.1	-1.6	1.4	0.0	0.0	0.0	0.0
	7:00	27.7	10.3	0.36	2.1	-1.3	0.5	0.0	0.2	0.0	0.0
	8:00	26.2	8.6	0.32	0.5	-1.5	-0.3	0.0	0.2	0.0	0.0
	9:00	22.0	7.2	0.30	0.3	-1.6	-0.2	0.0	0.2	0.0	0.0
	10:00	24.6	7.6	0.31	-0.1	-1.6	-0.5	0.0	0.2	0.0	0.0
	11:00	19.7	7.3	0.28	-0.2	-1.5	-0.4	0.0	0.5	0.0	0.1
	12:00	21.4	7.0	0.29	-0.4	-1.7	-0.2	0.0	0.0	0.0	0.0
	13:00	23.4	7.4	0.28	-0.1	-1.6	-0.4	0.0	0.3	0.0	0.0
	14:00	22.1	9.7	0.29	-0.5	-1.2	-0.5	0.0	0.0	0.1	0.0
	15:00	17.9	6.9	0.27	-1.0	-1.6	-0.3	0.0	0.0	0.0	0.0
	16:00	16.6	5.9	0.27	-1.1	-1.7	-0.2	0.0	0.3	0.0	0.0
	17:00	17.8	5.9	0.29	-0.9	-1.7	-0.3	0.0	0.2	0.0	0.0
	18:00	16.7	6.1	0.29	-0.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	19:00	13.7	5.8	0.31	-1.1	-1.6	-0.3	0.0	0.5	0.0	0.0
	20:00	13.9	5.9	0.30	-0.3	-1.8	-0.1	0.0	0.2	0.0	0.1
	21:00	18.3	6.8	0.39	0.2	-1.7	0.2	0.0	0.3	0.0	0.0
	22:00	19.2	8.4	0.48	-0.4	-1.6	0.1	0.0	0.0	0.0	0.0
	23:00	12.5	5.5	0.30	-1.6	-1.6	-0.1	0.2	0.3	0.0	0.1
	0:00	13.7	5.4	0.35	ZS	-1.7	0.1	0.0	0.0	0.0	0.1
Min		12.5	5.4	0.3	-1.6	-1.8	-0.5	0.0	0.0	0.0	0.0
Max		29.2	13.6	0.5	2.9	-1.2	1.4	0.2	0.5	0.1	0.2
Average		19.1	7.4	0.3	0.4	-1.6	0.0	0.0	0.2	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
12/11/2018	1:00	14.4	5.4	0.37	2.5	ZS	ZS	0.0	0.0	0.0	0.1
	2:00	16.4	7.0	0.33	3.7	-1.4	0.5	0.0	0.2	0.2	0.0
	3:00	14.3	6.5	0.32	2.8	-1.6	0.8	0.2	0.1	0.1	2.3
	4:00	18.0	7.5	0.40	21.7	-1.9	0.4	0.0	0.1	0.0	0.3
	5:00	19.4	7.9	0.52	15.1	-1.2	1.1	0.0	0.0	0.0	0.0
	6:00	31.6	11.3	0.56	13.6	-0.8	0.6	0.0	0.0	0.0	0.0
	7:00	25.1	9.2	0.51	9.6	-0.6	2.4	0.0	0.0	0.0	0.0
	8:00	28.8	6.6	0.43	5.9	-0.7	0.1	0.0	0.0	0.0	0.0
	9:00	20.3	4.6	0.32	4.2	-1.1	-0.5	0.0	0.0	0.0	0.0
	10:00	18.1	5.2	0.30	3.7	-1.7	-0.1	0.0	0.0	0.0	0.0
	11:00	16.5	5.0	0.31	3.1	-1.6	-0.2	0.0	0.3	0.0	0.0
	12:00	15.4	4.7	0.29	2.6	-1.8	-0.2	0.0	0.0	0.0	0.0
	13:00	17.9	6.3	0.30	2.8	-1.6	-0.5	0.0	0.0	0.0	0.0
	14:00	23.0	3.8	0.30	2.4	-1.9	-0.2	0.0	0.0	0.0	0.0
	15:00	19.7	3.7	0.31	3.8	-1.7	-0.4	0.0	0.0	0.0	0.0
	16:00	11.5	3.5	0.30	2.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	17:00	11.2	2.8	0.30	2.2	-1.7	-0.4	0.0	0.0	0.0	0.0
	18:00	8.7	3.0	0.32	1.3	-1.7	-0.1	0.0	0.0	0.0	0.0
	19:00	9.1	3.2	0.32	1.4	-1.5	-0.5	0.0	0.0	0.0	0.3
	20:00	8.7	3.2	0.30	1.2	-1.9	0.0	0.0	0.0	0.0	0.0
	21:00	12.3	4.2	0.28	1.1	-1.6	-0.6	0.0	0.0	0.0	0.0
	22:00	12.0	4.2	0.28	1.1	-1.9	-0.1	0.0	0.5	0.0	0.0
	23:00	10.8	3.9	0.29	0.9	-1.7	-0.4	0.0	0.4	0.0	0.0
	0:00	11.6	3.8	0.28	0.8	-1.7	-0.2	0.0	0.0	0.3	0.0
Min		8.7	2.8	0.3	0.8	-1.9	-0.6	0.0	0.0	0.0	0.0
Max		31.6	11.3	0.6	21.7	-0.6	2.4	0.2	0.5	0.3	2.3
Average		16.4	5.3	0.3	4.6	-1.5	0.1	0.0	0.1	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
13/11/2018	1:00	11.0	3.9	0.29	ZS	-1.9	-0.4	0.0	0.0	0.0	0.0
	2:00	11.0	4.0	0.28	BO	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	10.1	3.9	0.28	BO	-1.6	0.0	0.0	0.0	0.0	0.0
	4:00	10.9	4.1	0.28	BO	-1.6	-0.2	0.0	0.0	0.0	0.0
	5:00	12.0	4.1	0.28	BO	-1.7	-0.1	0.0	0.0	0.0	0.0
	6:00	14.9	4.5	0.31	BO	-1.6	-0.2	0.0	0.0	0.0	0.0
	7:00	19.7	4.6	0.33	BO	-1.6	-0.1	0.0	0.0	0.0	0.0
	8:00	26.2	4.9	0.32	BO	-1.7	-0.3	0.0	0.0	0.0	0.0
	9:00	37.6	5.8	0.35	BO	-1.4	-0.3	0.0	0.0	0.0	0.0
	10:00	41.2	6.1	0.33	BO	-1.6	-0.1	0.0	0.0	0.0	0.0
	11:00	31.2	4.7	0.30	3.2	-1.7	-0.3	0.0	0.0	0.0	0.0
	12:00	39.2	5.3	0.32	2.7	-1.6	-0.2	0.0	0.0	0.0	0.0
	13:00	24.3	4.3	0.29	2.6	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	46.3	5.0	0.30	1.8	-1.7	-0.5	0.0	0.0	0.0	0.0
	15:00	25.2	4.9	0.31	1.7	-1.6	-0.4	0.0	0.4	0.0	0.0
	16:00	19.3	4.7	0.31	1.9	-1.7	-0.2	0.0	0.0	0.0	0.1
	17:00	11.9	3.7	0.31	1.4	-1.8	-0.2	0.0	0.0	0.0	0.0
	18:00	11.6	3.8	0.32	1.2	-1.7	-0.4	0.0	0.2	0.0	0.0
	19:00	12.6	4.1	0.33	1.4	-1.9	-0.1	0.0	0.0	0.0	0.0
	20:00	13.8	6.8	0.35	1.2	-1.4	-0.5	0.1	0.2	0.0	0.0
	21:00	47.1	36.1	0.48	1.8	-0.4	0.0	0.2	0.0	0.0	0.0
	22:00	43.7	34.4	0.50	1.7	-0.2	0.2	0.0	0.0	0.0	0.0
	23:00	32.2	23.3	0.45	1.5	-0.4	-0.1	0.0	0.0	0.0	0.0
	0:00	43.6	33.8	0.51	ZS	-0.1	0.1	0.0	0.0	0.0	0.0
Min		10.1	3.7	0.3	ID	-1.9	-0.5	0.0	0.0	0.0	0.0
Max		47.1	36.1	0.5	ID	-0.1	0.2	0.2	0.4	0.0	0.1
Average		24.8	9.2	0.3	ID	-1.4	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
14/11/2018	1:00	13.3	6.7	0.33	1.1	ZS	ZS	0.0	0.2	0.0	0.0
	2:00	12.7	6.2	0.28	1.0	-1.3	0.1	0.0	0.0	0.0	0.0
	3:00	15.1	8.4	0.29	1.3	-1.4	0.2	0.0	0.2	0.0	0.0
	4:00	10.1	3.8	0.26	0.8	-1.6	0.1	0.0	0.0	0.0	0.0
	5:00	13.8	4.5	0.30	1.6	-1.5	0.0	0.0	0.0	0.0	0.0
	6:00	18.1	5.2	0.29	1.9	-1.5	0.3	0.0	0.0	0.1	0.0
	7:00	14.1	4.5	0.29	0.1	-1.7	0.0	0.0	0.0	0.0	0.0
	8:00	22.1	5.0	0.33	0.2	-1.4	-0.3	0.1	0.3	0.0	0.0
	9:00	27.4	4.7	0.29	0.4	-1.4	-0.2	0.0	0.2	0.0	0.0
	10:00	37.2	5.5	0.28	0.1	-1.4	-0.7	0.0	0.2	0.0	0.0
	11:00	32.4	5.0	0.29	-0.3	-1.4	-0.4	0.0	0.0	0.0	0.1
	12:00	36.8	6.0	0.27	0.0	-1.4	-0.6	0.0	0.0	0.0	0.0
	13:00	33.4	5.0	0.26	-0.6	-1.6	-0.3	0.0	0.2	0.0	0.0
	14:00	36.2	4.7	0.27	-0.1	-1.6	-0.3	0.0	0.1	0.0	0.0
	15:00	24.6	4.7	0.27	-0.5	-1.3	-0.4	0.0	0.0	0.0	0.0
	16:00	32.5	8.0	0.32	0.7	-1.0	-0.1	0.0	0.0	0.0	0.0
	17:00	29.7	4.7	0.28	-0.5	-1.5	-0.2	0.0	0.0	0.0	0.0
	18:00	25.1	5.6	0.34	-0.5	-1.3	-0.3	0.0	0.0	0.0	0.0
	19:00	22.4	8.1	0.33	-0.4	-1.1	-0.2	0.0	0.0	0.0	0.0
	20:00	25.1	10.7	0.32	-0.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	21:00	19.6	8.0	0.30	-0.9	-1.5	-0.2	0.0	0.0	0.0	0.0
	22:00	18.0	7.7	0.29	-0.9	-1.4	-0.2	0.0	0.0	0.0	0.0
	23:00	17.5	7.2	0.29	-1.2	-1.7	0.0	0.0	0.0	0.0	0.0
	0:00	17.7	7.5	0.30	-1.0	-1.6	-0.2	0.0	0.0	0.0	0.0
Min		10.1	3.8	0.3	-1.2	-1.7	-0.7	0.0	0.0	0.0	0.0
Max		37.2	10.7	0.3	1.9	-1.0	0.3	0.1	0.3	0.1	0.1
Average		23.1	6.1	0.3	0.1	-1.4	-0.2	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
15/11/2018	1:00	17.1	7.3	0.28	-1.4	-1.5	-0.3	0.0	0.4	0.0	0.0
	2:00	12.5	5.2	0.28	-1.4	-1.4	-0.3	0.0	0.0	0.0	0.0
	3:00	12.5	5.7	0.29	-1.2	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	17.1	7.8	0.31	-1.3	-1.4	-0.1	0.0	0.0	0.0	0.0
	5:00	22.3	9.0	0.33	-0.7	-1.3	-0.2	0.0	0.2	0.0	0.0
	6:00	34.5	12.2	0.35	0.5	-1.3	0.2	0.0	0.0	0.0	0.0
	7:00	28.7	15.1	0.41	-0.5	-1.1	0.0	0.0	0.2	0.0	0.0
	8:00	33.2	16.6	0.42	0.1	-1.0	0.3	0.0	0.0	0.0	0.0
	9:00	47.6	15.9	0.46	0.0	-0.9	0.6	0.0	0.0	0.0	0.0
	10:00	40.9	12.6	0.36	-0.1	-0.9	0.0	0.0	0.0	0.0	0.0
	11:00	58.7	12.7	0.34	-0.6	-0.8	-0.3	0.0	0.0	0.0	0.0
	12:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	13:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	14:00	77.5	11.3	0.46	-1.3	-1.1	-0.3	0.0	0.0	0.0	0.1
	15:00	27.6	8.7	0.45	-1.5	-1.3	-0.2	0.0	0.0	0.0	0.1
	16:00	24.5	7.9	0.43	-2.2	-1.4	-0.2	0.0	0.0	0.0	0.2
	17:00	21.8	7.8	0.41	-2.0	-1.6	-0.2	0.0	0.0	0.0	0.2
	18:00	26.1	9.0	0.40	-1.8	-1.7	0.0	0.0	0.0	0.0	0.0
	19:00	28.0	10.6	0.39	-1.7	-1.5	-0.2	0.0	0.0	0.0	0.0
	20:00	29.4	11.5	0.37	-1.5	-1.5	0.0	0.0	0.0	0.0	0.0
	21:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	22:00	33.7	12.0	0.86	PO	PO	PO	0.0	0.0	0.0	0.0
	23:00	31.0	11.3	1.00	-1.4	-1.1	0.0	0.0	0.1	0.0	0.6
	0:00	22.1	8.9	0.96	-1.7	-1.4	0.1	0.0	0.0	0.0	0.5
Min		12.5	5.2	0.3	-2.2	-1.7	-0.3	0.0	0.0	0.0	0.0
Max		77.5	16.6	1.0	0.5	-0.8	0.6	0.0	0.4	0.0	0.6
Average		30.8	10.4	0.5	-1.1	-1.3	0.0	0.0	0.0	0.0	0.1

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
16/11/2018	1:00	19.9	7.3	0.90	ZS	-1.4	-0.1	0.0	0.0	0.0	0.0
	2:00	18.8	6.4	0.85	1.0	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	17.8	6.6	0.68	-0.1	-1.2	0.5	0.0	0.0	0.2	0.0
	4:00	15.6	5.5	0.46	-0.4	-1.5	0.2	0.0	0.0	0.0	0.0
	5:00	15.6	5.1	0.38	0.2	-1.3	-0.1	0.0	0.0	0.0	0.0
	6:00	16.6	6.2	0.37	0.3	-1.4	0.1	0.0	0.0	0.0	0.1
	7:00	19.2	6.2	0.39	-1.1	-1.1	-0.1	0.0	0.2	0.0	0.0
	8:00	18.8	6.4	0.40	-1.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	9:00	20.5	6.9	0.37	-2.2	-1.2	0.0	0.0	0.0	0.0	0.4
	10:00	21.2	7.1	0.34	-1.9	-1.2	-0.2	0.0	0.0	0.0	0.1
	11:00	22.0	7.4	0.34	-1.7	-1.3	-0.1	0.0	0.0	0.0	0.0
	12:00	22.6	7.6	0.33	-2.0	-1.1	-0.5	0.0	0.0	0.0	0.0
	13:00	21.7	7.7	0.32	-2.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	14:00	29.7	13.1	0.38	-0.9	-0.8	-0.5	0.0	0.0	0.0	0.0
	15:00	23.0	8.2	0.33	-1.9	-1.2	-0.4	0.0	0.0	0.0	0.0
	16:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	17:00	23.1	8.3	0.46	PO	PO	PO	PO	PO	PO	PO
	18:00	24.1	8.1	0.44	-1.9	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	25.1	8.3	0.43	-1.6	-1.5	-0.1	0.0	0.0	0.0	0.0
	20:00	21.0	7.7	0.42	-1.0	-1.4	0.2	0.0	0.0	0.0	0.0
	21:00	19.8	7.5	0.39	-1.7	-1.3	-0.2	0.0	0.0	0.0	0.0
	22:00	19.7	7.7	0.37	-1.6	-1.4	-0.2	0.0	0.0	0.0	0.0
	23:00	21.8	8.2	0.38	-1.9	-1.2	0.2	0.0	0.0	0.0	0.0
	0:00	21.0	8.4	0.37	ZS	-1.6	0.1	0.0	0.0	0.0	0.0
Min		15.6	5.1	0.3	-2.2	-1.6	-0.5	0.0	0.0	0.0	0.0
Max		29.7	13.1	0.9	1.0	-0.8	0.5	0.0	0.2	0.2	0.4
Average		20.8	7.5	0.4	-1.2	-1.3	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
17/11/2018	1:00	21.2	8.3	0.36	-1.0	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	20.1	8.0	0.26	-1.0	-1.1	0.0	0.0	0.0	0.0	0.0
	3:00	16.5	6.8	0.26	-0.9	-1.5	0.1	0.0	0.0	0.0	0.0
	4:00	17.0	6.7	0.27	0.9	-1.4	0.6	0.0	0.0	0.0	0.0
	5:00	16.3	6.4	0.26	-0.3	-1.4	0.2	0.0	0.0	0.0	0.0
	6:00	19.4	6.9	0.30	0.9	-1.2	0.2	0.0	0.0	0.0	0.0
	7:00	21.0	7.9	0.39	0.0	-0.9	0.2	0.0	0.0	0.0	0.0
	8:00	20.6	6.6	0.29	-1.9	-0.9	-0.1	0.0	0.0	0.0	0.0
	9:00	20.8	6.7	0.26	-2.8	-1.3	-0.2	0.0	0.0	0.0	0.0
	10:00	20.2	6.3	0.25	-2.1	-1.3	-0.2	0.0	0.0	0.0	0.0
	11:00	17.8	5.9	0.25	-2.2	-1.2	-0.1	0.0	0.0	0.0	0.0
	12:00	18.0	5.9	0.24	-2.0	-1.2	-0.1	0.0	0.0	0.0	0.0
	13:00	18.6	6.1	0.24	-2.1	-1.4	-0.5	0.0	0.0	0.0	0.0
	14:00	16.6	6.1	0.24	-2.3	-1.2	-0.4	0.0	0.0	0.0	0.0
	15:00	15.6	6.0	0.24	-2.0	-1.3	-0.5	0.0	0.0	0.0	0.0
	16:00	17.0	6.1	0.24	-2.5	-1.3	-0.5	0.0	0.0	0.0	0.0
	17:00	16.5	6.0	0.24	-2.3	-1.3	-0.2	0.0	0.0	0.0	0.0
	18:00	14.6	5.9	0.25	-2.6	-1.4	-0.4	0.0	0.0	0.0	0.0
	19:00	14.7	5.7	0.26	-2.4	-1.2	-0.4	0.0	0.0	0.0	0.0
	20:00	14.1	5.6	0.25	-2.4	-1.3	-0.3	0.0	0.0	0.0	0.0
	21:00	14.6	5.3	0.24	-2.3	-1.3	-0.5	0.0	0.0	0.0	0.0
	22:00	14.2	5.5	0.24	-2.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	23:00	15.9	6.5	0.23	-2.1	-1.6	-0.1	0.0	0.0	0.0	0.0
	0:00	15.5	6.3	0.23	-1.9	-1.3	-0.4	0.0	0.0	0.0	0.0
Min		14.1	5.3	0.2	-2.8	-1.6	-0.5	0.0	0.0	0.0	0.0
Max		21.2	8.3	0.4	0.9	-0.9	0.6	0.0	0.0	0.0	0.0
Average		17.4	6.4	0.3	-1.6	-1.3	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
18/11/2018	1:00	15.1	6.3	0.23	-1.9	-1.3	-0.3	0.0	0.3	0.2	0.1
	2:00	14.4	6.1	0.23	-1.9	-1.5	-0.2	0.0	0.1	0.0	0.0
	3:00	15.6	6.4	0.23	-1.8	-1.5	-0.1	0.0	0.2	0.0	0.0
	4:00	14.7	6.1	0.23	-1.9	-1.5	-0.3	0.0	0.3	0.1	0.2
	5:00	14.5	6.2	0.24	-0.8	-1.4	0.1	0.0	0.0	0.0	0.0
	6:00	16.1	5.9	0.24	-1.3	-1.3	0.0	0.0	0.0	0.0	0.1
	7:00	20.3	6.5	0.29	-0.3	-1.2	0.1	0.0	0.0	0.0	0.0
	8:00	18.4	6.4	0.27	-1.9	-1.2	-0.2	0.0	0.1	0.0	0.0
	9:00	16.4	5.3	0.27	-1.8	-1.1	-0.2	0.0	0.0	0.0	0.2
	10:00	17.2	5.0	0.26	-1.5	-1.2	0.0	0.0	0.0	0.0	0.0
	11:00	14.1	4.9	0.26	-1.9	-1.3	-0.3	0.0	0.0	0.0	0.0
	12:00	14.2	4.9	0.26	-2.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	13:00	15.1	5.2	0.25	-2.0	-1.2	-0.2	0.0	0.1	0.0	0.1
	14:00	17.3	8.1	0.28	-1.5	-0.7	-0.7	0.0	0.0	0.0	0.0
	15:00	11.7	4.2	0.24	-2.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	16:00	12.4	4.2	0.24	-2.1	-1.4	-0.2	0.0	0.2	0.1	0.0
	17:00	12.6	4.3	0.25	-2.0	-1.4	-0.1	0.0	0.2	0.0	0.0
	18:00	12.6	4.6	0.26	-1.7	-1.2	-0.5	0.0	0.0	0.0	0.0
	19:00	15.6	6.5	0.27	-2.2	-1.5	-0.1	0.0	0.0	0.0	0.1
	20:00	12.9	4.9	0.25	-2.7	-1.3	-0.2	0.0	0.1	0.0	0.0
	21:00	13.7	5.3	0.24	-2.4	-1.1	-0.6	0.0	0.0	0.1	0.1
	22:00	15.1	5.7	0.25	-2.1	-1.4	-0.3	0.0	0.6	0.0	0.3
	23:00	16.9	6.7	0.26	-2.0	-1.6	-0.1	0.0	0.0	0.0	0.0
	0:00	16.6	6.6	0.25	ZS	-1.3	-0.4	0.1	0.2	0.0	0.0
Min		11.7	4.2	0.2	-2.7	-1.6	-0.7	0.0	0.0	0.0	0.0
Max		20.3	8.1	0.3	-0.3	-0.7	0.1	0.1	0.6	0.2	0.3
Average		15.1	5.7	0.3	-1.8	-1.3	-0.2	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
19/11/2018	1:00	17.0	6.9	0.26	-2.6	ZS	ZS	0.0	0.4	0.0	0.0
	2:00	17.5	6.9	0.26	-2.6	-1.2	0.3	0.0	0.0	0.2	0.0
	3:00	17.1	6.8	0.27	-2.2	-1.3	0.5	0.0	0.0	0.0	0.2
	4:00	11.6	4.5	0.26	-2.3	-1.2	0.2	0.0	0.5	0.0	0.0
	5:00	11.8	4.5	0.27	-1.8	-1.2	0.0	0.0	0.0	0.0	0.1
	6:00	15.1	4.6	0.31	-1.1	-1.1	0.0	0.0	0.0	0.0	0.0
	7:00	18.9	5.8	0.40	-1.5	-1.0	0.2	0.0	0.2	0.0	0.0
	8:00	21.8	6.5	0.35	-2.7	-1.0	-0.3	0.0	0.0	0.0	0.0
	9:00	24.4	7.4	0.30	-4.0	-1.0	-0.3	0.0	0.2	0.0	0.1
	10:00	23.6	8.4	0.28	-3.8	-1.2	-0.3	0.0	0.6	0.2	0.0
	11:00	24.9	9.8	0.30	-3.4	-1.0	-0.1	0.0	0.2	0.0	0.0
	12:00	22.9	9.1	0.29	-3.6	-1.0	-0.5	0.0	0.2	0.0	0.0
	13:00	24.8	8.1	0.26	-4.0	-1.0	-0.6	0.0	0.0	0.0	0.0
	14:00	17.9	6.5	0.28	-3.5	-1.2	-0.4	0.0	0.0	0.0	0.0
	15:00	21.8	8.1	0.28	-4.4	-1.4	-0.3	0.0	0.0	0.0	0.0
	16:00	22.6	7.7	0.27	-3.8	-1.3	-0.3	0.0	0.0	0.0	0.0
	17:00	18.0	6.8	0.29	-3.5	-1.3	-0.2	0.0	0.0	0.0	0.0
	18:00	16.9	6.6	0.46	-4.0	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	18.1	7.0	0.70	-1.8	-1.2	-0.1	0.0	0.0	0.0	0.0
	20:00	14.0	5.8	0.39	-2.2	-1.1	0.0	0.2	0.6	0.2	4.6
	21:00	14.4	5.7	0.38	-2.3	-1.0	0.1	0.1	0.2	0.1	7.9
	22:00	21.2	7.5	0.31	-3.9	-1.3	-0.2	0.0	0.0	0.0	0.0
	23:00	20.0	7.5	0.31	-4.0	-1.3	0.2	0.0	0.0	0.0	0.0
	0:00	14.9	5.8	ZS	ZS	-1.3	-0.1	0.0	0.0	0.0	0.1
Min		11.6	4.5	0.3	-4.4	-1.4	-0.6	0.0	0.0	0.0	0.0
Max		24.9	9.8	0.7	-1.1	-1.0	0.5	0.2	0.6	0.2	7.9
Average		18.8	6.8	0.3	-3.0	-1.2	-0.1	0.0	0.1	0.0	0.5

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
20/11/2018	1:00	15.0	4.8	0.30	ZS	-1.2	-0.4	0.0	0.0	0.0	0.0
	2:00	16.9	5.4	0.29	-2.8	ZS	ZS	0.0	0.3	0.0	0.4
	3:00	16.9	5.5	0.29	-3.7	-1.1	0.3	0.0	0.4	0.0	0.0
	4:00	17.2	6.0	0.29	-3.8	-1.1	-0.1	0.0	0.0	0.0	0.0
	5:00	18.9	6.7	0.29	-3.9	-1.2	-0.2	0.0	0.0	0.0	0.0
	6:00	20.1	7.7	0.31	-3.5	-1.5	0.1	0.0	0.0	0.0	0.0
	7:00	22.2	7.4	0.31	-3.5	-1.2	-0.1	0.0	0.0	0.0	0.0
	8:00	17.9	6.3	0.29	-4.3	-1.1	-0.4	0.0	0.0	0.0	0.0
	9:00	13.7	5.2	0.30	-4.1	-1.1	-0.3	0.0	0.0	0.0	0.0
	10:00	17.1	5.5	0.28	-4.3	-1.0	-0.5	0.0	0.0	0.0	0.0
	11:00	18.9	6.7	PO	-4.2	-1.4	-0.5	0.0	0.0	0.0	0.0
	12:00	19.7	7.1	0.38	-4.3	-1.3	-0.4	0.0	0.0	0.0	0.0
	13:00	19.5	6.9	0.36	-4.5	-1.3	-0.4	0.0	0.0	0.0	0.0
	14:00	20.7	7.5	0.35	-4.4	-1.2	-0.5	0.0	0.0	0.0	0.0
	15:00	23.0	7.2	0.34	-4.2	-1.3	-0.2	0.0	0.4	0.0	0.0
	16:00	18.4	7.0	0.32	-4.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	17:00	19.9	7.2	0.32	-4.4	-1.4	-0.1	0.0	0.0	0.0	0.0
	18:00	19.5	7.4	0.33	-4.2	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	20.4	7.6	0.33	-4.2	-1.4	-0.1	0.0	0.0	0.0	0.0
	20:00	21.0	7.5	0.33	-4.2	-1.3	-0.1	0.0	0.0	0.0	0.0
	21:00	20.5	7.5	0.31	-4.3	-1.1	-0.4	0.0	0.0	0.0	0.0
	22:00	20.1	7.6	0.31	-4.2	-1.3	-0.1	0.0	0.0	0.0	0.0
	23:00	19.0	7.4	0.30	-4.0	-1.3	-0.2	0.0	0.0	0.0	0.0
	0:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
Min		13.7	4.8	0.3	-4.5	-1.5	-0.5	0.0	0.0	0.0	0.0
Max		23.0	7.7	0.4	-2.8	-1.0	0.3	0.0	0.4	0.0	0.4
Average		19.0	6.7	0.3	-4.0	-1.3	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
21/11/2018	1:00	19.1	7.4	PO	-2.5	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	18.4	7.2	0.33	-3.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	3:00	17.5	7.0	0.31	-3.4	-1.3	-0.3	0.0	0.0	0.0	0.0
	4:00	15.6	6.4	0.30	-3.8	-1.2	-0.1	0.0	0.0	0.0	0.0
	5:00	16.2	6.2	0.29	-3.6	-1.3	-0.1	0.0	0.0	0.0	0.0
	6:00	18.4	6.4	0.31	-1.9	-1.1	-0.4	0.0	0.0	0.0	0.0
	7:00	19.0	6.4	0.33	-3.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	8:00	21.9	6.5	0.32	-4.0	-1.1	-0.5	0.0	0.0	0.0	0.0
	9:00	23.8	6.4	0.33	-2.1	-0.9	-0.3	0.0	0.0	0.0	0.0
	10:00	22.8	7.0	0.30	-3.2	-1.1	-0.2	0.0	0.0	0.0	0.0
	11:00	23.0	6.4	0.28	-4.0	-1.2	-0.2	0.0	0.0	0.0	0.0
	12:00	20.4	6.8	0.28	-4.0	-1.4	-0.2	0.0	0.0	0.0	0.0
	13:00	21.7	7.2	0.28	-4.0	-1.1	-0.4	0.0	0.0	0.0	0.0
	14:00	28.1	7.1	0.28	-3.8	-1.3	-0.5	0.0	0.0	0.0	0.0
	15:00	21.5	7.0	0.28	-4.1	-1.3	-0.3	0.0	0.0	0.0	0.0
	16:00	22.8	7.1	0.28	-4.1	-1.3	-0.5	0.0	0.0	0.0	0.0
	17:00	27.0	7.3	0.28	-4.2	-1.4	-0.2	0.0	0.0	0.0	0.0
	18:00	18.1	6.8	0.28	-4.1	-1.2	-0.5	0.0	0.0	0.0	0.0
	19:00	19.1	6.8	0.28	-3.7	-1.4	-0.1	0.0	0.0	0.0	0.0
	20:00	18.5	6.5	0.27	-4.2	-1.2	-0.1	0.0	0.0	0.0	0.0
	21:00	17.5	6.6	0.27	-4.3	-1.3	-0.3	0.0	0.0	0.0	0.0
	22:00	16.1	6.3	0.26	-4.1	-1.3	-0.2	0.0	0.0	0.0	0.0
	23:00	16.2	6.2	0.26	-4.0	-1.4	-0.2	0.0	0.0	0.0	0.0
	0:00	17.1	6.4	0.26	-4.0	-1.3	-0.1	0.0	0.0	0.0	0.0
Min		15.6	6.2	0.3	-4.3	-1.4	-0.5	0.0	0.0	0.0	0.0
Max		28.1	7.4	0.3	-1.9	-0.9	-0.1	0.0	0.0	0.0	0.0
Average		20.0	6.7	0.3	-3.7	-1.2	-0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
22/11/2018	1:00	15.7	6.2	0.25	-3.8	-1.4	-0.1	0.0	0.0	0.0	0.0
	2:00	14.8	5.7	0.26	-3.5	-1.2	-0.2	0.0	0.0	0.0	0.0
	3:00	14.9	5.7	0.26	-3.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	4:00	15.9	5.7	0.25	-3.6	-1.4	0.2	0.0	0.0	0.0	0.0
	5:00	18.3	5.8	0.27	-3.5	-1.4	0.3	0.0	0.0	0.0	0.0
	6:00	17.4	5.9	0.28	-3.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	7:00	16.7	5.7	0.28	-3.9	-1.4	0.1	0.0	0.0	0.0	0.0
	8:00	18.0	6.0	0.29	-3.3	-1.5	0.0	0.0	0.0	0.0	0.0
	9:00	17.2	5.8	0.28	-3.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	10:00	16.4	5.5	0.26	-4.0	-1.2	-0.3	0.0	0.0	0.0	0.0
	11:00	16.1	5.3	0.26	-3.6	-1.3	-0.3	0.0	0.0	0.0	0.0
	12:00	16.2	5.4	0.26	-3.6	-1.2	-0.5	0.0	0.0	0.0	0.0
	13:00	18.5	5.8	0.27	-3.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	14:00	17.5	6.1	0.26	-3.2	-0.9	-0.5	0.0	0.0	0.0	0.0
	15:00	17.2	5.7	0.26	-3.6	-1.2	-0.4	0.0	0.0	0.0	0.0
	16:00	17.0	6.1	0.27	-3.8	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	17.1	6.1	0.27	-3.5	-1.2	-0.3	0.0	0.0	0.0	0.0
	18:00	17.5	6.2	0.29	-3.5	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	17.3	6.0	0.29	-3.7	-1.3	-0.1	0.0	0.0	0.0	0.0
	20:00	15.4	5.8	0.29	-3.4	-1.0	-0.2	0.0	0.0	0.0	0.0
	21:00	14.5	5.8	0.28	-3.1	-1.4	0.1	0.0	0.0	0.0	0.0
	22:00	13.8	5.6	0.27	-3.5	-1.2	-0.3	0.0	0.0	0.0	0.0
	23:00	14.7	5.7	0.28	-3.7	-1.2	-0.4	0.0	0.0	0.0	0.0
	0:00	15.7	5.6	0.24	-3.3	-1.3	-0.3	0.0	0.0	0.0	0.0
Min		13.8	5.3	0.2	-4.0	-1.5	-0.5	0.0	0.0	0.0	0.0
Max		18.5	6.2	0.3	-3.1	-0.9	0.3	0.0	0.0	0.0	0.0
Average		16.4	5.8	0.3	-3.5	-1.2	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
23/11/2018	1:00	14.5	5.6	0.25	ZS	-1.3	-0.1	0.0	0.0	0.0	0.0
	2:00	14.7	5.6	0.25	-1.0	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	14.0	5.3	0.24	-1.5	-0.8	-0.2	0.0	0.0	0.0	0.0
	4:00	14.1	5.2	0.24	-2.2	-1.4	0.2	0.0	0.0	0.0	0.0
	5:00	14.5	5.4	0.24	-2.4	-1.2	0.0	0.0	0.0	0.0	0.0
	6:00	16.0	5.3	0.27	-1.1	-1.1	0.0	0.0	0.0	0.0	0.0
	7:00	22.3	7.0	0.31	0.2	-0.9	0.0	0.0	0.0	0.0	0.0
	8:00	22.7	5.8	0.28	-2.5	-0.9	-0.2	0.0	0.0	0.0	0.0
	9:00	21.2	5.8	0.27	-2.9	-1.1	-0.2	0.0	0.0	0.0	0.0
	10:00	20.5	5.5	0.24	-2.9	-1.2	-0.4	0.0	0.0	0.0	0.0
	11:00	23.3	7.6	0.27	-2.9	-1.0	-0.2	0.0	0.5	0.0	0.0
	12:00	22.3	6.9	0.25	-2.5	-0.9	-0.4	0.0	0.0	0.0	0.0
	13:00	25.8	6.0	0.25	-2.5	-1.0	-0.3	0.0	0.2	0.0	0.1
	14:00	22.4	5.9	0.25	-3.2	-1.1	-0.4	0.0	0.1	0.0	0.0
	15:00	19.9	5.5	0.26	-2.6	-1.1	-0.3	0.1	0.0	0.0	0.2
	16:00	25.0	6.4	0.26	-2.5	-1.0	-0.3	0.0	0.0	0.0	0.2
	17:00	19.1	5.5	0.26	-2.9	-1.2	-0.3	0.0	0.0	0.0	0.0
	18:00	19.7	7.6	0.31	-2.6	-0.8	-0.4	0.0	0.0	0.0	0.0
	19:00	16.0	5.9	0.32	-2.8	-0.9	-0.2	0.0	0.2	0.0	0.0
	20:00	15.6	5.5	0.30	-2.8	-1.0	-0.2	0.0	0.0	0.0	0.1
	21:00	15.1	5.3	0.28	-2.6	-1.0	-0.1	0.0	0.0	0.0	0.1
	22:00	14.3	5.1	0.27	-2.3	-1.2	0.1	0.0	0.2	0.0	0.0
	23:00	13.2	5.2	0.27	-2.3	-1.2	0.2	0.0	0.4	0.0	0.0
	0:00	13.9	5.4	0.26	ZS	-1.1	-0.2	0.0	0.1	0.0	0.0
Min		13.2	5.1	0.2	-3.2	-1.4	-0.4	0.0	0.0	0.0	0.0
Max		25.8	7.6	0.3	0.2	-0.8	0.2	0.1	0.5	0.0	0.2
Average		18.3	5.8	0.3	-2.3	-1.1	-0.2	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
24/11/2018	1:00	12.9	4.9	0.26	-1.9	ZS	ZS	0.1	0.0	0.0	0.0
	2:00	13.7	5.1	0.27	-2.1	-1.0	0.0	0.0	0.0	0.0	0.0
	3:00	13.8	5.1	0.25	-2.4	-1.2	-0.2	0.1	0.0	0.0	0.0
	4:00	13.1	5.1	0.25	-2.6	-1.1	-0.4	0.1	0.1	0.0	0.0
	5:00	14.8	5.2	0.26	-2.7	-1.3	0.5	0.0	0.0	0.0	0.3
	6:00	17.5	5.5	0.30	-1.1	-1.0	0.1	0.1	0.1	0.0	0.2
	7:00	24.0	6.7	0.47	0.3	-0.6	0.2	0.0	0.0	0.0	0.0
	8:00	18.2	5.6	0.33	-2.3	-0.9	-0.2	0.0	0.1	0.0	0.0
	9:00	16.5	5.0	0.29	-2.7	-0.8	-0.7	0.0	0.2	0.0	0.0
	10:00	14.4	4.8	0.27	-3.0	-1.1	-0.4	0.0	0.1	0.0	0.0
	11:00	14.7	4.6	0.27	-2.7	-1.1	-0.4	0.0	0.0	0.0	0.0
	12:00	13.2	4.2	0.27	-3.0	-1.0	-0.5	0.0	0.0	0.0	0.0
	13:00	15.1	4.0	0.27	-2.7	-1.2	-0.4	0.0	0.0	0.0	0.0
	14:00	15.0	6.9	0.30	-3.1	-1.1	-0.4	0.0	0.0	0.0	0.0
	15:00	11.1	3.8	0.28	-3.5	-1.3	-0.4	0.0	0.0	0.0	0.1
	16:00	12.1	4.2	0.29	-2.9	-1.2	-0.5	0.0	0.0	0.0	0.0
	17:00	12.3	5.3	0.31	-2.7	-1.1	-0.3	0.0	0.1	0.0	0.1
	18:00	11.9	3.9	0.31	-2.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	9.1	3.1	0.32	-2.9	-1.1	-0.3	0.0	0.2	0.0	0.0
	20:00	9.9	3.6	0.30	-3.0	-1.5	0.1	0.0	0.0	0.0	0.0
	21:00	10.3	3.6	0.28	-3.1	-1.4	0.0	0.0	0.0	0.0	0.0
	22:00	11.6	4.3	0.29	-3.0	-1.3	-0.1	0.0	0.2	0.0	0.1
	23:00	12.4	4.7	0.29	-3.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	0:00	14.5	5.3	0.32	-2.4	-1.2	0.1	0.0	0.1	0.0	0.1
Min		9.1	3.1	0.2	-3.5	-1.5	-0.7	0.0	0.0	0.0	0.0
Max		24.0	6.9	0.5	0.3	-0.6	0.5	0.1	0.2	0.0	0.3
Average		13.8	4.8	0.3	-2.6	-1.1	-0.2	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
25/11/2018	1:00	13.7	5.1	0.30	-2.8	-1.0	0.2	0.0	0.2	0.0	0.2
	2:00	14.1	5.5	0.28	-2.3	-1.1	-0.3	0.0	0.0	0.0	0.0
	3:00	14.1	5.7	0.28	-3.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	4:00	14.4	5.8	0.28	-3.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	5:00	13.4	5.3	0.28	-3.0	-1.2	-0.2	0.0	0.0	0.0	0.0
	6:00	12.5	4.8	0.31	-1.9	-1.2	0.1	0.0	0.0	0.0	0.0
	7:00	19.0	5.9	0.33	-2.6	-1.4	0.2	0.0	0.0	0.0	0.0
	8:00	12.1	4.4	0.32	-3.4	-1.1	-0.1	0.0	0.0	0.0	0.0
	9:00	12.4	4.5	0.32	-3.5	-1.0	-0.3	0.0	0.0	0.0	0.0
	10:00	15.4	5.4	0.32	-3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	11:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	12:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	13:00	19.3	7.2	0.46	-3.5	-1.0	-0.5	0.0	0.0	0.0	0.0
	14:00	19.0	7.0	0.44	-3.7	-1.1	-0.3	0.0	0.0	0.0	0.0
	15:00	12.5	4.7	0.43	-3.5	-1.5	-0.1	0.0	0.0	0.0	0.0
	16:00	27.0	9.4	0.40	-3.4	-1.5	-0.1	0.0	0.0	0.0	0.0
	17:00	27.9	10.1	0.39	-3.8	-1.2	-0.4	0.0	0.0	0.0	0.0
	18:00	29.3	10.2	0.37	-3.6	-1.3	-0.1	0.0	0.0	0.0	0.0
	19:00	29.2	10.2	0.36	-3.4	-1.2	-0.1	0.0	0.0	0.0	0.0
	20:00	27.0	10.0	0.36	-3.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	21:00	25.6	9.4	0.36	-3.5	-1.2	-0.3	0.0	0.0	0.0	0.0
	22:00	24.0	9.0	0.35	-3.5	-1.6	0.0	0.0	0.0	0.0	0.0
	23:00	23.2	8.8	0.34	-3.6	-1.4	-0.1	0.0	0.0	0.0	0.0
	0:00	22.9	8.7	0.34	ZS	-1.3	-0.1	0.0	0.0	0.0	0.0
Min		12.1	4.4	0.3	-3.8	-1.6	-0.5	0.0	0.0	0.0	0.0
Max		29.3	10.2	0.5	-1.9	-1.0	0.2	0.0	0.2	0.0	0.2
Average		19.4	7.1	0.3	-3.2	-1.2	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
26/11/2018	1:00	24.1	8.9	0.34	-0.8	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	24.2	8.9	0.34	-1.4	-1.2	-0.1	0.0	0.0	0.0	0.0
	3:00	23.2	9.0	0.34	-1.6	-1.3	0.0	0.0	0.0	0.0	0.0
	4:00	23.5	9.3	0.33	-0.9	-1.2	0.0	0.0	0.0	0.0	0.0
	5:00	24.4	9.3	0.33	-1.2	-1.1	0.0	0.0	0.0	0.0	0.0
	6:00	25.4	9.3	0.37	-0.2	-1.1	0.0	0.0	0.0	0.0	0.0
	7:00	24.1	9.3	0.38	-1.3	-1.2	-0.1	0.0	0.0	0.0	0.0
	8:00	27.7	10.0	0.38	-1.4	-1.0	-0.3	0.0	0.0	0.0	0.0
	9:00	30.5	10.5	0.38	-1.8	-1.2	-0.2	0.0	0.0	0.0	0.0
	10:00	29.2	10.3	0.35	-1.5	-1.1	-0.2	0.0	0.0	0.0	0.0
	11:00	30.8	10.4	0.34	-1.8	-1.3	-0.2	0.0	0.0	0.0	0.0
	12:00	28.7	9.8	0.34	-1.7	-1.3	-0.1	0.0	0.0	0.0	0.0
	13:00	29.0	10.8	0.35	-1.6	-1.0	-0.4	0.0	0.0	0.0	0.0
	14:00	31.1	13.1	0.38	-1.1	-0.7	-0.7	0.0	0.0	0.0	0.0
	15:00	23.0	8.9	0.35	-1.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	16:00	24.2	10.7	0.37	-1.2	-0.9	-0.4	0.0	0.0	0.0	0.0
	17:00	21.5	8.6	0.36	-1.8	-1.1	-0.5	0.0	0.0	0.0	0.0
	18:00	19.3	7.0	0.37	-1.7	-1.4	0.0	0.0	0.0	0.0	0.0
	19:00	19.6	7.4	0.37	-1.8	-1.1	-0.4	0.0	0.0	0.0	0.0
	20:00	21.3	8.7	0.37	-1.9	-1.3	0.0	0.0	0.0	0.0	0.0
	21:00	22.2	9.1	0.36	-2.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	22:00	21.5	9.0	0.36	-1.8	-0.9	-0.4	0.0	0.0	0.0	0.0
	23:00	20.7	8.0	0.36	-1.7	-1.2	0.0	0.0	0.0	0.0	0.0
	0:00	19.8	8.0	0.36	-1.9	-1.3	0.0	0.0	0.0	0.0	0.0
Min		19.3	7.0	0.3	-2.1	-1.4	-0.7	0.0	0.0	0.0	0.0
Max		31.1	13.1	0.4	-0.2	-0.7	0.0	0.0	0.0	0.0	0.0
Average		24.5	9.3	0.4	-1.5	-1.1	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
27/11/2018	1:00	18.8	7.4	0.36	ZS	-1.1	-0.3	0.0	0.0	0.0	0.0
	2:00	19.3	7.4	0.36	-1.1	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	17.4	6.7	0.35	-1.4	-1.0	0.0	0.0	0.0	0.0	0.0
	4:00	15.7	5.3	0.35	-0.9	-1.0	0.7	0.0	0.0	0.0	0.0
	5:00	21.1	6.6	0.38	0.7	-1.1	1.5	0.0	0.0	0.0	0.0
	6:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	7:00	21.1	6.5	0.52	-0.5	-1.0	0.2	0.0	0.0	0.0	0.0
	8:00	19.4	7.5	0.56	0.7	-0.8	0.0	0.0	0.0	0.0	0.0
	9:00	28.4	9.5	0.54	-0.9	-0.7	0.2	0.0	0.0	0.0	0.0
	10:00	21.9	9.2	0.48	-1.7	-1.1	-0.1	0.0	0.0	0.0	0.0
	11:00	14.8	5.4	0.44	-2.3	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	19.2	6.6	0.44	-2.3	-1.1	-0.4	0.0	0.0	0.0	0.0
	13:00	15.2	5.3	0.43	-2.1	-1.1	-0.5	0.0	0.0	0.0	0.0
	14:00	10.1	3.3	0.42	-1.9	-1.1	-0.2	0.0	0.0	0.0	0.0
	15:00	11.6	4.0	0.41	-2.0	-1.2	-0.1	0.0	0.0	0.0	0.0
	16:00	13.2	4.5	0.44	-1.4	-1.2	0.0	0.0	0.0	0.0	0.0
	17:00	15.0	5.6	0.42	-1.8	-1.2	-0.2	0.0	0.0	0.0	0.0
	18:00	20.0	7.0	0.43	-1.0	-1.1	-0.3	0.0	0.0	0.0	0.0
	19:00	20.0	7.0	0.42	-1.5	-1.2	-0.1	0.0	0.0	0.0	0.0
	20:00	23.0	7.9	0.40	-1.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	21:00	25.0	9.5	0.38	-2.2	-1.1	-0.3	0.0	0.0	0.0	0.0
	22:00	30.5	12.4	0.42	-1.3	-0.9	-0.1	0.0	0.0	0.0	0.0
	23:00	35.4	14.0	0.39	-2.1	-1.1	-0.3	0.0	0.0	0.0	0.0
	0:00	37.2	14.9	0.39	ZS	-1.3	0.0	0.0	0.0	0.0	0.0
Min		10.1	3.3	0.4	-2.3	-1.3	-0.5	0.0	0.0	0.0	0.0
Max		37.2	14.9	0.6	0.7	-0.7	1.5	0.0	0.0	0.0	0.0
Average		20.6	7.5	0.4	-1.4	-1.1	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
28/11/2018	1:00	30.8	11.7	0.37	-1.0	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	26.9	10.0	0.28	-1.2	-1.1	0.5	0.0	0.0	0.0	0.0
	3:00	26.1	9.5	0.29	-1.5	-1.2	0.1	0.0	0.0	0.0	0.0
	4:00	26.6	8.9	0.29	-1.7	-1.1	0.1	0.0	0.0	0.0	0.0
	5:00	18.5	5.7	0.30	-0.2	-1.1	-0.1	0.0	0.0	0.0	0.0
	6:00	21.7	6.1	0.32	0.5	-1.1	0.1	0.0	0.0	0.0	0.0
	7:00	20.2	6.0	0.38	0.6	-0.8	0.2	0.0	0.0	0.0	0.0
	8:00	15.1	5.0	0.38	-0.4	-0.7	0.0	0.0	0.0	0.0	0.0
	9:00	18.7	4.9	0.34	-1.1	-0.8	-0.2	0.0	0.0	0.0	0.0
	10:00	25.2	7.2	0.32	-1.5	-1.0	-0.1	0.0	0.0	0.0	0.0
	11:00	28.4	8.8	0.30	-2.3	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	22.5	7.8	0.29	-2.5	-1.1	-0.2	0.0	0.0	0.0	0.0
	13:00	28.7	10.1	0.30	-2.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	25.9	9.3	0.29	-2.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	15:00	31.1	10.7	0.30	-2.3	-1.1	-0.6	0.0	0.0	0.0	0.0
	16:00	30.2	9.9	0.30	-2.2	-1.1	-0.3	0.0	0.0	0.0	0.0
	17:00	33.7	12.1	0.30	-1.7	-1.1	-0.5	0.0	0.0	0.0	0.0
	18:00	35.9	13.1	0.31	-1.7	-1.1	-0.2	0.0	0.0	0.0	0.0
	19:00	41.2	14.7	0.31	-2.1	-1.0	-0.4	0.0	0.0	0.0	0.0
	20:00	40.0	15.2	0.31	-2.2	-1.0	-0.3	0.0	0.0	0.0	0.0
	21:00	41.0	15.5	0.30	-2.4	-1.1	-0.5	0.0	0.0	0.0	0.0
	22:00	44.4	16.6	0.29	-2.2	-1.1	-0.2	0.0	0.0	0.0	0.0
	23:00	46.2	17.3	0.30	-2.2	-1.3	0.0	0.0	0.0	0.0	0.0
	0:00	45.3	17.3	0.29	-2.3	-1.3	-0.1	0.0	0.0	0.0	0.0
Min		15.1	4.9	0.3	-2.5	-1.3	-0.6	0.0	0.0	0.0	0.0
Max		46.2	17.3	0.4	0.6	-0.7	0.5	0.0	0.0	0.0	0.0
Average		30.2	10.6	0.3	-1.6	-1.1	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	CO ppm	NO_2 ppb	SO_2 ppb	H_2S ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
29/11/2018	1:00	44.2	16.8	0.29	-2.3	-1.2	-0.1	0.0	0.0	0.0	0.0
	2:00	39.7	15.6	0.28	-2.4	-1.3	0.0	0.0	0.0	0.0	0.0
	3:00	39.5	15.7	0.28	-2.4	-1.2	0.1	0.0	0.0	0.0	0.0
	4:00	39.4	15.7	0.28	-2.3	-1.1	0.1	0.0	0.0	0.0	0.0
	5:00	40.5	15.8	0.28	-2.0	-1.2	0.2	0.0	0.0	0.0	0.0
	6:00	39.7	15.8	0.30	-1.9	-1.0	0.0	0.0	0.0	0.0	0.0
	7:00	39.2	15.2	0.30	-1.6	-1.1	-0.2	0.0	0.0	0.0	0.0
	8:00	38.1	13.9	0.30	-1.8	-1.0	-0.4	0.0	0.0	0.0	0.0
	9:00	41.7	14.4	0.30	PF	-1.1	-0.4	0.0	0.0	0.0	0.0
	10:00	41.3	13.9	0.28	PF	-1.0	-0.5	0.0	0.0	0.0	0.0
	11:00	44.2	13.1	0.28	PF	-0.9	-0.6	0.0	0.0	0.0	0.0
	12:00	45.2	12.9	0.28	PF	-1.3	-0.2	0.0	0.0	0.0	0.0
	13:00	40.8	12.2	0.27	PF	-1.2	0.0	0.0	0.0	0.0	0.0
	14:00	42.5	12.3	0.27	PF	-1.2	-0.2	0.0	0.0	0.0	0.0
	15:00	37.0	11.6	0.27	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	16:00	36.6	11.4	0.27	PF	-1.3	0.0	0.0	0.0	0.0	0.0
	17:00	35.3	11.7	0.28	PF	-1.0	-0.6	0.0	0.0	0.0	0.0
	18:00	36.0	12.0	0.29	PF	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	33.3	12.0	0.29	PF	-1.0	-0.6	0.0	0.0	0.0	0.0
	20:00	31.8	11.8	0.29	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
	21:00	36.5	12.2	0.28	PF	-1.4	-0.1	0.0	0.0	0.0	0.0
	22:00	34.1	12.6	0.28	PF	-1.4	0.1	0.0	0.0	0.0	0.0
	23:00	35.3	13.0	0.28	PF	-1.2	0.0	0.0	0.0	0.0	0.0
	0:00	33.7	12.7	0.27	PF	-1.2	0.0	0.0	0.0	0.0	0.0
Min		31.8	11.4	0.3	ID	-1.4	-0.6	0.0	0.0	0.0	0.0
Max		45.2	16.8	0.3	ID	-0.9	0.2	0.0	0.0	0.0	0.0
Average		38.6	13.5	0.3	ID	-1.1	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
30/11/2018	1:00	33.0	12.8	0.27	PF	-1.0	-0.2	0.0	0.0	0.0	0.0
	2:00	32.4	12.5	0.27	PF	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	32.7	12.7	0.27	PF	-0.8	0.1	0.0	0.0	0.0	0.0
	4:00	33.6	13.1	0.28	PF	-1.2	0.5	0.0	0.0	0.0	0.0
	5:00	36.6	14.0	0.28	PF	-1.0	0.4	0.0	0.0	0.0	0.0
	6:00	40.1	14.5	0.30	PF	-1.0	0.4	0.0	0.0	0.0	0.0
	7:00	44.0	15.9	0.32	PF	-1.0	0.2	0.0	0.0	0.0	0.0
	8:00	49.8	15.5	0.30	PF	-1.1	0.3	0.0	0.0	0.0	0.0
	9:00	52.7	14.5	0.30	PF	-1.0	0.1	0.0	0.0	0.0	0.0
	10:00	51.4	13.0	0.28	PF	-1.2	0.1	0.0	0.0	0.0	0.0
	11:00	67.5	12.0	0.26	PF	-1.0	0.0	0.0	0.0	0.0	0.0
	12:00	48.6	11.4	0.25	PF	-1.2	0.2	0.0	2.3	0.2	0.1
	13:00	42.5	11.9	0.27	PF	-1.0	-0.1	0.0	0.2	0.0	0.0
	14:00	44.9	12.2	0.27	PF	-1.0	-0.5	0.0	0.0	0.0	0.0
	15:00	44.2	12.7	0.27	PF	-1.0	-0.2	0.0	0.0	0.0	0.0
	16:00	45.6	13.8	0.28	PF	-1.0	-0.1	0.0	0.0	0.0	0.0
	17:00	40.3	12.7	0.28	PF	-1.1	0.2	0.0	0.2	0.0	0.0
	18:00	35.6	12.6	0.28	PF	-1.1	0.0	0.0	0.0	0.0	0.0
	19:00	34.5	12.8	0.28	PF	-1.2	-0.1	0.1	0.0	0.0	0.0
	20:00	32.1	12.1	0.28	PF	-1.0	-0.2	0.0	0.2	0.0	0.0
	21:00	30.4	11.7	0.27	PF	-1.4	0.3	0.0	0.0	0.0	0.0
	22:00	27.2	11.2	0.26	PF	-1.2	0.2	0.0	0.0	0.0	0.0
	23:00	29.1	11.4	0.26	PF	-1.2	-0.1	0.0	0.1	0.0	0.0
	0:00	27.2	11.1	0.26	PF	-1.3	0.0	0.0	0.2	0.0	0.0
Min		27.2	11.1	0.3	ID	-1.4	-0.5	0.0	0.0	0.0	0.0
Max		67.5	15.9	0.3	ID	-0.8	0.5	0.1	2.3	0.2	0.1
Average		39.8	12.8	0.3	ID	-1.1	0.1	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
01/12/2018	1:00	26.8	11.0	0.26	PF	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	25.7	10.6	0.24	PF	-1.1	0.0	0.0	0.0	0.0	0.0
	3:00	27.4	10.6	0.24	PF	-1.1	0.1	0.0	0.0	0.0	0.0
	4:00	26.1	10.5	0.24	PF	-1.2	0.2	0.0	0.0	0.0	0.0
	5:00	26.1	10.4	0.24	PF	-1.3	0.2	0.0	0.0	0.0	0.0
	6:00	25.7	10.2	0.24	PF	-1.3	0.2	0.0	0.0	0.0	0.0
	7:00	27.2	10.1	0.25	PF	-1.2	0.1	0.0	0.0	0.0	0.0
	8:00	39.9	10.5	0.25	PF	-1.2	0.3	0.0	0.0	0.0	0.0
	9:00	37.3	10.2	0.24	PF	-1.0	0.2	0.0	0.2	0.0	0.0
	10:00	38.1	10.1	0.24	PF	-1.2	-0.1	0.0	0.1	0.0	0.0
	11:00	29.6	9.8	0.30	PF	-1.2	0.0	0.0	0.0	0.0	0.0
	12:00	34.6	9.9	0.25	PF	-1.1	-0.4	0.0	0.0	0.0	0.1
	13:00	31.1	9.7	0.24	PF	-1.4	-0.1	0.0	0.0	0.0	0.0
	14:00	28.7	9.2	0.25	PF	-1.1	-0.2	0.0	0.0	0.0	0.1
	15:00	28.4	9.1	0.24	PF	-1.1	-0.4	0.1	0.0	0.0	0.1
	16:00	26.2	9.2	0.24	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
	17:00	34.0	15.1	0.26	PF	-1.1	0.0	0.0	0.2	0.0	0.0
	18:00	29.7	12.6	0.28	PF	-0.9	-0.4	0.0	0.0	0.1	0.0
	19:00	28.8	13.7	0.29	PF	-1.0	-0.1	0.0	0.0	0.0	0.0
	20:00	21.9	8.8	0.26	PF	-0.9	-0.6	0.0	0.0	0.0	0.1
	21:00	21.5	8.0	0.25	PF	-1.2	-0.2	0.0	0.0	0.1	0.0
	22:00	19.8	7.3	0.25	PF	-1.3	0.1	0.0	0.0	0.0	0.0
	23:00	20.9	8.2	0.24	PF	-1.4	0.0	0.0	0.2	0.0	0.0
	0:00	21.9	8.1	0.24	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
Min		19.8	7.3	0.2	ID	-1.4	-0.6	0.0	0.0	0.0	0.0
Max		39.9	15.1	0.3	ID	-0.9	0.3	0.1	0.2	0.1	0.1
Average		28.2	10.1	0.3	ID	-1.1	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
02/12/2018	1:00	19.4	7.7	0.24	PF	-1.1	0.0	0.0	0.0	0.0	0.0
	2:00	19.0	7.6	0.24	PF	-1.3	-0.1	0.0	0.0	0.0	0.0
	3:00	19.6	7.6	0.24	PF	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	19.4	7.7	0.24	PF	-1.5	0.1	0.0	0.0	0.0	0.0
	5:00	19.3	7.5	0.23	PF	-1.3	0.2	0.0	0.2	0.0	0.0
	6:00	18.5	7.2	0.25	PF	-1.4	0.3	0.0	0.0	0.0	0.0
	7:00	20.2	7.5	0.26	PF	-1.3	0.3	0.0	0.0	0.0	0.0
	8:00	21.2	7.3	0.24	PF	-1.3	-0.1	0.0	0.0	0.0	0.0
	9:00	22.1	7.4	0.24	PF	-1.4	0.0	0.0	0.0	0.0	0.0
	10:00	24.5	7.5	0.24	PF	-1.3	-0.3	0.0	0.0	0.0	0.0
	11:00	22.6	7.4	0.24	PF	-1.2	-0.2	0.0	0.3	0.0	0.0
	12:00	23.7	7.6	0.23	PF	-1.3	-0.2	0.0	0.0	0.0	0.0
	13:00	22.1	7.8	0.25	PF	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	21.7	7.2	0.24	PF	-1.2	-0.4	0.0	0.0	0.1	0.0
	15:00	21.1	7.0	0.23	PF	-1.5	-0.2	0.0	0.0	0.0	0.0
	16:00	18.3	6.7	0.23	PF	-1.5	-0.1	0.0	0.0	0.0	0.0
	17:00	21.4	7.4	0.25	PF	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	21.3	7.4	0.25	PF	-0.9	-0.7	0.0	0.0	0.0	0.0
	19:00	21.0	7.5	0.27	PF	-1.0	-0.4	0.0	0.0	0.0	0.0
	20:00	20.1	7.5	0.27	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
	21:00	18.9	7.2	0.25	PF	-1.2	-0.3	0.0	0.2	0.0	0.0
	22:00	21.0	7.2	0.25	PF	-1.2	-0.2	0.0	0.0	0.0	0.0
	23:00	18.4	7.2	0.22	PF	-1.3	-0.1	0.1	0.0	0.0	0.0
	0:00	19.3	7.2	0.22	PF	-1.3	-0.3	0.0	0.2	0.0	0.0
Min		18.3	6.7	0.2	ID	-1.5	-0.7	0.0	0.0	0.0	0.0
Max		24.5	7.8	0.3	ID	-0.9	0.3	0.1	0.3	0.1	0.0
Average		20.6	7.4	0.2	ID	-1.3	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
		$\mu g/m^3$	$\mu g/m^3$	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
03/12/2018	1:00	19.4	7.2	0.23	PF	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	18.8	7.2	0.29	PF	-0.8	-0.1	0.0	0.0	0.0	0.0
	3:00	18.1	7.2	0.23	PF	-1.1	-0.4	0.0	0.0	0.0	0.0
	4:00	20.0	7.7	0.22	PF	-1.2	-0.3	0.0	0.2	0.0	0.1
	5:00	21.0	8.0	0.21	PF	-1.1	-0.2	0.0	0.0	0.0	0.2
	6:00	24.2	8.3	0.21	PF	-1.2	-0.2	0.1	0.0	0.0	0.2
	7:00	25.2	8.9	0.23	PF	-1.1	-0.4	0.0	0.2	0.0	0.0
	8:00	32.7	9.5	0.24	PF	-1.3	-0.2	0.0	0.0	0.0	0.0
	9:00	34.2	9.7	0.25	PF	-1.0	-0.4	0.1	0.1	0.0	0.0
	10:00	30.4	9.4	0.24	PF	-1.4	-0.1	0.0	0.1	0.0	0.0
	11:00	34.4	9.6	0.24	PF	-1.3	-0.1	0.0	0.2	0.0	0.0
	12:00	35.0	10.1	0.26	PF	MM	MM	0.0	0.0	0.0	0.0
	13:00	43.1	11.6	MM	PF	MM	MM	0.0	0.0	0.0	0.0
	14:00	40.2	11.0	MM	PF	-1.1	-0.3	0.0	0.0	0.0	0.1
	15:00	36.3	10.8	0.25	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	16:00	41.8	11.4	0.25	PF	-0.7	-0.5	0.0	0.0	0.0	0.0
	17:00	41.6	12.2	0.27	PF	-0.8	-0.4	0.0	0.0	0.0	0.0
	18:00	43.3	14.5	0.30	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	19:00	47.5	15.1	0.34	PF	-0.9	-0.1	0.0	0.0	0.0	0.0
	20:00	42.4	13.6	0.29	PF	-1.0	0.4	0.0	0.0	0.0	0.0
	21:00	35.0	16.4	0.33	PF	-0.9	0.1	0.0	0.0	0.0	0.0
	22:00	35.5	13.5	0.30	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	23:00	26.9	10.6	0.29	PF	-1.1	-0.1	0.0	0.0	0.0	0.0
	0:00	30.9	11.8	0.28	PF	-1.2	0.0	0.0	0.0	0.0	0.0
Min		18.1	7.2	0.2	ID	-1.4	-0.5	0.0	0.0	0.0	0.0
Max		47.5	16.4	0.3	ID	-0.7	0.4	0.1	0.2	0.0	0.2
Average		32.4	10.6	0.3	ID	-1.1	-0.2	0.0	0.0	0.0	0.0

New Guyana School Data Record

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
12/04/2019	1:00	19.8	7.6	0.083	ZS	0.9	7.1	ID	ID	ID	ID
	2:00	19.0	7.2	0.073	0.3	ZS	ZS	ID	ID	ID	ID
	3:00	18.4	6.9	0.070	0.5	0.3	3.1	ID	ID	ID	ID
	4:00	18.9	7.1	0.076	0.5	0.6	3.7	ID	ID	ID	ID
	5:00	21.5	8.1	0.080	1.0	0.7	0.9	ID	ID	ID	ID
	6:00	21.4	8.4	0.087	0.8	0.6	1.3	ID	ID	ID	ID
	7:00	25.4	9.0	0.104	1.6	0.9	1.9	ID	ID	ID	ID
	8:00	28.8	11.2	0.119	1.4	0.8	5.1	ID	ID	ID	ID
	9:00	24.3	8.7	0.085	0.4	0.7	4.2	ID	ID	ID	ID
	10:00	25.9	9.1	0.089	0.7	0.6	4.7	ID	ID	ID	ID
	11:00	23.1	7.8	0.074	0.4	0.9	4.9	ID	ID	ID	ID
	12:00	25.3	9.9	0.085	0.7	0.9	4.7	ID	ID	ID	ID
	13:00	28.8	10.1	0.090	0.9	1.0	7.0	ID	ID	ID	ID
	14:00	31.1	12.6	0.096	0.8	1.1	8.3	ID	ID	ID	ID
	15:00	29.3	11.3	0.082	0.5	1.0	7.7	ID	ID	ID	ID
	16:00	25.4	7.6	0.080	0.6	0.7	5.4	ID	ID	ID	ID
	17:00	28.2	8.3	0.090	1.2	0.6	5.4	ID	ID	ID	ID
	18:00	34.0	12.3	0.119	2.2	1.1	2.3	ID	ID	ID	ID
	19:00	35.3	12.3	0.120	2.8	1.0	5.0	ID	ID	ID	ID
	20:00	36.9	14.0	0.128	2.6	1.2	6.7	ID	ID	ID	ID
	21:00	32.2	11.0	0.106	1.9	1.0	6.9	ID	ID	ID	ID
	22:00	33.7	10.8	0.090	1.6	0.9	7.9	ID	ID	ID	ID
	23:00	36.6	12.0	0.082	1.3	0.9	7.2	ID	ID	ID	ID
	0:00	42.3	13.5	0.078	ZS	0.7	7.0	ID	ID	ID	ID
Min		**18.4**	**6.9**	**0.070**	**0.3**	**0.3**	**0.9**	**ID**	**ID**	**ID**	**ID**
Max		**42.3**	**14.0**	**0.128**	**2.8**	**1.2**	**8.3**	**ID**	**ID**	**ID**	**ID**
Average		**27.7**	**9.9**	**0.091**	**1.1**	**0.8**	**5.2**	**ID**	**ID**	**ID**	**ID**
13/04/2019	1:00	44.7	14.7	ZS	1.5	ZS	ZS	ID	ID	ID	ID
	2:00	50.8	16.2	0.087	0.9	0.7	3.8	ID	ID	ID	ID
	3:00	49.9	15.9	0.069	0.3	0.8	8.1	ID	ID	ID	ID
	4:00	48.6	16.1	0.067	0.6	0.7	7.6	ID	ID	ID	ID
	5:00	49.6	16.7	0.076	0.9	0.7	6.5	ID	ID	ID	ID
	6:00	49.0	17.1	0.083	0.9	0.9	8.4	ID	ID	ID	ID
	7:00	55.4	18.2	0.124	2.5	0.9	6.5	ID	ID	ID	ID
	8:00	50.2	16.9	0.085	0.5	1.1	5.2	ID	ID	ID	ID
	9:00	55.3	17.7	0.092	0.9	0.6	7.3	ID	ID	ID	ID
	10:00	54.1	16.9	0.079	0.6	0.8	7.1	ID	ID	ID	ID
	11:00	49.6	15.3	0.076	0.4	0.9	8.5	ID	ID	ID	ID
	12:00	43.8	14.4	0.077	0.5	1.0	8.0	ID	ID	ID	ID
	13:00	43.5	14.2	0.075	0.5	0.9	7.5	ID	ID	ID	ID
	14:00	39.6	12.3	0.069	0.5	1.0	9.9	ID	ID	ID	ID
	15:00	35.3	11.6	0.068	0.4	0.9	8.9	ID	ID	ID	ID
	16:00	37.0	13.0	0.076	0.8	1.1	10.8	ID	ID	ID	ID
	17:00	38.0	13.0	0.081	0.7	1.2	12.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	18:00	38.0	13.6	0.107	1.4	1.0	10.7	ID	ID	ID	ID
	19:00	43.6	16.1	0.121	2.3	1.1	14.5	ID	ID	ID	ID
	20:00	41.6	15.7	0.135	3.5	1.6	11.6	ID	ID	ID	ID
	21:00	46.0	16.8	0.116	2.1	1.0	14.6	ID	ID	ID	ID
	22:00	42.4	15.8	0.080	1.0	1.2	13.3	ID	ID	ID	ID
	23:00	45.4	16.9	ZS	0.9	0.9	12.0	ID	ID	ID	ID
	0:00	43.9	15.7	0.067	0.5	ZS	ZS	ID	ID	ID	ID
Min		**35.3**	**11.6**	**0.067**	**0.3**	**0.6**	**3.8**	**ID**	**ID**	**ID**	**ID**
Max		**55.4**	**18.2**	**0.135**	**3.5**	**1.6**	**14.6**	**ID**	**ID**	**ID**	**ID**
Average		**45.6**	**15.5**	**0.087**	**1.0**	**1.0**	**9.2**	**ID**	**ID**	**ID**	**ID**
14/04/2019	1:00	41.1	15.3	0.052	0.1	0.8	13.5	ID	ID	ID	ID
	2:00	40.1	15.0	0.051	ZS	0.7	10.8	ID	ID	ID	ID
	3:00	41.6	15.2	0.053	0.5	0.9	7.6	ID	ID	ID	ID
	4:00	44.4	16.1	0.055	0.3	0.8	7.5	ID	ID	ID	ID
	5:00	47.2	16.2	0.055	0.6	0.8	6.2	ID	ID	ID	ID
	6:00	45.7	16.0	0.066	0.8	0.8	2.8	ID	ID	ID	ID
	7:00	50.7	17.0	0.088	1.5	0.8	1.9	ID	ID	ID	ID
	8:00	51.4	17.9	0.077	0.7	0.7	1.8	ID	ID	ID	ID
	9:00	47.6	15.9	0.061	0.2	0.6	2.2	ID	ID	ID	ID
	10:00	47.9	15.9	0.061	0.5	0.6	4.0	ID	ID	ID	ID
	11:00	49.8	15.3	0.056	0.2	0.8	4.9	ID	ID	ID	ID
	12:00	52.3	15.8	0.050	0.2	0.8	4.2	ID	ID	ID	ID
	13:00	48.1	15.1	0.047	0.1	0.7	6.0	ID	ID	ID	ID
	14:00	46.8	14.8	0.045	0.2	0.9	5.8	ID	ID	ID	ID
	15:00	45.0	14.4	0.039	0.2	0.8	7.2	ID	ID	ID	ID
	16:00	39.8	13.4	0.031	0.1	1.0	6.4	ID	ID	ID	ID
	17:00	44.1	13.7	0.040	0.3	0.7	8.4	ID	ID	ID	ID
	18:00	43.1	13.9	0.049	0.9	1.0	6.2	ID	ID	ID	ID
	19:00	44.6	17.5	0.084	1.9	1.0	7.2	ID	ID	ID	ID
	20:00	41.6	17.3	0.082	2.2	1.0	6.5	ID	ID	ID	ID
	21:00	42.9	17.6	0.088	1.7	0.9	6.3	ID	ID	ID	ID
	22:00	42.3	17.9	0.070	1.2	0.9	9.7	ID	ID	ID	ID
	23:00	35.4	13.1	ZS	1.1	0.6	4.6	ID	ID	ID	ID
	0:00	33.9	12.4	0.028	ZS	0.6	3.6	ID	ID	ID	ID
Min		**33.9**	**12.4**	**0.028**	**0.1**	**0.6**	**1.8**	**ID**	**ID**	**ID**	**ID**
Max		**52.3**	**17.9**	**0.088**	**2.2**	**1.0**	**13.5**	**ID**	**ID**	**ID**	**ID**
Average		**44.5**	**15.5**	**0.058**	**0.7**	**0.8**	**6.1**	**ID**	**ID**	**ID**	**ID**
15/04/2019	1:00	35.8	13.0	0.026	0.5	ZS	ZS	ID	ID	ID	ID
	2:00	35.8	12.3	0.014	0.3	0.8	2.2	ID	ID	ID	ID
	3:00	31.9	11.3	0.002	0.3	0.6	1.6	ID	ID	ID	ID
	4:00	31.4	11.7	0.009	0.8	0.6	1.6	ID	ID	ID	ID
	5:00	34.1	12.6	0.015	0.5	0.4	2.1	ID	ID	ID	ID
	6:00	32.7	11.8	0.015	0.8	0.6	2.0	ID	ID	ID	ID
	7:00	36.0	12.8	0.067	2.7	0.8	1.5	ID	ID	ID	ID
	8:00	36.3	13.0	0.055	1.6	0.7	1.1	ID	ID	ID	ID
	9:00	35.5	12.8	0.073	1.6	0.8	0.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	10:00	38.4	12.6	0.047	1.1	0.7	0.2	ID	ID	ID	ID
	11:00	37.8	12.6	0.039	0.9	0.7	-0.4	ID	ID	ID	ID
	12:00	38.4	13.3	0.048	0.9	0.5	-0.7	ID	ID	ID	ID
	13:00	36.8	12.5	0.049	0.8	0.7	-0.8	ID	ID	ID	ID
	14:00	35.0	11.9	0.033	0.5	0.7	-0.9	ID	ID	ID	ID
	15:00	34.4	12.1	0.059	1.0	0.6	-0.7	ID	ID	ID	ID
	16:00	35.2	11.8	0.036	1.0	0.5	-0.6	ID	ID	ID	ID
	17:00	36.6	13.1	0.032	1.2	0.7	-0.8	ID	ID	ID	ID
	18:00	40.9	14.9	0.062	3.2	1.2	-0.6	ID	ID	ID	ID
	19:00	44.2	15.3	0.080	3.4	0.8	-0.2	ID	ID	ID	ID
	20:00	43.6	16.5	0.091	3.5	0.7	0.2	ID	ID	ID	ID
	21:00	44.5	16.7	0.083	2.9	1.0	0.1	ID	ID	ID	ID
	22:00	48.4	19.4	0.075	2.2	0.8	0.6	ID	ID	ID	ID
	23:00	48.3	16.6	0.053	1.4	0.8	0.6	ID	ID	ID	ID
	0:00	47.4	16.2	0.043	1.3	0.8	0.5	ID	ID	ID	ID
Min		**31.4**	**11.3**	**0.002**	**0.3**	**0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**48.4**	**19.4**	**0.091**	**3.5**	**1.2**	**2.2**	**ID**	**ID**	**ID**	**ID**
Average		**38.3**	**13.6**	**0.046**	**1.4**	**0.7**	**0.4**	**ID**	**ID**	**ID**	**ID**
16/04/2019	1:00	43.7	15.8	0.028	ZS	0.7	0.5	ID	ID	ID	ID
	2:00	41.5	14.3	0.023	0.6	ZS	ZS	ID	ID	ID	ID
	3:00	39.9	14.2	0.025	0.5	0.7	0.9	ID	ID	ID	ID
	4:00	39.7	14.4	0.027	0.7	0.5	0.4	ID	ID	ID	ID
	5:00	37.5	13.8	0.017	0.6	0.6	0.7	ID	ID	ID	ID
	6:00	44.8	17.5	0.037	2.0	1.0	1.1	ID	ID	ID	ID
	7:00	84.9	39.8	0.147	4.8	3.6	0.6	ID	ID	ID	ID
	8:00	49.6	18.8	0.071	1.3	1.6	1.4	ID	ID	ID	ID
	9:00	41.3	14.2	0.026	0.4	0.8	2.1	ID	ID	ID	ID
	10:00	41.4	13.9	0.023	0.4	1.1	8.7	ID	ID	ID	ID
	11:00	42.5	14.0	0.025	0.5	1.2	10.6	ID	ID	ID	ID
	12:00	46.1	15.3	0.029	0.6	1.2	10.4	ID	ID	ID	ID
	13:00	42.5	13.8	0.036	0.7	1.2	11.4	ID	ID	ID	ID
	14:00	41.2	13.4	0.020	0.4	0.8	13.3	ID	ID	ID	ID
	15:00	41.9	13.3	0.024	0.6	0.9	12.6	ID	ID	ID	ID
	16:00	51.2	13.4	0.022	0.5	0.9	12.1	ID	ID	ID	ID
	17:00	74.7	15.7	0.037	1.1	1.0	12.1	ID	ID	ID	ID
	18:00	55.4	16.2	0.063	1.5	1.0	11.2	ID	ID	ID	ID
	19:00	54.7	19.3	0.081	2.5	1.1	11.6	ID	ID	ID	ID
	20:00	46.5	16.9	0.085	2.4	1.2	10.0	ID	ID	ID	ID
	21:00	47.7	17.7	0.082	2.7	1.0	6.7	ID	ID	ID	ID
	22:00	47.9	17.3	0.067	2.2	0.8	3.9	ID	ID	ID	ID
	23:00	43.3	16.0	0.050	1.8	1.1	1.4	ID	ID	ID	ID
	0:00	43.7	14.9	0.033	ZS	0.9	3.7	ID	ID	ID	ID
Min		**37.5**	**13.3**	**0.017**	**0.4**	**0.5**	**0.4**	**ID**	**ID**	**ID**	**ID**
Max		**84.9**	**39.8**	**0.147**	**4.8**	**3.6**	**13.3**	**ID**	**ID**	**ID**	**ID**
Average		**47.6**	**16.4**	**0.045**	**1.3**	**1.1**	**6.4**	**ID**	**ID**	**ID**	**ID**
17/04/2019	1:00	41.1	13.9	0.013	0.3	ZS	ZS	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	2:00	42.0	14.5	-0.001	0.0	0.7	6.3	ID	ID	ID	ID
	3:00	40.0	13.7	-0.004	0.0	0.6	5.6	ID	ID	ID	ID
	4:00	38.7	13.4	0.001	0.3	0.8	3.9	ID	ID	ID	ID
	5:00	37.8	14.1	0.024	1.7	0.6	1.4	ID	ID	ID	ID
	6:00	38.6	13.9	0.040	2.3	0.6	0.7	ID	ID	ID	ID
	7:00	62.2	27.1	0.178	5.5	0.9	0.2	ID	ID	ID	ID
	8:00	45.2	16.8	0.070	1.8	0.9	0.0	ID	ID	ID	ID
	9:00	39.5	13.6	0.028	0.9	0.8	1.9	ID	ID	ID	ID
	10:00	37.7	12.7	0.017	0.5	0.9	8.6	ID	ID	ID	ID
	11:00	37.4	12.1	0.010	0.3	0.9	12.0	ID	ID	ID	ID
	12:00	37.0	11.7	0.005	0.2	0.9	11.6	ID	ID	ID	ID
	13:00	37.5	11.9	0.011	0.3	1.1	13.9	ID	ID	ID	ID
	14:00	35.4	11.9	0.022	0.3	1.2	14.6	ID	ID	ID	ID
	15:00	35.9	11.8	0.018	0.2	1.0	13.7	ID	ID	ID	ID
	16:00	37.6	13.5	0.034	1.1	1.3	17.5	ID	ID	ID	ID
	17:00	43.1	17.4	0.054	0.8	1.1	16.5	ID	ID	ID	ID
	18:00	43.4	17.0	0.083	1.9	1.5	16.5	ID	ID	ID	ID
	19:00	56.6	27.6	0.156	2.5	1.8	16.7	ID	ID	ID	ID
	20:00	37.7	14.6	0.076	1.9	1.5	21.5	ID	ID	ID	ID
	21:00	33.4	13.3	0.052	1.1	1.2	18.0	ID	ID	ID	ID
	22:00	24.4	9.6	0.040	1.1	1.0	9.0	ID	ID	ID	ID
	23:00	28.0	10.7	0.046	1.5	0.9	2.2	ID	ID	ID	ID
	0:00	31.5	14.8	0.085	2.0	ZS	ZS	ID	ID	ID	ID
Min		**24.4**	**9.6**	**-0.004**	**0.0**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**62.2**	**27.6**	**0.178**	**5.5**	**1.8**	**21.5**	**ID**	**ID**	**ID**	**ID**
Average		**39.2**	**14.6**	**0.044**	**1.2**	**1.0**	**9.7**	**ID**	**ID**	**ID**	**ID**
18/04/2019	1:00	27.0	11.4	0.037	0.8	0.9	8.7	ID	ID	ID	ID
	2:00	23.7	9.8	0.025	ZS	1.1	11.5	ID	ID	ID	ID
	3:00	22.2	9.5	0.006	0.5	0.6	3.6	ID	ID	ID	ID
	4:00	18.2	7.7	-0.001	0.6	0.6	-0.5	ID	ID	ID	ID
	5:00	26.4	10.7	0.001	0.2	0.8	9.5	ID	ID	ID	ID
	6:00	28.3	11.0	0.012	0.5	0.8	6.5	ID	ID	ID	ID
	7:00	36.0	13.0	0.046	2.0	0.8	8.5	ID	ID	ID	ID
	8:00	25.9	11.4	0.087	2.1	0.8	5.7	ID	ID	ID	ID
	9:00	31.2	12.6	0.042	1.4	0.9	6.6	ID	ID	ID	ID
	10:00	31.7	12.3	0.025	0.5	1.0	14.3	ID	ID	ID	ID
	11:00	30.3	12.4	0.029	0.6	1.0	18.2	ID	ID	ID	ID
	12:00	40.8	18.1	0.045	0.4	1.3	12.6	ID	ID	ID	ID
	13:00	35.5	12.3	0.020	0.3	1.4	20.9	ID	ID	ID	ID
	14:00	35.1	12.3	0.018	0.1	1.2	24.0	ID	ID	ID	ID
	15:00	37.3	12.7	0.017	0.3	1.3	23.2	ID	ID	ID	ID
	16:00	39.2	13.0	0.025	0.6	1.3	25.6	ID	ID	ID	ID
	17:00	37.8	13.0	0.035	1.2	1.1	24.7	ID	ID	ID	ID
	18:00	42.7	15.3	0.066	2.2	1.4	22.6	ID	ID	ID	ID
	19:00	48.3	20.4	0.097	2.6	1.8	23.4	ID	ID	ID	ID
	20:00	42.3	16.8	0.076	2.4	1.7	29.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	21:00	38.3	14.4	0.059	1.9	1.5	21.2	ID	ID	ID	ID
	22:00	38.0	16.0	0.065	2.2	1.2	20.0	ID	ID	ID	ID
	23:00	37.9	15.1	0.051	1.7	1.0	4.4	ID	ID	ID	ID
	0:00	37.3	14.0	0.032	1.4	0.7	2.8	ID	ID	ID	ID
Min		**18.2**	**7.7**	**-0.001**	**0.1**	**0.6**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**48.3**	**20.4**	**0.097**	**2.6**	**1.8**	**29.7**	**ID**	**ID**	**ID**	**ID**
Average		**33.8**	**13.1**	**0.038**	**1.2**	**1.1**	**14.5**	**ID**	**ID**	**ID**	**ID**
19/04/2019	1:00	36.3	13.3	0.023	ZS	0.8	1.7	ID	ID	ID	ID
	2:00	43.4	20.7	0.040	0.6	ZS	ZS	ID	ID	ID	ID
	3:00	39.7	17.7	0.063	1.2	0.7	2.5	ID	ID	ID	ID
	4:00	51.8	25.1	0.102	1.0	1.0	1.4	ID	ID	ID	ID
	5:00	48.5	22.7	0.094	0.6	1.1	4.2	ID	ID	ID	ID
	6:00	39.1	15.3	0.056	0.7	0.8	3.6	ID	ID	ID	ID
	7:00	38.4	13.9	0.039	1.1	0.6	1.4	ID	ID	ID	ID
	8:00	36.0	13.2	0.029	0.5	0.9	11.9	ID	ID	ID	ID
	9:00	34.0	12.5	0.014	-0.2	1.0	12.6	ID	ID	ID	ID
	10:00	36.1	12.6	0.011	-0.1	0.9	15.5	ID	ID	ID	ID
	11:00	33.7	12.2	0.002	-0.2	1.0	14.3	ID	ID	ID	ID
	12:00	32.8	12.1	0.004	-0.3	1.0	16.7	ID	ID	ID	ID
	13:00	33.5	12.7	0.004	-0.2	1.0	15.7	ID	ID	ID	ID
	14:00	32.9	12.7	0.004	-0.3	1.0	19.8	ID	ID	ID	ID
	15:00	34.3	13.1	0.014	-0.1	0.9	17.8	ID	ID	ID	ID
	16:00	32.9	12.2	0.008	-0.1	1.1	17.5	ID	ID	ID	ID
	17:00	32.7	12.6	0.017	0.0	1.0	16.0	ID	ID	ID	ID
	18:00	36.6	14.3	0.042	0.5	1.1	15.3	ID	ID	ID	ID
	19:00	42.2	18.9	0.076	1.2	1.0	16.5	ID	ID	ID	ID
	20:00	36.3	15.4	0.056	1.1	1.4	19.1	ID	ID	ID	ID
	21:00	33.7	13.7	0.045	1.1	1.4	25.0	ID	ID	ID	ID
	22:00	37.5	14.7	0.043	0.8	1.3	18.7	ID	ID	ID	ID
	23:00	35.4	14.7	0.037	0.6	1.0	8.1	ID	ID	ID	ID
	0:00	34.6	15.2	0.028	ZS	0.9	4.4	ID	ID	ID	ID
Min		**32.7**	**12.1**	**0.002**	**-0.3**	**0.6**	**1.4**	**ID**	**ID**	**ID**	**ID**
Max		**51.8**	**25.1**	**0.102**	**1.2**	**1.4**	**25.0**	**ID**	**ID**	**ID**	**ID**
Average		**37.2**	**15.1**	**0.035**	**0.4**	**1.0**	**12.2**	**ID**	**ID**	**ID**	**ID**
20/04/2019	1:00	33.2	14.6	0.025	0.5	ZS	ZS	ID	ID	ID	ID
	2:00	30.2	13.1	0.015	0.3	0.7	1.5	ID	ID	ID	ID
	3:00	31.6	13.8	0.031	0.5	0.5	0.3	ID	ID	ID	ID
	4:00	31.0	12.9	0.013	0.4	0.5	0.2	ID	ID	ID	ID
	5:00	29.5	12.7	0.019	0.4	0.7	2.1	ID	ID	ID	ID
	6:00	30.4	12.2	0.021	0.6	0.6	2.8	ID	ID	ID	ID
	7:00	33.9	14.3	0.045	1.6	0.7	3.1	ID	ID	ID	ID
	8:00	32.8	13.5	0.037	0.9	0.9	13.2	ID	ID	ID	ID
	9:00	33.5	13.2	0.037	0.8	0.8	9.5	ID	ID	ID	ID
	10:00	35.7	12.7	0.027	0.6	0.9	14.6	ID	ID	ID	ID
	11:00	31.6	11.7	0.013	0.3	1.3	21.3	ID	ID	ID	ID
	12:00	32.8	12.3	0.023	0.4	1.2	18.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	13:00	32.0	11.6	0.011	0.2	1.0	16.1	ID	ID	ID	ID
	14:00	30.6	12.1	0.022	0.2	1.0	13.8	ID	ID	ID	ID
	15:00	28.5	11.4	0.014	0.0	1.1	12.2	ID	ID	ID	ID
	16:00	32.8	11.5	0.016	0.3	1.1	14.1	ID	ID	ID	ID
	17:00	32.1	12.1	0.030	0.8	1.5	20.8	ID	ID	ID	ID
	18:00	35.1	12.3	0.034	1.3	1.4	21.1	ID	ID	ID	ID
	19:00	39.3	16.3	0.064	2.3	1.8	24.4	ID	ID	ID	ID
	20:00	30.7	12.3	0.047	1.7	1.5	21.0	ID	ID	ID	ID
	21:00	31.9	12.0	0.052	2.0	1.4	20.4	ID	ID	ID	ID
	22:00	31.9	12.2	0.039	1.7	1.3	17.0	ID	ID	ID	ID
	23:00	29.7	11.4	0.045	2.1	1.1	14.7	ID	ID	ID	ID
	0:00	29.6	11.4	ZS	1.8	ZS	ZS	ID	ID	ID	ID
Min		**28.5**	**11.4**	**0.011**	**0.0**	**0.5**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**39.3**	**16.3**	**0.064**	**2.3**	**1.8**	**24.4**	**ID**	**ID**	**ID**	**ID**
Average		**32.1**	**12.6**	**0.030**	**0.9**	**1.0**	**12.8**	**ID**	**ID**	**ID**	**ID**
21/04/2019	1:00	30.4	11.6	0.035	1.3	0.8	5.8	ID	ID	ID	ID
	2:00	29.3	11.9	0.029	ZS	0.9	6.0	ID	ID	ID	ID
	3:00	30.7	12.3	0.022	1.1	1.1	20.1	ID	ID	ID	ID
	4:00	31.5	12.4	0.027	1.3	1.0	6.1	ID	ID	ID	ID
	5:00	34.2	13.5	0.039	1.4	0.8	4.2	ID	ID	ID	ID
	6:00	35.3	13.2	0.017	1.1	0.7	0.6	ID	ID	ID	ID
	7:00	35.8	13.5	0.015	0.6	0.6	3.8	ID	ID	ID	ID
	8:00	37.3	14.7	0.023	0.4	0.6	3.2	ID	ID	ID	ID
	9:00	36.8	14.5	0.020	0.4	0.8	3.8	ID	ID	ID	ID
	10:00	35.0	12.6	0.012	0.2	0.7	7.8	ID	ID	ID	ID
	11:00	31.6	11.2	0.008	0.0	0.9	9.9	ID	ID	ID	ID
	12:00	32.9	13.2	0.008	0.1	1.0	9.8	ID	ID	ID	ID
	13:00	26.0	9.9	0.001	-0.1	1.1	12.3	ID	ID	ID	ID
	14:00	30.3	11.0	0.007	0.0	1.0	14.4	ID	ID	ID	ID
	15:00	34.1	11.6	0.005	0.0	1.0	14.7	ID	ID	ID	ID
	16:00	33.6	11.5	0.000	-0.1	1.1	14.4	ID	ID	ID	ID
	17:00	35.7	12.4	0.006	-0.1	0.9	12.9	ID	ID	ID	ID
	18:00	36.4	12.9	0.018	0.6	0.7	11.7	ID	ID	ID	ID
	19:00	41.1	15.9	0.058	1.8	1.2	12.1	ID	ID	ID	ID
	20:00	40.0	14.7	0.061	1.5	1.2	14.8	ID	ID	ID	ID
	21:00	37.0	13.7	0.048	1.6	1.2	15.2	ID	ID	ID	ID
	22:00	38.7	14.4	0.042	1.7	1.1	15.4	ID	ID	ID	ID
	23:00	35.6	13.6	0.040	1.4	1.0	7.0	ID	ID	ID	ID
	0:00	36.3	13.4	0.024	ZS	0.9	8.7	ID	ID	ID	ID
Min		**26.0**	**9.9**	**0.000**	**-0.1**	**0.6**	**0.6**	**ID**	**ID**	**ID**	**ID**
Max		**41.1**	**15.9**	**0.061**	**1.8**	**1.2**	**20.1**	**ID**	**ID**	**ID**	**ID**
Average		**34.4**	**12.9**	**0.023**	**0.7**	**0.9**	**9.8**	**ID**	**ID**	**ID**	**ID**
22/04/2019	1:00	36.5	14.0	0.030	1.3	ZS	ZS	ID	ID	ID	ID
	2:00	37.7	15.5	0.019	1.0	0.9	2.6	ID	ID	ID	ID
	3:00	38.5	13.7	0.015	0.7	1.0	12.0	ID	ID	ID	ID
	4:00	35.5	13.3	0.021	1.5	1.1	15.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	5:00	36.4	12.7	0.014	1.4	0.8	1.2	ID	ID	ID	ID
	6:00	38.9	14.6	0.012	0.5	0.6	1.7	ID	ID	ID	ID
	7:00	41.1	16.6	0.038	1.2	0.9	1.1	ID	ID	ID	ID
	8:00	34.7	13.0	0.002	0.1	0.7	0.4	ID	ID	ID	ID
	9:00	35.9	12.7	0.003	0.3	0.6	0.4	ID	ID	ID	ID
	10:00	36.0	12.4	-0.001	0.3	0.8	-0.4	ID	ID	ID	ID
	11:00	37.8	12.7	0.008	0.3	0.6	-0.3	ID	ID	ID	ID
	12:00	36.6	12.5	0.009	0.3	0.6	-0.5	ID	ID	ID	ID
	13:00	36.6	12.1	0.008	0.0	0.8	4.3	ID	ID	ID	ID
	14:00	34.5	12.0	0.007	-0.1	1.0	7.1	ID	ID	ID	ID
	15:00	35.9	11.6	0.005	0.0	0.9	7.1	ID	ID	ID	ID
	16:00	34.8	12.4	0.008	-0.1	0.9	6.5	ID	ID	ID	ID
	17:00	35.4	12.0	0.015	0.2	1.0	6.9	ID	ID	ID	ID
	18:00	39.9	17.7	0.078	1.8	1.5	9.2	ID	ID	ID	ID
	19:00	40.0	16.7	0.081	3.4	2.3	6.6	ID	ID	ID	ID
	20:00	37.4	14.1	0.094	2.8	1.3	3.3	ID	ID	ID	ID
	21:00	37.9	13.5	0.076	2.5	1.1	3.8	ID	ID	ID	ID
	22:00	35.3	12.7	0.058	2.0	1.0	3.7	ID	ID	ID	ID
	23:00	37.6	12.9	0.058	2.4	1.0	3.6	ID	ID	ID	ID
	0:00	35.6	12.4	0.049	2.1	0.8	0.7	ID	ID	ID	ID
Min		**34.5**	**11.6**	**-0.001**	**-0.1**	**0.6**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**41.1**	**17.7**	**0.094**	**3.4**	**2.3**	**15.0**	**ID**	**ID**	**ID**	**ID**
Average		**36.9**	**13.5**	**0.030**	**1.1**	**1.0**	**4.2**	**ID**	**ID**	**ID**	**ID**
23/04/2019	1:00	36.7	12.2	0.034	ZS	0.7	0.4	ID	ID	ID	ID
	2:00	34.9	13.1	0.039	1.9	ZS	ZS	ID	ID	ID	ID
	3:00	36.5	12.6	0.041	2.0	1.0	-0.3	ID	ID	ID	ID
	4:00	30.9	11.9	0.028	1.7	0.9	-0.4	ID	ID	ID	ID
	5:00	33.0	11.9	0.032	2.0	0.7	0.0	ID	ID	ID	ID
	6:00	30.4	11.4	0.039	2.5	1.0	-0.1	ID	ID	ID	ID
	7:00	36.4	13.1	0.096	4.0	1.2	0.4	ID	ID	ID	ID
	8:00	32.2	11.5	0.047	1.6	1.1	-0.8	ID	ID	ID	ID
	9:00	29.2	10.7	0.021	1.0	0.8	-0.7	ID	ID	ID	ID
	10:00	29.6	9.9	0.006	0.6	0.5	-0.8	ID	ID	ID	ID
	11:00	30.1	9.8	0.011	0.4	0.7	-0.2	ID	ID	ID	ID
	12:00	31.5	10.2	0.020	0.4	0.7	3.1	ID	ID	ID	ID
	13:00	31.7	10.6	0.017	0.4	0.8	3.3	ID	ID	ID	ID
	14:00	29.9	9.6	0.011	0.2	0.9	7.1	ID	ID	ID	ID
	15:00	26.8	9.6	0.017	0.2	0.8	4.1	ID	ID	ID	ID
	16:00	24.8	8.8	0.015	0.5	0.8	2.5	ID	ID	ID	ID
	17:00	29.5	9.7	0.024	0.7	0.9	3.3	ID	ID	ID	ID
	18:00	33.6	12.2	0.050	1.6	0.8	3.8	ID	ID	ID	ID
	19:00	38.2	16.1	0.082	1.5	1.1	6.0	ID	ID	ID	ID
	20:00	32.1	13.4	0.062	0.8	1.1	6.1	ID	ID	ID	ID
	21:00	30.5	12.2	0.052	0.4	0.9	7.7	ID	ID	ID	ID
	22:00	30.1	12.3	0.055	0.4	1.1	8.7	ID	ID	ID	ID
	23:00	30.9	12.2	0.032	0.0	0.9	9.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	0:00	32.3	12.9	0.037	ZS	1.0	9.0	ID	ID	ID	ID
Min		**24.8**	**8.8**	**0.006**	**0.0**	**0.5**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**38.2**	**16.1**	**0.096**	**4.0**	**1.2**	**9.1**	**ID**	**ID**	**ID**	**ID**
Average		**31.7**	**11.6**	**0.036**	**1.1**	**0.9**	**3.1**	**ID**	**ID**	**ID**	**ID**
24/04/2019	1:00	28.2	11.4	0.032	0.0	ZS	ZS	ID	ID	ID	ID
	2:00	11.8	5.5	0.003	-0.1	0.7	1.8	ID	ID	ID	ID
	3:00	10.6	4.8	0.022	1.0	0.9	3.9	ID	ID	ID	ID
	4:00	11.8	5.2	0.026	0.5	0.4	-0.2	ID	ID	ID	ID
	5:00	25.0	14.4	0.202	0.7	0.6	-0.3	ID	ID	ID	ID
	6:00	44.9	27.8	0.424	1.1	1.1	-0.4	ID	ID	ID	ID
	7:00	71.4	45.8	0.761	1.1	1.5	-0.4	ID	ID	ID	ID
	8:00	57.8	36.7	0.540	0.5	1.5	-0.5	ID	ID	ID	ID
	9:00	13.9	6.5	0.044	0.3	0.7	-0.6	ID	ID	ID	ID
	10:00	17.8	7.9	0.033	0.5	0.7	1.4	ID	ID	ID	ID
	11:00	21.9	7.8	0.020	0.2	0.5	3.1	ID	ID	ID	ID
	12:00	19.9	7.7	0.015	0.0	0.6	3.3	ID	ID	ID	ID
	13:00	17.7	7.3	0.025	0.1	0.7	3.9	ID	ID	ID	ID
	14:00	20.5	7.4	0.024	0.2	0.6	3.1	ID	ID	ID	ID
	15:00	21.1	7.4	0.024	0.1	0.7	4.8	ID	ID	ID	ID
	16:00	22.5	7.4	0.029	0.5	0.9	4.1	ID	ID	ID	ID
	17:00	17.3	6.2	0.031	0.5	0.6	3.4	ID	ID	ID	ID
	18:00	17.9	7.5	0.044	0.8	0.8	4.6	ID	ID	ID	ID
	19:00	19.4	8.2	0.056	1.3	1.0	5.3	ID	ID	ID	ID
	20:00	23.3	9.5	0.086	2.1	0.8	4.9	ID	ID	ID	ID
	21:00	24.0	9.6	0.104	2.7	1.1	2.1	ID	ID	ID	ID
	22:00	19.7	8.1	0.056	2.5	1.5	1.7	ID	ID	ID	ID
	23:00	15.5	6.3	0.044	1.0	ZS	ZS	ID	ID	ID	ID
	0:00	12.3	4.7	0.034	0.8	ZS	ZS	ID	ID	ID	ID
Min		**10.6**	**4.7**	**0.003**	**-0.1**	**0.4**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**71.4**	**45.8**	**0.761**	**2.7**	**1.5**	**5.3**	**ID**	**ID**	**ID**	**ID**
Average		**23.6**	**11.3**	**0.112**	**0.8**	**0.8**	**2.3**	**ID**	**ID**	**ID**	**ID**
25/04/2019	1:00	13.7	5.9	0.021	0.4	0.6	3.6	ID	ID	ID	ID
	2:00	19.4	8.1	0.023	ZS	0.6	2.2	ID	ID	ID	ID
	3:00	19.2	7.1	0.021	0.2	2.3	57.9	ID	ID	ID	ID
	4:00	9.1	4.2	0.016	0.2	2.5	71.8	ID	ID	ID	ID
	5:00	9.4	4.2	0.031	1.6	1.1	14.0	ID	ID	ID	ID
	6:00	14.3	6.4	0.035	1.6	0.9	3.4	ID	ID	ID	ID
	7:00	16.6	7.9	0.065	3.3	0.6	5.8	ID	ID	ID	ID
	8:00	14.6	6.5	0.038	1.4	0.8	0.4	ID	ID	ID	ID
	9:00	22.7	10.0	0.124	5.1	0.8	0.0	ID	ID	ID	ID
	10:00	18.1	7.9	0.059	3.2	0.7	0.2	ID	ID	ID	ID
	11:00	12.5	4.4	0.064	7.7	1.6	0.6	ID	ID	ID	ID
	12:00	7.8	3.3	0.052	4.6	2.3	2.4	ID	ID	ID	ID
	13:00	13.2	5.7	0.056	1.2	0.7	0.9	ID	ID	ID	ID
	14:00	18.3	7.8	0.030	0.3	0.8	2.6	ID	ID	ID	ID
	15:00	22.0	9.4	0.046	0.7	1.0	7.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	16:00	25.9	9.6	0.049	0.8	0.9	7.6	ID	ID	ID	ID
	17:00	31.4	11.4	0.048	0.8	1.0	6.2	ID	ID	ID	ID
	18:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	19:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	20:00	40.2	15.0	PO	PO	1.1	3.0	ID	ID	ID	ID
	21:00	44.2	18.4	0.278	1.4	1.0	3.7	ID	ID	ID	ID
	22:00	42.3	17.0	0.252	0.9	0.8	2.8	ID	ID	ID	ID
	23:00	45.9	18.2	0.233	0.8	0.9	2.4	ID	ID	ID	ID
	0:00	46.0	18.2	0.218	0.6	0.8	1.5	ID	ID	ID	ID
Min		**7.8**	**3.3**	**0.016**	**0.2**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**46.0**	**18.4**	**0.278**	**7.7**	**2.5**	**71.8**	**ID**	**ID**	**ID**	**ID**
Average		**23.0**	**9.4**	**0.084**	**1.8**	**1.1**	**9.1**	**ID**	**ID**	**ID**	**ID**
26/04/2019	1:00	38.8	15.8	0.193	ZS	0.7	0.7	ID	ID	ID	ID
	2:00	38.6	15.5	0.179	0.7	ZS	ZS	ID	ID	ID	ID
	3:00	37.4	14.7	0.170	0.8	0.6	0.5	ID	ID	ID	ID
	4:00	35.7	14.3	0.159	0.9	0.8	-0.1	ID	ID	ID	ID
	5:00	35.3	13.9	0.145	0.9	0.5	0.4	ID	ID	ID	ID
	6:00	37.0	14.2	0.157	2.2	0.6	0.2	ID	ID	ID	ID
	7:00	38.8	15.0	0.163	1.8	0.9	0.0	ID	ID	ID	ID
	8:00	43.5	16.0	0.172	1.0	0.7	0.0	ID	ID	ID	ID
	9:00	44.5	16.3	0.164	1.2	0.6	0.3	ID	ID	ID	ID
	10:00	45.5	16.6	0.170	1.1	0.7	0.6	ID	ID	ID	ID
	11:00	47.3	16.2	0.145	0.9	0.7	0.8	ID	ID	ID	ID
	12:00	44.9	15.2	0.126	0.7	0.7	1.3	ID	ID	ID	ID
	13:00	47.3	15.9	0.132	0.9	0.7	1.6	ID	ID	ID	ID
	14:00	47.6	18.2	0.123	1.0	1.0	2.7	ID	ID	ID	ID
	15:00	49.2	15.6	0.117	0.8	1.0	3.0	ID	ID	ID	ID
	16:00	42.1	13.9	0.108	0.8	0.7	4.4	ID	ID	ID	ID
	17:00	40.0	13.1	0.118	1.5	0.9	8.9	ID	ID	ID	ID
	18:00	38.0	13.0	0.140	2.8	1.0	8.9	ID	ID	ID	ID
	19:00	37.7	12.6	0.142	2.8	1.1	7.8	ID	ID	ID	ID
	20:00	33.9	11.9	0.142	3.0	0.9	6.6	ID	ID	ID	ID
	21:00	31.1	10.7	0.122	2.8	1.3	5.5	ID	ID	ID	ID
	22:00	27.7	9.4	0.105	1.9	0.8	6.3	ID	ID	ID	ID
	23:00	23.1	8.8	0.095	1.3	1.1	6.8	ID	ID	ID	ID
	0:00	23.5	8.7	0.086	ZS	0.9	5.9	ID	ID	ID	ID
Min		**23.1**	**8.7**	**0.086**	**0.7**	**0.5**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**49.2**	**18.2**	**0.193**	**3.0**	**1.3**	**8.9**	**ID**	**ID**	**ID**	**ID**
Average		**38.7**	**14.0**	**0.140**	**1.5**	**0.8**	**3.2**	**ID**	**ID**	**ID**	**ID**
27/04/2019	1:00	22.4	8.6	0.078	1.6	ZS	ZS	ID	ID	ID	ID
	2:00	21.9	9.0	0.071	1.7	0.9	7.2	ID	ID	ID	ID
	3:00	20.5	8.0	0.066	1.2	0.9	7.6	ID	ID	ID	ID
	4:00	21.5	7.8	0.070	1.6	0.8	6.8	ID	ID	ID	ID
	5:00	19.2	7.5	0.067	1.8	0.9	5.1	ID	ID	ID	ID
	6:00	19.9	7.4	0.069	1.8	0.8	2.5	ID	ID	ID	ID
	7:00	27.1	8.2	0.096	3.3	0.8	0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	26.2	8.5	0.081	1.0	0.8	0.4	ID	ID	ID	ID
	9:00	25.0	8.5	0.075	0.9	0.9	2.3	ID	ID	ID	ID
	10:00	24.1	8.0	MM	0.4	0.9	4.9	ID	ID	ID	ID
	11:00	23.5	7.8	MM	0.6	0.9	3.6	ID	ID	ID	ID
	12:00	24.3	7.8	0.267	0.6	0.8	3.4	ID	ID	ID	ID
	13:00	25.8	7.8	0.248	0.5	0.9	4.2	ID	ID	ID	ID
	14:00	26.0	8.0	0.262	0.5	0.7	3.7	ID	ID	ID	ID
	15:00	30.9	9.0	0.270	0.6	0.8	3.3	ID	ID	ID	ID
	16:00	24.6	8.2	0.274	0.6	0.8	3.3	ID	ID	ID	ID
	17:00	25.6	8.8	0.280	0.8	1.0	3.7	ID	ID	ID	ID
	18:00	28.7	9.3	0.302	2.3	1.2	2.9	ID	ID	ID	ID
	19:00	30.4	10.8	0.339	5.7	2.3	3.1	ID	ID	ID	ID
	20:00	27.8	9.9	0.326	2.8	1.2	1.8	ID	ID	ID	ID
	21:00	26.3	9.6	0.321	3.1	1.0	0.8	ID	ID	ID	ID
	22:00	24.7	9.3	0.311	4.4	2.0	1.0	ID	ID	ID	ID
	23:00	24.1	9.0	0.313	2.6	1.1	1.3	ID	ID	ID	ID
	0:00	22.6	9.2	0.308	2.2	ZS	ZS	ID	ID	ID	ID
Min		**19.2**	**7.4**	**0.066**	**0.4**	**0.7**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**30.9**	**10.8**	**0.339**	**5.7**	**2.3**	**7.6**	**ID**	**ID**	**ID**	**ID**
Average		**24.7**	**8.6**	**0.204**	**1.8**	**1.0**	**3.3**	**ID**	**ID**	**ID**	**ID**
28/04/2019	1:00	21.4	8.2	0.286	1.9	0.8	0.7	ID	ID	ID	ID
	2:00	21.3	8.5	0.289	ZS	0.8	1.2	ID	ID	ID	ID
	3:00	22.4	8.9	0.292	2.3	1.0	0.5	ID	ID	ID	ID
	4:00	19.8	8.0	0.280	1.4	0.8	0.5	ID	ID	ID	ID
	5:00	22.3	8.5	0.278	1.0	0.9	0.7	ID	ID	ID	ID
	6:00	23.7	8.7	0.278	1.0	0.6	0.6	ID	ID	ID	ID
	7:00	24.1	9.0	0.291	1.1	0.5	1.2	ID	ID	ID	ID
	8:00	28.7	9.2	0.289	0.9	0.7	0.6	ID	ID	ID	ID
	9:00	26.8	9.4	0.283	0.7	0.7	0.6	ID	ID	ID	ID
	10:00	29.9	9.1	0.283	0.7	0.9	0.4	ID	ID	ID	ID
	11:00	30.4	9.1	0.264	0.6	0.9	0.4	ID	ID	ID	ID
	12:00	27.7	8.9	0.249	0.6	0.9	0.3	ID	ID	ID	ID
	13:00	25.9	8.6	0.247	0.6	0.9	0.2	ID	ID	ID	ID
	14:00	24.7	8.2	0.242	0.6	0.8	0.1	ID	ID	ID	ID
	15:00	24.0	8.3	0.254	0.6	0.8	-0.2	ID	ID	ID	ID
	16:00	25.6	9.2	0.275	0.7	0.7	-0.3	ID	ID	ID	ID
	17:00	23.2	9.0	0.288	0.9	0.7	-0.6	ID	ID	ID	ID
	18:00	26.5	9.6	0.294	2.1	1.3	-0.5	ID	ID	ID	ID
	19:00	26.4	10.4	0.319	3.7	1.7	-0.3	ID	ID	ID	ID
	20:00	27.3	10.9	0.342	5.7	2.5	0.5	ID	ID	ID	ID
	21:00	24.0	9.0	0.326	4.7	2.0	0.8	ID	ID	ID	ID
	22:00	22.6	9.4	0.332	2.6	0.9	0.9	ID	ID	ID	ID
	23:00	23.2	9.1	0.306	1.8	0.7	0.2	ID	ID	ID	ID
	0:00	21.9	8.4	0.292	ZS	ZS	ZS	ID	ID	ID	ID
Min		**19.8**	**8.0**	**0.242**	**0.6**	**0.5**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**30.4**	**10.9**	**0.342**	**5.7**	**2.5**	**1.2**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Average		**24.7**	**9.0**	**0.287**	**1.7**	**1.0**	**0.4**	**ID**	**ID**	**ID**	**ID**
29/04/2019	1:00	21.4	8.4	0.285	1.2	ZS	ZS	ID	ID	ID	ID
	2:00	22.7	9.1	0.274	1.0	0.4	1.0	ID	ID	ID	ID
	3:00	21.8	8.6	0.271	0.8	0.6	0.7	ID	ID	ID	ID
	4:00	22.2	8.6	0.275	1.5	0.6	0.7	ID	ID	ID	ID
	5:00	21.9	8.6	0.262	1.1	0.4	0.5	ID	ID	ID	ID
	6:00	22.1	9.0	0.269	1.4	0.8	0.9	ID	ID	ID	ID
	7:00	22.0	8.9	0.290	2.1	0.5	1.5	ID	ID	ID	ID
	8:00	25.0	9.1	0.377	1.4	0.7	1.1	ID	ID	ID	ID
	9:00	27.4	9.5	0.342	1.1	0.5	0.6	ID	ID	ID	ID
	10:00	26.3	10.2	0.290	0.7	0.7	0.2	ID	ID	ID	ID
	11:00	25.0	9.2	0.279	0.4	0.7	0.1	ID	ID	ID	ID
	12:00	25.6	9.4	0.300	0.7	0.7	0.1	ID	ID	ID	ID
	13:00	28.4	9.8	0.361	1.6	1.1	-0.9	ID	ID	ID	ID
	14:00	28.1	9.9	0.361	1.0	1.0	-0.5	ID	ID	ID	ID
	15:00	26.4	10.2	0.287	0.6	0.7	-0.5	ID	ID	ID	ID
	16:00	20.5	8.5	0.434	2.7	1.0	1.6	ID	ID	ID	ID
	17:00	26.3	10.0	0.419	2.7	1.1	0.1	ID	ID	ID	ID
	18:00	26.5	9.8	0.333	2.8	1.2	0.6	ID	ID	ID	ID
	19:00	28.3	10.4	0.363	4.9	1.4	1.0	ID	ID	ID	ID
	20:00	25.9	9.7	0.345	6.0	2.5	0.0	ID	ID	ID	ID
	21:00	23.2	8.7	0.322	4.3	2.1	0.2	ID	ID	ID	ID
	22:00	19.8	7.8	0.303	4.3	2.5	0.0	ID	ID	ID	ID
	23:00	20.3	7.3	0.288	1.3	1.0	0.7	ID	ID	ID	ID
	0:00	19.8	7.4	0.283	1.5	0.7	0.3	ID	ID	ID	ID
Min		**19.8**	**7.3**	**0.262**	**0.4**	**0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**28.4**	**10.4**	**0.434**	**6.0**	**2.5**	**1.6**	**ID**	**ID**	**ID**	**ID**
Average		**24.0**	**9.1**	**0.317**	**2.0**	**1.0**	**0.4**	**ID**	**ID**	**ID**	**ID**
30/04/2019	1:00	21.0	8.0	0.278	ZS	0.7	0.3	ID	ID	ID	ID
	2:00	20.4	8.1	0.266	0.8	ZS	ZS	ID	ID	ID	ID
	3:00	22.1	8.3	0.269	1.3	0.7	1.1	ID	ID	ID	ID
	4:00	21.9	8.5	0.275	1.8	0.8	1.3	ID	ID	ID	ID
	5:00	19.8	8.3	0.269	0.3	0.9	3.4	ID	ID	ID	ID
	6:00	9.6	3.9	0.275	0.6	0.6	2.3	ID	ID	ID	ID
	7:00	10.1	4.2	0.323	1.6	0.6	5.2	ID	ID	ID	ID
	8:00	14.8	5.8	0.408	2.6	0.8	0.6	ID	ID	ID	ID
	9:00	18.3	7.2	0.427	1.8	0.9	0.5	ID	ID	ID	ID
	10:00	24.1	8.1	0.292	0.8	0.7	0.2	ID	ID	ID	ID
	11:00	22.5	8.0	0.288	0.7	0.7	0.4	ID	ID	ID	ID
	12:00	20.8	7.0	0.295	0.9	0.7	1.0	ID	ID	ID	ID
	13:00	18.6	6.1	0.357	2.4	0.8	1.0	ID	ID	ID	ID
	14:00	19.8	5.9	0.369	1.8	1.0	1.3	ID	ID	ID	ID
	15:00	18.9	7.1	0.305	0.7	1.0	2.1	ID	ID	ID	ID
	16:00	19.2	6.0	0.349	1.9	0.9	2.3	ID	ID	ID	ID
	17:00	23.0	7.2	0.380	2.2	1.1	2.3	ID	ID	ID	ID
	18:00	22.9	7.8	0.324	2.2	0.8	1.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	19:00	25.9	10.0	0.358	5.2	1.5	1.2	ID	ID	ID	ID
	20:00	24.2	9.2	0.325	2.6	1.2	0.3	ID	ID	ID	ID
	21:00	28.7	10.2	0.322	4.4	2.1	0.0	ID	ID	ID	ID
	22:00	28.5	10.6	0.316	2.2	1.2	1.1	ID	ID	ID	ID
	23:00	27.2	11.0	0.318	ZS	1.4	0.5	ID	ID	ID	ID
	0:00	27.3	11.2	0.306	ZS	1.1	0.5	ID	ID	ID	ID
Min		**9.6**	**3.9**	**0.266**	**0.3**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**28.7**	**11.2**	**0.427**	**5.2**	**2.1**	**5.2**	**ID**	**ID**	**ID**	**ID**
Average		**21.2**	**7.8**	**0.321**	**1.9**	**1.0**	**1.3**	**ID**	**ID**	**ID**	**ID**
01/05/2019	1:00	26.1	10.6	0.296	1.5	ZS	ZS	ID	ID	ID	ID
	2:00	25.9	10.8	0.299	1.6	0.7	1.7	ID	ID	ID	ID
	3:00	24.6	10.4	0.296	0.6	0.7	2.2	ID	ID	ID	ID
	4:00	26.4	11.6	0.302	0.3	0.8	2.7	ID	ID	ID	ID
	5:00	29.7	12.3	0.301	0.5	0.7	2.3	ID	ID	ID	ID
	6:00	29.5	12.2	0.301	0.8	0.7	1.2	ID	ID	ID	ID
	7:00	30.6	12.9	0.327	1.2	0.6	2.2	ID	ID	ID	ID
	8:00	26.5	11.5	0.338	1.2	1.0	2.7	ID	ID	ID	ID
	9:00	27.1	10.9	0.321	0.9	0.9	11.6	ID	ID	ID	ID
	10:00	24.7	10.4	0.340	0.9	0.6	2.7	ID	ID	ID	ID
	11:00	25.1	10.4	0.324	0.7	0.8	3.0	ID	ID	ID	ID
	12:00	24.3	9.5	0.314	0.2	0.7	3.0	ID	ID	ID	ID
	13:00	20.5	8.0	0.311	0.6	1.0	3.4	ID	ID	ID	ID
	14:00	21.1	8.3	0.302	0.3	0.7	4.2	ID	ID	ID	ID
	15:00	24.8	9.9	0.322	0.9	1.0	4.6	ID	ID	ID	ID
	16:00	27.6	10.7	0.318	1.0	1.2	5.6	ID	ID	ID	ID
	17:00	31.3	12.0	0.321	0.9	1.0	5.2	ID	ID	ID	ID
	18:00	32.2	12.7	0.327	0.9	0.8	4.7	ID	ID	ID	ID
	19:00	29.4	11.5	0.334	1.1	1.0	4.4	ID	ID	ID	ID
	20:00	30.6	12.2	0.329	1.9	0.8	1.6	ID	ID	ID	ID
	21:00	29.3	11.9	0.320	1.2	0.9	1.1	ID	ID	ID	ID
	22:00	30.1	11.6	0.309	0.7	0.7	1.4	ID	ID	ID	ID
	23:00	30.4	12.1	0.299	0.6	ZS	ZS	ID	ID	ID	ID
	0:00	32.2	12.4	0.300	0.3	ZS	ZS	ID	ID	ID	ID
Min		**20.5**	**8.0**	**0.296**	**0.2**	**0.6**	**1.1**	**ID**	**ID**	**ID**	**ID**
Max		**32.2**	**12.9**	**0.340**	**1.9**	**1.2**	**11.6**	**ID**	**ID**	**ID**	**ID**
Average		**27.5**	**11.1**	**0.315**	**0.9**	**0.8**	**3.4**	**ID**	**ID**	**ID**	**ID**
02/05/2019	1:00	31.5	12.1	0.293	0.3	0.5	2.0	ID	ID	ID	ID
	2:00	32.9	12.7	0.291	ZS	0.6	1.3	ID	ID	ID	ID
	3:00	31.1	12.3	0.295	0.2	0.5	1.5	ID	ID	ID	ID
	4:00	35.3	13.6	0.287	0.0	0.5	2.0	ID	ID	ID	ID
	5:00	35.0	12.5	0.285	0.2	0.5	2.2	ID	ID	ID	ID
	6:00	34.4	12.6	0.291	0.5	0.6	2.3	ID	ID	ID	ID
	7:00	31.4	13.0	0.329	1.5	0.8	5.8	ID	ID	ID	ID
	8:00	38.2	14.1	0.445	2.6	0.6	1.2	ID	ID	ID	ID
	9:00	40.7	14.8	0.387	2.0	0.9	0.5	ID	ID	ID	ID
	10:00	41.4	14.9	0.316	1.1	0.8	1.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	11:00	43.2	14.9	0.315	0.8	1.0	2.9	ID	ID	ID	ID
	12:00	40.9	13.9	0.322	0.7	0.7	4.3	ID	ID	ID	ID
	13:00	35.1	12.6	0.430	1.7	1.0	7.9	ID	ID	ID	ID
	14:00	29.2	11.7	0.442	1.2	1.0	3.7	ID	ID	ID	ID
	15:00	21.5	9.5	0.336	0.3	0.7	7.6	ID	ID	ID	ID
	16:00	25.5	10.7	0.468	4.5	1.1	2.2	ID	ID	ID	ID
	17:00	30.1	12.5	0.583	5.8	1.5	3.5	ID	ID	ID	ID
	18:00	36.0	13.7	0.379	4.0	1.7	2.6	ID	ID	ID	ID
	19:00	35.1	12.9	0.347	4.3	1.9	1.3	ID	ID	ID	ID
	20:00	36.7	13.4	0.347	4.1	2.0	1.5	ID	ID	ID	ID
	21:00	35.7	13.5	0.349	1.9	1.3	2.4	ID	ID	ID	ID
	22:00	24.3	10.5	0.344	0.9	0.8	1.9	ID	ID	ID	ID
	23:00	24.0	10.9	0.332	0.7	0.8	0.8	ID	ID	ID	ID
	0:00	22.5	10.5	0.325	1.2	0.9	1.2	ID	ID	ID	ID
Min		**21.5**	**9.5**	**0.285**	**0.0**	**0.5**	**0.5**	**ID**	**ID**	**ID**	**ID**
Max		**43.2**	**14.9**	**0.583**	**5.8**	**2.0**	**7.9**	**ID**	**ID**	**ID**	**ID**
Average		**33.0**	**12.7**	**0.356**	**1.8**	**0.9**	**2.7**	**ID**	**ID**	**ID**	**ID**
03/05/2019	1:00	29.6	12.4	0.317	ZS	0.7	5.1	ID	ID	ID	ID
	2:00	35.0	14.3	0.311	0.6	ZS	ZS	ID	ID	ID	ID
	3:00	26.7	11.9	0.306	-0.1	0.4	2.9	ID	ID	ID	ID
	4:00	32.5	12.9	0.306	0.1	0.6	1.5	ID	ID	ID	ID
	5:00	33.3	12.7	0.309	0.2	0.5	2.4	ID	ID	ID	ID
	6:00	32.5	12.8	0.323	1.0	0.7	1.2	ID	ID	ID	ID
	7:00	37.5	14.6	0.361	1.8	0.6	1.0	ID	ID	ID	ID
	8:00	42.4	15.6	0.427	2.7	0.9	0.2	ID	ID	ID	ID
	9:00	46.3	15.5	0.422	1.6	0.8	0.1	ID	ID	ID	ID
	10:00	44.6	15.4	0.358	2.8	1.1	6.6	ID	ID	ID	ID
	11:00	40.3	14.8	0.343	1.1	1.0	6.1	ID	ID	ID	ID
	12:00	38.8	13.7	0.323	1.0	0.9	6.0	ID	ID	ID	ID
	13:00	44.7	14.2	0.383	0.6	1.1	7.0	ID	ID	ID	ID
	14:00	26.0	10.2	0.368	1.7	1.1	9.9	ID	ID	ID	ID
	15:00	27.7	11.1	0.354	1.2	1.1	5.3	ID	ID	ID	ID
	16:00	40.7	14.2	0.446	1.8	0.9	3.2	ID	ID	ID	ID
	17:00	40.7	14.7	0.467	3.2	1.2	3.2	ID	ID	ID	ID
	18:00	41.8	14.2	0.364	2.8	1.0	4.5	ID	ID	ID	ID
	19:00	40.9	14.4	0.361	2.6	0.9	5.1	ID	ID	ID	ID
	20:00	41.7	14.5	0.357	2.5	1.2	3.7	ID	ID	ID	ID
	21:00	39.8	14.1	0.351	1.7	1.0	2.3	ID	ID	ID	ID
	22:00	37.7	13.8	0.333	1.0	0.7	1.9	ID	ID	ID	ID
	23:00	40.2	14.0	0.332	0.6	0.7	2.6	ID	ID	ID	ID
	0:00	42.5	14.1	0.318	ZS	0.8	4.1	ID	ID	ID	ID
Min		**26.0**	**10.2**	**0.306**	**-0.1**	**0.4**	**0.1**	**ID**	**ID**	**ID**	**ID**
Max		**46.3**	**15.6**	**0.467**	**3.2**	**1.2**	**9.9**	**ID**	**ID**	**ID**	**ID**
Average		**37.7**	**13.8**	**0.356**	**1.5**	**0.9**	**3.7**	**ID**	**ID**	**ID**	**ID**
04/05/2019	1:00	37.7	13.5	0.313	0.3	ZS	ZS	ID	ID	ID	ID
	2:00	37.9	13.3	0.308	-0.1	0.9	4.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	3:00	37.2	13.2	0.309	0.0	0.8	3.9	ID	ID	ID	ID
	4:00	31.3	12.0	0.313	-0.1	0.7	4.2	ID	ID	ID	ID
	5:00	36.1	13.2	0.306	0.1	0.5	2.2	ID	ID	ID	ID
	6:00	38.4	13.4	0.315	0.6	0.6	1.7	ID	ID	ID	ID
	7:00	38.2	14.1	0.343	1.6	0.6	1.6	ID	ID	ID	ID
	8:00	32.0	12.5	0.366	1.4	0.7	1.2	ID	ID	ID	ID
	9:00	30.8	12.7	0.376	2.1	0.7	1.5	ID	ID	ID	ID
	10:00	32.5	12.5	0.333	0.7	0.8	1.5	ID	ID	ID	ID
	11:00	34.8	12.4	0.340	0.7	1.2	7.3	ID	ID	ID	ID
	12:00	35.6	11.8	0.343	0.6	0.9	8.3	ID	ID	ID	ID
	13:00	35.2	11.7	0.332	0.5	0.9	7.3	ID	ID	ID	ID
	14:00	26.5	10.1	0.349	1.0	1.2	9.0	ID	ID	ID	ID
	15:00	27.2	10.3	0.342	0.4	1.1	5.4	ID	ID	ID	ID
	16:00	29.6	11.1	0.337	0.5	0.8	5.8	ID	ID	ID	ID
	17:00	34.3	12.3	0.357	1.3	1.0	5.8	ID	ID	ID	ID
	18:00	35.0	12.8	0.373	2.0	1.1	5.9	ID	ID	ID	ID
	19:00	23.4	9.5	0.358	1.9	1.2	8.9	ID	ID	ID	ID
	20:00	22.5	9.2	0.349	1.6	1.3	11.0	ID	ID	ID	ID
	21:00	21.4	9.0	0.341	1.0	0.8	9.1	ID	ID	ID	ID
	22:00	19.4	7.9	0.371	4.5	1.8	11.7	ID	ID	ID	ID
	23:00	25.4	9.8	0.347	1.6	1.2	6.8	ID	ID	ID	ID
	0:00	28.3	10.2	0.330	0.8	ZS	ZS	ID	ID	ID	ID
Min		**19.4**	**7.9**	**0.306**	**-0.1**	**0.5**	**1.2**	**ID**	**ID**	**ID**	**ID**
Max		**38.4**	**14.1**	**0.376**	**4.5**	**1.8**	**11.7**	**ID**	**ID**	**ID**	**ID**
Average		**31.3**	**11.6**	**0.340**	**1.0**	**0.9**	**5.7**	**ID**	**ID**	**ID**	**ID**
05/05/2019	1:00	18.7	7.6	0.303	-0.3	0.8	7.8	ID	ID	ID	ID
	2:00	15.2	5.8	0.307	ZS	0.9	9.5	ID	ID	ID	ID
	3:00	17.8	6.5	0.303	0.0	0.9	10.6	ID	ID	ID	ID
	4:00	17.0	6.5	0.299	0.1	0.6	12.1	ID	ID	ID	ID
	5:00	23.5	8.8	0.300	0.0	0.7	11.0	ID	ID	ID	ID
	6:00	22.7	9.3	0.295	-0.4	0.5	10.5	ID	ID	ID	ID
	7:00	22.5	8.5	0.315	0.0	0.4	10.4	ID	ID	ID	ID
	8:00	26.2	9.5	0.332	0.2	0.6	7.0	ID	ID	ID	ID
	9:00	29.2	9.6	0.323	0.4	0.8	7.7	ID	ID	ID	ID
	10:00	18.3	6.7	0.312	0.0	0.7	9.5	ID	ID	ID	ID
	11:00	17.9	6.8	0.308	-0.3	0.5	9.3	ID	ID	ID	ID
	12:00	13.1	5.5	0.331	0.2	0.9	13.7	ID	ID	ID	ID
	13:00	21.8	7.4	0.317	-0.2	0.9	14.2	ID	ID	ID	ID
	14:00	19.4	6.7	0.317	-0.2	1.0	14.1	ID	ID	ID	ID
	15:00	20.1	7.2	0.323	0.1	0.8	11.4	ID	ID	ID	ID
	16:00	13.0	5.3	0.336	0.3	0.7	14.2	ID	ID	ID	ID
	17:00	14.7	5.8	0.341	0.3	0.9	13.4	ID	ID	ID	ID
	18:00	12.5	4.9	0.328	0.4	1.1	18.9	ID	ID	ID	ID
	19:00	12.0	4.8	0.391	3.6	1.8	17.2	ID	ID	ID	ID
	20:00	12.2	5.3	0.395	3.3	1.3	14.4	ID	ID	ID	ID
	21:00	17.2	7.1	0.386	5.9	2.5	12.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	22:00	20.2	7.5	0.319	0.0	3.0	69.6	ID	ID	ID	ID
	23:00	18.8	7.7	0.332	0.5	2.1	49.9	ID	ID	ID	ID
	0:00	20.6	7.9	0.316	ZS	ZS	ZS	ID	ID	ID	ID
Min		**12.0**	**4.8**	**0.295**	**-0.4**	**0.4**	**7.0**	**ID**	**ID**	**ID**	**ID**
Max		**29.2**	**9.6**	**0.395**	**5.9**	**3.0**	**69.6**	**ID**	**ID**	**ID**	**ID**
Average		**18.5**	**7.0**	**0.326**	**0.6**	**1.1**	**16.0**	**ID**	**ID**	**ID**	**ID**
06/05/2019	1:00	22.7	9.0	ZS	0.4	ZS	ZS	ID	ID	ID	ID
	2:00	31.1	11.5	0.313	0.0	0.9	5.9	ID	ID	ID	ID
	3:00	23.7	9.0	0.299	-0.4	0.8	8.8	ID	ID	ID	ID
	4:00	17.7	7.1	0.294	-0.4	1.8	38.4	ID	ID	ID	ID
	5:00	17.7	7.4	0.305	0.0	0.8	3.5	ID	ID	ID	ID
	6:00	17.8	7.4	0.323	0.9	1.2	9.1	ID	ID	ID	ID
	7:00	21.3	8.5	0.336	0.7	0.8	3.8	ID	ID	ID	ID
	7:00	20.5	8.6	0.332	0.4	0.8	2.7	ID	ID	ID	ID
	9:00	23.5	9.0	0.332	0.2	0.6	2.2	ID	ID	ID	ID
	10:00	26.2	9.4	0.321	-0.1	0.9	2.3	ID	ID	ID	ID
	11:00	18.4	7.2	0.320	-0.3	0.9	9.9	ID	ID	ID	ID
	12:00	13.4	5.6	0.320	-0.3	0.9	11.5	ID	ID	ID	ID
	13:00	15.9	6.2	0.317	-0.4	1.2	11.9	ID	ID	ID	ID
	14:00	15.1	6.0	0.323	-0.2	1.0	9.7	ID	ID	ID	ID
	15:00	16.6	6.6	0.325	-0.1	0.8	7.7	ID	ID	ID	ID
	16:00	15.9	6.4	0.330	-0.1	0.7	8.2	ID	ID	ID	ID
	17:00	17.0	6.3	0.335	0.0	0.8	10.1	ID	ID	ID	ID
	18:00	11.5	4.6	0.350	0.7	1.0	11.9	ID	ID	ID	ID
	19:00	19.6	9.5	0.388	1.8	1.2	15.1	ID	ID	ID	ID
	20:00	23.3	9.1	0.385	2.2	1.2	16.4	ID	ID	ID	ID
	21:00	19.9	7.7	0.385	1.7	1.0	13.5	ID	ID	ID	ID
	22:00	24.6	9.4	0.359	1.2	1.0	10.7	ID	ID	ID	ID
	23:00	31.9	10.9	ZS	0.6	1.0	10.6	ID	ID	ID	ID
	0:00	32.7	11.7	0.330	0.0	1.0	13.2	ID	ID	ID	ID
Min		**11.5**	**4.6**	**0.294**	**-0.4**	**0.6**	**2.2**	**ID**	**ID**	**ID**	**ID**
Max		**32.7**	**11.7**	**0.388**	**2.2**	**1.8**	**38.4**	**ID**	**ID**	**ID**	**ID**
Average		**20.7**	**8.1**	**0.333**	**0.4**	**1.0**	**10.3**	**ID**	**ID**	**ID**	**ID**
07/05/2019	1:00	37.2	12.5	0.319	ZS	0.7	4.4	ID	ID	ID	ID
	2:00	37.2	12.5	0.314	-0.1	ZS	ZS	ID	ID	ID	ID
	3:00	30.7	11.3	0.311	-0.4	0.6	8.2	ID	ID	ID	ID
	4:00	17.4	6.9	0.309	-0.6	0.9	18.4	ID	ID	ID	ID
	5:00	17.2	7.3	0.317	0.1	1.3	30.9	ID	ID	ID	ID
	6:00	19.2	7.1	0.321	0.5	0.7	5.9	ID	ID	ID	ID
	7:00	22.4	8.6	0.374	2.8	1.2	13.2	ID	ID	ID	ID
	8:00	20.3	8.0	0.406	1.2	0.9	9.0	ID	ID	ID	ID
	9:00	17.9	7.3	0.374	0.5	0.8	10.1	ID	ID	ID	ID
	10:00	20.4	8.2	0.349	0.7	0.7	6.8	ID	ID	ID	ID
	11:00	24.9	9.1	0.327	-0.1	0.9	8.8	ID	ID	ID	ID
	12:00	27.6	9.8	0.333	0.2	0.6	8.6	ID	ID	ID	ID
	13:00	27.4	9.2	0.492	0.8	0.9	8.9	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	14:00	30.0	10.1	0.441	0.6	0.9	6.9	ID	ID	ID	ID
	15:00	34.2	11.9	0.348	0.6	0.5	5.9	ID	ID	ID	ID
	16:00	37.0	12.7	0.440	1.1	0.6	5.4	ID	ID	ID	ID
	17:00	37.0	12.3	0.485	3.0	1.1	5.7	ID	ID	ID	ID
	18:00	38.7	13.1	0.397	2.6	1.0	5.8	ID	ID	ID	ID
	19:00	38.2	13.2	0.403	3.6	0.9	8.1	ID	ID	ID	ID
	20:00	35.0	13.0	0.383	2.5	1.0	7.3	ID	ID	ID	ID
	21:00	27.9	10.7	0.365	2.0	1.0	6.5	ID	ID	ID	ID
	22:00	36.7	13.6	0.359	1.5	0.8	6.5	ID	ID	ID	ID
	23:00	38.3	14.2	ZS	ZS	0.6	3.6	ID	ID	ID	ID
	0:00	35.1	13.5	0.335	ZS	0.5	8.0	ID	ID	ID	ID
Min		**17.2**	**6.9**	**0.309**	**-0.6**	**0.5**	**3.6**	**ID**	**ID**	**ID**	**ID**
Max		**38.7**	**14.2**	**0.492**	**3.6**	**1.3**	**30.9**	**ID**	**ID**	**ID**	**ID**
Average		**29.5**	**10.7**	**0.370**	**1.1**	**0.8**	**8.8**	**ID**	**ID**	**ID**	**ID**
08/05/2019	1:00	38.8	14.2	ZS	-0.2	ZS	ZS	ID	ID	ID	ID
	2:00	24.0	9.6	0.309	-0.3	0.5	5.0	ID	ID	ID	ID
	3:00	35.6	13.0	0.315	-0.3	0.3	5.7	ID	ID	ID	ID
	4:00	40.1	14.6	0.314	-0.2	0.7	6.3	ID	ID	ID	ID
	5:00	37.0	13.9	0.315	-0.1	0.3	7.9	ID	ID	ID	ID
	6:00	37.2	13.4	0.325	0.3	0.6	8.6	ID	ID	ID	ID
	7:00	38.4	14.0	0.343	0.9	0.6	6.3	ID	ID	ID	ID
	7:00	40.5	14.1	0.437	0.7	0.5	5.4	ID	ID	ID	ID
	9:00	40.9	13.9	0.435	1.2	0.6	7.5	ID	ID	ID	ID
	10:00	33.0	12.2	0.340	0.1	0.6	4.4	ID	ID	ID	ID
	11:00	29.0	10.7	0.341	-0.2	0.4	4.8	ID	ID	ID	ID
	12:00	25.3	9.5	0.348	0.0	0.6	9.7	ID	ID	ID	ID
	13:00	16.2	6.6	0.407	2.6	0.6	6.4	ID	ID	ID	ID
	14:00	15.0	6.3	0.421	1.9	0.7	7.6	ID	ID	ID	ID
	15:00	20.4	8.1	0.354	0.6	0.5	5.1	ID	ID	ID	ID
	16:00	27.3	10.3	0.509	1.8	0.7	10.5	ID	ID	ID	ID
	17:00	23.7	9.2	0.474	1.8	0.8	4.7	ID	ID	ID	ID
	18:00	29.3	11.6	0.395	2.1	0.7	5.6	ID	ID	ID	ID
	19:00	31.0	11.9	0.386	2.5	0.7	7.5	ID	ID	ID	ID
	20:00	32.2	12.2	0.395	2.5	0.8	5.4	ID	ID	ID	ID
	21:00	31.7	12.0	0.375	1.9	0.7	5.6	ID	ID	ID	ID
	22:00	31.5	11.5	0.360	1.6	0.5	5.5	ID	ID	ID	ID
	23:00	29.5	11.5	0.342	0.6	ZS	ZS	ID	ID	ID	ID
	0:00	30.1	11.9	0.348	1.1	ZS	ZS	ID	ID	ID	ID
Min		**15.0**	**6.3**	**0.309**	**-0.3**	**0.3**	**4.4**	**ID**	**ID**	**ID**	**ID**
Max		**40.9**	**14.6**	**0.509**	**2.6**	**0.8**	**10.5**	**ID**	**ID**	**ID**	**ID**
Average		**30.8**	**11.5**	**0.373**	**1.0**	**0.6**	**6.5**	**ID**	**ID**	**ID**	**ID**
09/05/2019	1:00	31.9	11.9	0.335	0.5	0.5	4.1	ID	ID	ID	ID
	2:00	30.2	11.9	0.331	ZS	0.6	3.2	ID	ID	ID	ID
	3:00	31.6	12.3	0.330	0.2	0.6	3.0	ID	ID	ID	ID
	4:00	31.6	12.3	0.331	0.4	0.3	2.1	ID	ID	ID	ID
	5:00	32.1	12.6	0.337	0.8	0.3	0.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	6:00	32.4	13.0	0.350	1.5	0.1	0.0	ID	ID	ID	ID
	7:00	33.0	13.1	0.388	2.3	0.5	0.3	ID	ID	ID	ID
	8:00	35.0	13.8	0.522	2.1	0.6	-0.4	ID	ID	ID	ID
	9:00	40.6	14.5	0.432	1.2	0.8	-0.2	ID	ID	ID	ID
	10:00	37.1	14.2	0.364	0.4	0.5	0.5	ID	ID	ID	ID
	11:00	37.3	13.8	0.360	0.4	0.5	0.3	ID	ID	ID	ID
	12:00	38.0	13.3	0.375	1.6	0.4	0.6	ID	ID	ID	ID
	13:00	42.2	13.5	0.444	2.7	0.4	0.7	ID	ID	ID	ID
	14:00	52.9	14.8	0.469	2.1	0.7	4.3	ID	ID	ID	ID
	15:00	43.9	15.6	0.411	0.7	0.7	5.5	ID	ID	ID	ID
	16:00	42.7	14.7	0.440	1.5	0.8	3.5	ID	ID	ID	ID
	17:00	54.5	15.8	0.502	2.4	0.8	4.3	ID	ID	ID	ID
	18:00	43.2	14.1	0.397	1.7	0.7	4.3	ID	ID	ID	ID
	19:00	44.8	15.6	0.402	2.0	0.5	5.4	ID	ID	ID	ID
	20:00	41.9	14.1	0.396	1.8	0.4	5.0	ID	ID	ID	ID
	21:00	41.4	14.0	0.408	1.9	0.5	4.5	ID	ID	ID	ID
	22:00	43.9	14.7	0.396	1.9	0.4	5.5	ID	ID	ID	ID
	23:00	26.9	11.1	0.415	2.9	0.8	14.8	ID	ID	ID	ID
	0:00	24.0	10.2	0.353	1.8	0.9	10.4	ID	ID	ID	ID
Min		**24.0**	**10.2**	**0.330**	**0.2**	**0.1**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**54.5**	**15.8**	**0.522**	**2.9**	**0.9**	**14.8**	**ID**	**ID**	**ID**	**ID**
Average		**38.0**	**13.5**	**0.395**	**1.5**	**0.6**	**3.4**	**ID**	**ID**	**ID**	**ID**
10/05/2019	1:00	23.9	9.1	0.338	ZS	1.0	22.7	ID	ID	ID	ID
	2:00	21.9	7.9	0.338	-0.1	ZS	ZS	ID	ID	ID	ID
	3:00	18.3	6.3	0.327	-0.4	0.1	7.5	ID	ID	ID	ID
	4:00	22.3	7.2	0.331	-0.3	0.2	2.8	ID	ID	ID	ID
	5:00	20.3	6.1	0.336	-0.2	0.3	1.9	ID	ID	ID	ID
	6:00	15.8	4.7	0.341	-0.2	0.1	0.7	ID	ID	ID	ID
	7:00	20.8	7.6	0.341	-0.2	0.1	-0.3	ID	ID	ID	ID
	7:00	17.7	6.8	0.371	-0.3	0.1	1.7	ID	ID	ID	ID
	9:00	20.6	8.0	0.502	2.1	0.4	0.0	ID	ID	ID	ID
	10:00	44.1	16.6	0.371	0.4	0.1	0.0	ID	ID	ID	ID
	11:00	44.8	17.0	0.373	0.4	0.3	0.7	ID	ID	ID	ID
	12:00	44.9	16.1	0.376	0.5	0.2	1.5	ID	ID	ID	ID
	13:00	49.4	18.1	0.450	1.2	0.4	1.7	ID	ID	ID	ID
	14:00	50.5	17.7	0.485	1.5	0.8	1.3	ID	ID	ID	ID
	15:00	44.5	17.0	0.384	0.8	0.7	7.7	ID	ID	ID	ID
	16:00	51.0	18.7	0.522	1.7	0.7	7.7	ID	ID	ID	ID
	17:00	53.8	18.4	0.556	2.2	0.8	5.7	ID	ID	ID	ID
	18:00	52.7	19.3	0.438	2.9	0.9	6.9	ID	ID	ID	ID
	19:00	51.2	18.4	0.436	3.2	1.0	6.7	ID	ID	ID	ID
	20:00	47.2	18.3	0.420	2.1	0.9	7.7	ID	ID	ID	ID
	21:00	48.1	18.2	0.409	1.4	0.8	6.7	ID	ID	ID	ID
	22:00	47.6	17.8	0.413	1.6	0.7	4.7	ID	ID	ID	ID
	23:00	42.9	16.6	0.394	1.1	0.7	5.0	ID	ID	ID	ID
	0:00	41.4	15.8	0.377	ZS	0.8	6.8	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Min		**15.8**	**4.7**	**0.327**	**-0.4**	**0.1**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**53.8**	**19.3**	**0.556**	**3.2**	**1.0**	**22.7**	**ID**	**ID**	**ID**	**ID**
Average		**37.3**	**13.7**	**0.401**	**1.0**	**0.5**	**4.7**	**ID**	**ID**	**ID**	**ID**
11/05/2019	1:00	39.1	15.4	0.378	0.7	ZS	ZS	ID	ID	ID	ID
	2:00	41.5	15.5	0.376	0.4	0.7	6.6	ID	ID	ID	ID
	3:00	39.1	15.0	0.380	0.4	0.5	3.1	ID	ID	ID	ID
	4:00	39.9	15.3	0.379	0.2	0.5	4.3	ID	ID	ID	ID
	5:00	39.9	15.0	0.377	0.2	0.5	2.3	ID	ID	ID	ID
	6:00	37.9	14.9	0.385	0.9	0.5	2.4	ID	ID	ID	ID
	7:00	31.6	13.8	0.414	1.7	0.6	2.4	ID	ID	ID	ID
	8:00	35.8	14.6	0.407	1.4	0.5	0.7	ID	ID	ID	ID
	9:00	40.5	14.8	0.382	0.4	0.6	3.0	ID	ID	ID	ID
	10:00	40.8	14.3	0.376	0.3	0.4	5.5	ID	ID	ID	ID
	11:00	45.2	14.5	0.369	0.2	0.6	6.4	ID	ID	ID	ID
	12:00	43.0	14.3	0.363	0.2	0.7	6.4	ID	ID	ID	ID
	13:00	44.4	14.2	0.364	0.2	0.7	6.1	ID	ID	ID	ID
	14:00	44.7	14.4	0.374	0.5	0.7	5.7	ID	ID	ID	ID
	15:00	46.2	16.6	0.394	1.0	0.6	5.5	ID	ID	ID	ID
	16:00	44.6	14.4	0.376	0.4	0.7	4.2	ID	ID	ID	ID
	17:00	45.4	14.9	0.416	1.6	0.7	3.3	ID	ID	ID	ID
	18:00	46.3	15.9	0.421	3.8	1.0	3.7	ID	ID	ID	ID
	19:00	50.7	16.8	0.416	4.3	1.2	2.6	ID	ID	ID	ID
	20:00	46.1	15.7	0.425	3.6	1.1	3.0	ID	ID	ID	ID
	21:00	46.1	14.7	0.402	2.7	0.9	4.3	ID	ID	ID	ID
	22:00	47.9	15.1	0.392	2.9	0.9	3.5	ID	ID	ID	ID
	23:00	44.7	14.5	0.382	1.4	0.4	5.0	ID	ID	ID	ID
	0:00	38.5	13.3	0.360	0.7	ZS	ZS	ID	ID	ID	ID
Min		**31.6**	**13.3**	**0.360**	**0.2**	**0.4**	**0.7**	**ID**	**ID**	**ID**	**ID**
Max		**50.7**	**16.8**	**0.425**	**4.3**	**1.2**	**6.6**	**ID**	**ID**	**ID**	**ID**
Average		**42.5**	**14.9**	**0.388**	**1.3**	**0.7**	**4.1**	**ID**	**ID**	**ID**	**ID**
12/05/2019	1:00	34.3	12.4	0.348	0.4	0.2	8.1	ID	ID	ID	ID
	2:00	33.1	12.3	0.339	ZS	0.5	5.8	ID	ID	ID	ID
	3:00	32.5	11.8	0.342	0.5	0.3	3.0	ID	ID	ID	ID
	4:00	30.0	11.6	0.340	0.3	0.3	2.3	ID	ID	ID	ID
	5:00	28.2	11.0	0.347	0.7	0.5	0.7	ID	ID	ID	ID
	6:00	29.5	11.8	0.348	0.4	0.5	1.5	ID	ID	ID	ID
	7:00	33.5	12.7	0.358	0.5	0.7	1.1	ID	ID	ID	ID
	7:00	33.6	13.1	0.375	0.4	0.5	0.4	ID	ID	ID	ID
	9:00	35.4	13.2	0.374	0.2	0.5	3.6	ID	ID	ID	ID
	10:00	38.6	13.5	0.378	0.2	0.5	4.6	ID	ID	ID	ID
	11:00	35.2	12.9	0.373	0.4	0.5	3.9	ID	ID	ID	ID
	12:00	34.7	12.4	0.374	0.5	0.9	6.6	ID	ID	ID	ID
	13:00	34.7	11.9	0.364	0.1	0.7	7.5	ID	ID	ID	ID
	14:00	32.4	11.6	0.363	0.0	0.6	5.7	ID	ID	ID	ID
	15:00	32.8	12.1	0.364	0.1	0.8	5.8	ID	ID	ID	ID
	16:00	29.8	10.9	0.363	0.1	0.8	5.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	17:00	30.9	11.4	0.369	0.4	0.9	3.0	ID	ID	ID	ID
	18:00	33.2	12.3	0.403	1.1	0.8	2.0	ID	ID	ID	ID
	19:00	37.6	13.9	0.403	1.8	0.8	1.4	ID	ID	ID	ID
	20:00	36.3	13.9	0.419	2.0	0.8	1.2	ID	ID	ID	ID
	21:00	36.0	13.4	0.393	1.4	0.8	0.9	ID	ID	ID	ID
	22:00	34.4	12.6	0.388	1.2	0.8	0.6	ID	ID	ID	ID
	23:00	35.9	13.1	0.383	1.0	0.8	0.8	ID	ID	ID	ID
	0:00	33.1	12.8	0.370	ZS	0.7	0.8	ID	ID	ID	ID
Min		**28.2**	**10.9**	**0.339**	**0.0**	**0.2**	**0.4**	**ID**	**ID**	**ID**	**ID**
Max		**38.6**	**13.9**	**0.419**	**2.0**	**0.9**	**8.1**	**ID**	**ID**	**ID**	**ID**
Average		**33.6**	**12.4**	**0.370**	**0.6**	**0.6**	**3.2**	**ID**	**ID**	**ID**	**ID**
13/05/2019	1:00	34.8	13.0	0.371	0.7	ZS	ZS	ID	ID	ID	ID
	2:00	26.8	11.1	0.353	0.0	0.5	2.7	ID	ID	ID	ID
	3:00	25.1	10.6	0.356	0.5	0.8	2.3	ID	ID	ID	ID
	4:00	25.5	10.1	0.357	0.8	0.6	2.1	ID	ID	ID	ID
	5:00	29.7	12.0	0.360	0.9	0.7	0.8	ID	ID	ID	ID
	6:00	31.5	12.5	0.364	1.3	0.8	0.7	ID	ID	ID	ID
	7:00	35.3	13.0	0.419	2.4	0.9	0.7	ID	ID	ID	ID
	8:00	41.4	13.2	0.482	3.3	0.9	0.8	ID	ID	ID	ID
	9:00	42.2	13.4	0.453	1.6	0.8	0.5	ID	ID	ID	ID
	10:00	37.4	13.5	0.383	1.0	0.7	0.2	ID	ID	ID	ID
	11:00	36.9	13.3	0.375	0.8	0.6	0.7	ID	ID	ID	ID
	12:00	33.8	12.8	0.367	0.6	0.4	0.3	ID	ID	ID	ID
	13:00	36.3	12.7	0.443	2.6	0.5	0.5	ID	ID	ID	ID
	14:00	36.1	12.1	0.413	1.9	0.6	0.6	ID	ID	ID	ID
	15:00	37.2	12.6	0.380	0.7	0.8	1.4	ID	ID	ID	ID
	16:00	40.1	12.4	0.466	2.2	1.0	1.6	ID	ID	ID	ID
	17:00	49.4	13.3	0.516	2.9	1.1	1.8	ID	ID	ID	ID
	18:00	44.5	13.7	0.421	3.1	1.0	2.4	ID	ID	ID	ID
	19:00	48.3	18.6	0.461	4.1	1.1	1.4	ID	ID	ID	ID
	20:00	41.3	14.9	0.435	4.2	1.3	0.5	ID	ID	ID	ID
	21:00	36.0	13.1	0.404	3.9	1.8	0.6	ID	ID	ID	ID
	22:00	34.5	13.1	0.385	1.7	0.9	0.9	ID	ID	ID	ID
	23:00	33.8	12.9	0.372	1.1	0.9	1.0	ID	ID	ID	ID
	0:00	32.1	12.2	0.354	0.2	0.7	1.2	ID	ID	ID	ID
Min		**25.1**	**10.1**	**0.353**	**0.0**	**0.4**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**49.4**	**18.6**	**0.516**	**4.2**	**1.8**	**2.7**	**ID**	**ID**	**ID**	**ID**
Average		**36.3**	**12.9**	**0.404**	**1.8**	**0.8**	**1.1**	**ID**	**ID**	**ID**	**ID**
14/05/2019	1:00	30.8	12.0	0.350	ZS	ZS	ZS	ID	ID	ID	ID
	2:00	28.2	11.3	0.351	0.2	ZS	ZS	ID	ID	ID	ID
	3:00	29.4	11.8	0.348	0.1	0.7	3.7	ID	ID	ID	ID
	4:00	28.2	11.4	0.345	-0.1	0.6	4.5	ID	ID	ID	ID
	5:00	28.7	11.2	0.343	-0.1	0.7	5.6	ID	ID	ID	ID
	6:00	31.4	12.1	0.369	1.0	0.8	5.6	ID	ID	ID	ID
	7:00	34.6	13.0	0.402	2.1	0.8	3.9	ID	ID	ID	ID
	7:00	38.7	13.8	0.503	1.7	0.9	3.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	9:00	41.5	12.7	0.468	1.4	1.0	4.3	ID	ID	ID	ID
	10:00	34.8	12.5	0.375	0.6	0.8	4.8	ID	ID	ID	ID
	11:00	35.0	12.2	0.370	0.4	0.8	4.8	ID	ID	ID	ID
	12:00	32.9	12.1	0.369	0.5	0.7	4.7	ID	ID	ID	ID
	13:00	34.6	11.1	0.487	2.3	0.9	3.2	ID	ID	ID	ID
	14:00	36.3	11.0	0.452	0.7	1.2	5.3	ID	ID	ID	ID
	15:00	32.7	10.7	0.366	0.5	1.0	6.1	ID	ID	ID	ID
	16:00	36.3	11.7	0.546	1.7	1.1	5.3	ID	ID	ID	ID
	17:00	40.8	11.8	0.518	2.0	1.1	5.6	ID	ID	ID	ID
	18:00	36.5	12.4	0.463	2.4	1.0	4.6	ID	ID	ID	ID
	19:00	33.9	11.6	0.394	3.9	1.6	6.1	ID	ID	ID	ID
	20:00	33.2	13.3	0.405	4.1	2.1	7.1	ID	ID	ID	ID
	21:00	32.5	11.6	0.396	2.8	1.4	6.4	ID	ID	ID	ID
	22:00	33.2	11.9	0.390	1.7	0.8	5.6	ID	ID	ID	ID
	23:00	32.8	12.0	0.383	1.6	1.0	2.7	ID	ID	ID	ID
	0:00	31.5	11.7	0.358	ZS	0.9	1.6	ID	ID	ID	ID
Min		**28.2**	**10.7**	**0.343**	**-0.1**	**0.6**	**1.6**	**ID**	**ID**	**ID**	**ID**
Max		**41.5**	**13.8**	**0.546**	**4.1**	**2.1**	**7.1**	**ID**	**ID**	**ID**	**ID**
Average		**33.7**	**12.0**	**0.406**	**1.4**	**1.0**	**4.8**	**ID**	**ID**	**ID**	**ID**
15/05/2019	1:00	29.7	11.2	ZS	1.0	ZS	ZS	ID	ID	ID	ID
	2:00	28.9	10.8	0.341	0.7	0.7	0.6	ID	ID	ID	ID
	3:00	29.8	10.8	0.349	0.9	0.7	0.1	ID	ID	ID	ID
	4:00	26.1	10.6	0.353	0.9	0.8	0.1	ID	ID	ID	ID
	5:00	28.7	10.9	0.354	1.5	0.9	0.2	ID	ID	ID	ID
	6:00	32.4	12.2	0.377	2.9	0.7	0.3	ID	ID	ID	ID
	7:00	31.8	12.3	0.425	3.2	1.1	0.4	ID	ID	ID	ID
	8:00	38.6	13.0	0.492	3.6	1.0	3.3	ID	ID	ID	ID
	9:00	35.9	11.4	0.473	1.9	1.0	6.7	ID	ID	ID	ID
	10:00	32.3	10.9	0.379	0.6	0.8	6.3	ID	ID	ID	ID
	11:00	30.6	10.9	0.386	0.8	1.0	4.2	ID	ID	ID	ID
	12:00	27.4	11.7	0.415	1.5	1.2	15.4	ID	ID	ID	ID
	13:00	34.3	12.4	0.482	3.9	1.4	9.0	ID	ID	ID	ID
	14:00	35.4	12.4	0.477	1.8	1.3	8.3	ID	ID	ID	ID
	15:00	32.8	12.0	0.407	0.7	1.2	10.1	ID	ID	ID	ID
	16:00	36.5	12.2	0.501	1.4	1.2	9.2	ID	ID	ID	ID
	17:00	40.2	13.3	0.518	2.3	1.1	5.7	ID	ID	ID	ID
	18:00	36.9	12.7	0.426	2.0	1.1	7.5	ID	ID	ID	ID
	19:00	37.9	13.3	0.413	2.8	1.2	8.9	ID	ID	ID	ID
	20:00	36.1	13.0	0.404	3.5	1.8	7.8	ID	ID	ID	ID
	21:00	35.0	12.5	0.405	3.4	1.7	4.7	ID	ID	ID	ID
	22:00	33.1	12.7	0.404	4.1	1.7	5.2	ID	ID	ID	ID
	23:00	32.4	12.7	0.385	2.2	ZS	ZS	ID	ID	ID	ID
	0:00	33.2	12.9	0.377	0.9	ZS	ZS	ID	ID	ID	ID
Min		**26.1**	**10.6**	**0.341**	**0.6**	**0.7**	**0.1**	**ID**	**ID**	**ID**	**ID**
Max		**40.2**	**13.3**	**0.518**	**4.1**	**1.8**	**15.4**	**ID**	**ID**	**ID**	**ID**
Average		**33.2**	**12.0**	**0.415**	**2.0**	**1.1**	**5.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
16/05/2019	1:00	31.0	11.6	0.361	0.5	0.9	-0.2	ID	ID	ID	ID
	2:00	24.6	10.2	0.367	ZS	0.7	0.4	ID	ID	ID	ID
	3:00	25.7	10.4	0.355	0.4	0.6	0.0	ID	ID	ID	ID
	4:00	24.9	9.7	0.344	0.0	0.7	1.5	ID	ID	ID	ID
	5:00	23.9	9.3	0.359	1.1	0.7	3.0	ID	ID	ID	ID
	6:00	25.0	10.0	0.379	2.7	0.8	0.7	ID	ID	ID	ID
	7:00	26.1	9.9	0.464	2.5	1.0	0.5	ID	ID	ID	ID
	7:00	26.1	10.3	0.524	4.0	1.0	0.3	ID	ID	ID	ID
	9:00	22.6	10.0	0.580	4.4	1.4	8.2	ID	ID	ID	ID
	10:00	26.5	9.8	0.370	0.5	1.2	9.9	ID	ID	ID	ID
	11:00	27.2	9.9	0.365	0.4	1.0	7.9	ID	ID	ID	ID
	12:00	27.8	10.1	0.369	0.8	1.0	8.7	ID	ID	ID	ID
	13:00	32.5	10.1	0.456	2.4	1.4	11.4	ID	ID	ID	ID
	14:00	29.5	9.7	0.474	0.2	1.4	9.2	ID	ID	ID	ID
	15:00	26.9	9.6	0.375	0.4	1.1	10.6	ID	ID	ID	ID
	16:00	31.6	12.0	0.450	0.5	1.2	8.7	ID	ID	ID	ID
	17:00	40.2	13.7	0.504	1.6	1.3	7.2	ID	ID	ID	ID
	18:00	33.9	13.8	0.447	2.1	1.3	6.5	ID	ID	ID	ID
	19:00	28.9	11.6	0.438	3.4	2.1	35.2	ID	ID	ID	ID
	20:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	21:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	22:00	30.2	11.5	PO	PO	PO	PO	ID	ID	ID	ID
	23:00	28.8	10.7	0.600	2.1	0.9	1.2	ID	ID	ID	ID
	0:00	27.5	10.2	0.541	1.0	0.8	1.4	ID	ID	ID	ID
Min		**22.6**	**9.3**	**0.344**	**0.0**	**0.6**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**40.2**	**13.8**	**0.600**	**4.4**	**2.1**	**35.2**	**ID**	**ID**	**ID**	**ID**
Average		**28.2**	**10.6**	**0.434**	**1.6**	**1.1**	**6.3**	**ID**	**ID**	**ID**	**ID**
17/05/2019	1:00	25.8	9.3	0.518	0.1	0.9	4.0	ID	ID	ID	ID
	2:00	24.5	9.5	0.509	0.0	0.9	11.0	ID	ID	ID	ID
	3:00	25.9	9.7	0.493	0.0	1.0	9.9	ID	ID	ID	ID
	4:00	24.9	9.5	0.481	0.0	0.8	7.8	ID	ID	ID	ID
	5:00	26.2	10.0	0.480	0.2	0.9	6.7	ID	ID	ID	ID
	6:00	27.7	10.5	0.496	1.0	0.8	6.8	ID	ID	ID	ID
	7:00	27.4	10.8	0.523	2.1	0.9	5.0	ID	ID	ID	ID
	8:00	30.0	12.2	0.589	2.7	1.3	11.9	ID	ID	ID	ID
	9:00	31.8	12.5	0.552	0.9	1.3	5.7	ID	ID	ID	ID
	10:00	33.6	12.8	0.473	0.1	0.9	8.5	ID	ID	ID	ID
	11:00	35.8	12.7	0.479	0.3	1.0	8.4	ID	ID	ID	ID
	12:00	38.6	13.6	0.477	1.0	0.9	4.5	ID	ID	ID	ID
	13:00	41.3	13.5	0.510	3.1	1.1	4.3	ID	ID	ID	ID
	14:00	42.3	13.5	0.537	1.8	1.2	5.1	ID	ID	ID	ID
	15:00	39.4	13.1	0.445	0.3	1.0	5.8	ID	ID	ID	ID
	16:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	17:00	42.7	12.9	0.715	1.9	1.3	5.1	ID	ID	ID	ID
	18:00	36.8	12.7	0.585	1.3	0.9	3.4	ID	ID	ID	ID
	19:00	36.9	13.4	0.584	2.2	1.0	2.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	20:00	36.5	12.8	0.581	2.0	0.9	2.6	ID	ID	ID	ID
	21:00	33.7	12.2	0.570	2.0	0.9	1.6	ID	ID	ID	ID
	22:00	33.5	12.0	0.555	2.0	0.8	1.1	ID	ID	ID	ID
	23:00	35.8	13.2	0.537	1.8	0.8	0.6	ID	ID	ID	ID
	0:00	38.4	12.8	0.529	1.7	0.9	0.3	ID	ID	ID	ID
Min		**24.5**	**9.3**	**0.445**	**0.0**	**0.8**	**0.3**	**ID**	**ID**	**ID**	**ID**
Max		**42.7**	**13.6**	**0.715**	**3.1**	**1.3**	**11.9**	**ID**	**ID**	**ID**	**ID**
Average		**33.5**	**12.0**	**0.531**	**1.3**	**1.0**	**5.3**	**ID**	**ID**	**ID**	**ID**
18/05/2019	1:00	35.5	11.7	0.523	2.2	0.7	0.5	ID	ID	ID	ID
	2:00	33.8	11.8	0.487	1.0	0.8	0.2	ID	ID	ID	ID
	3:00	34.7	12.6	0.476	0.4	0.7	0.2	ID	ID	ID	ID
	4:00	32.1	11.8	0.471	0.7	0.7	0.4	ID	ID	ID	ID
	5:00	32.7	11.3	0.466	1.1	0.7	0.9	ID	ID	ID	ID
	6:00	28.0	10.3	0.462	0.9	0.7	0.9	ID	ID	ID	ID
	7:00	29.9	10.5	0.488	0.7	0.7	6.2	ID	ID	ID	ID
	7:00	27.6	10.3	0.494	0.4	1.1	1.1	ID	ID	ID	ID
	9:00	27.9	10.3	0.473	-0.1	0.8	2.3	ID	ID	ID	ID
	10:00	27.7	9.8	0.472	0.0	0.9	3.0	ID	ID	ID	ID
	11:00	25.4	9.0	0.477	0.2	0.8	3.7	ID	ID	ID	ID
	12:00	23.9	8.1	0.467	0.1	0.8	2.7	ID	ID	ID	ID
	13:00	23.4	8.1	0.476	0.5	0.8	1.1	ID	ID	ID	ID
	14:00	24.9	8.1	0.475	0.3	0.8	1.7	ID	ID	ID	ID
	15:00	23.7	8.0	0.469	0.1	0.9	2.7	ID	ID	ID	ID
	16:00	22.5	8.1	0.464	0.1	0.9	2.8	ID	ID	ID	ID
	17:00	24.5	8.3	0.461	0.2	0.8	2.6	ID	ID	ID	ID
	18:00	25.6	9.3	0.471	1.0	0.5	2.1	ID	ID	ID	ID
	19:00	33.2	11.5	0.524	2.7	0.7	0.7	ID	ID	ID	ID
	20:00	39.7	14.5	0.540	3.3	0.9	0.1	ID	ID	ID	ID
	21:00	34.5	12.3	0.503	1.9	0.9	0.8	ID	ID	ID	ID
	22:00	29.1	10.3	0.477	1.7	0.7	1.1	ID	ID	ID	ID
	23:00	31.0	9.9	0.476	1.5	0.9	0.6	ID	ID	ID	ID
	0:00	31.0	10.5	0.465	1.1	0.7	0.0	ID	ID	ID	ID
Min		**22.5**	**8.0**	**0.461**	**-0.1**	**0.5**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**39.7**	**14.5**	**0.540**	**3.3**	**1.1**	**6.2**	**ID**	**ID**	**ID**	**ID**
Average		**29.3**	**10.3**	**0.482**	**0.9**	**0.8**	**1.6**	**ID**	**ID**	**ID**	**ID**
19/05/2019	1:00	29.1	10.0	0.444	0.4	0.7	0.9	ID	ID	ID	ID
	2:00	25.2	8.9	0.439	0.2	0.8	1.1	ID	ID	ID	ID
	3:00	24.2	8.7	0.435	0.1	0.8	1.1	ID	ID	ID	ID
	4:00	26.5	9.0	0.437	0.4	0.5	1.7	ID	ID	ID	ID
	5:00	26.5	9.2	0.430	0.6	0.6	2.1	ID	ID	ID	ID
	6:00	31.5	9.9	UM	1.8	0.8	1.6	ID	ID	ID	ID
	7:00	32.8	11.6	0.603	2.3	1.1	-0.1	ID	ID	ID	ID
	8:00	27.5	10.8	0.577	0.9	0.8	-0.4	ID	ID	ID	ID
	9:00	30.1	11.4	0.574	0.9	0.6	-0.6	ID	ID	ID	ID
	10:00	33.8	11.2	0.546	0.6	0.8	-0.3	ID	ID	ID	ID
	11:00	35.2	11.7	0.541	0.4	0.8	1.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	12:00	34.0	11.4	0.522	0.4	0.8	1.1	ID	ID	ID	ID
	13:00	33.0	11.1	0.523	0.1	0.7	1.1	ID	ID	ID	ID
	14:00	31.3	10.8	0.536	0.1	0.8	2.3	ID	ID	ID	ID
	15:00	32.3	11.2	0.519	0.3	0.6	1.1	ID	ID	ID	ID
	16:00	34.2	11.8	0.520	0.3	0.5	1.2	ID	ID	ID	ID
	17:00	36.1	12.5	0.525	0.4	0.7	1.9	ID	ID	ID	ID
	18:00	35.3	12.8	0.540	1.1	0.8	3.5	ID	ID	ID	ID
	19:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	20:00	33.3	13.0	0.656	2.1	1.0	0.5	ID	ID	ID	ID
	21:00	33.0	12.0	0.614	1.9	0.9	2.3	ID	ID	ID	ID
	22:00	36.4	12.5	0.617	4.1	1.4	1.5	ID	ID	ID	ID
	23:00	33.4	12.3	0.594	2.7	1.2	0.2	ID	ID	ID	ID
	0:00	33.7	12.0	0.572	1.8	0.7	0.2	ID	ID	ID	ID
Min		**24.2**	**8.7**	**0.430**	**0.1**	**0.5**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**36.4**	**13.0**	**0.656**	**4.1**	**1.4**	**3.5**	**ID**	**ID**	**ID**	**ID**
Average		**31.7**	**11.1**	**0.535**	**1.0**	**0.8**	**1.1**	**ID**	**ID**	**ID**	**ID**
20/05/2019	1:00	26.5	10.2	0.545	0.5	1.2	12.6	ID	ID	ID	ID
	2:00	19.3	8.1	0.535	0.1	1.6	23.6	ID	ID	ID	ID
	3:00	18.4	8.1	0.533	0.4	1.8	37.4	ID	ID	ID	ID
	4:00	13.2	5.6	0.544	0.9	1.0	7.1	ID	ID	ID	ID
	5:00	11.3	4.6	0.510	-0.2	2.2	47.1	ID	ID	ID	ID
	6:00	11.3	4.6	0.493	-0.2	2.0	45.7	ID	ID	ID	ID
	7:00	10.5	4.4	0.526	2.2	1.8	28.2	ID	ID	ID	ID
	7:00	11.8	5.2	0.630	3.1	1.6	19.2	ID	ID	ID	ID
	9:00	10.1	4.5	0.611	2.8	1.8	18.2	ID	ID	ID	ID
	10:00	12.4	5.4	0.591	5.5	1.3	9.6	ID	ID	ID	ID
	11:00	11.0	4.3	0.531	1.8	1.1	7.3	ID	ID	ID	ID
	12:00	11.3	4.4	0.522	1.0	0.9	4.4	ID	ID	ID	ID
	13:00	14.8	5.6	0.610	2.6	1.1	2.2	ID	ID	ID	ID
	14:00	15.4	5.3	0.667	1.3	1.2	2.4	ID	ID	ID	ID
	15:00	12.5	4.4	0.515	1.0	1.0	1.7	ID	ID	ID	ID
	16:00	13.5	4.9	0.622	2.0	1.0	2.3	ID	ID	ID	ID
	17:00	12.8	3.4	0.609	2.8	1.1	1.9	ID	ID	ID	ID
	18:00	12.1	3.4	0.576	5.0	1.0	1.6	ID	ID	ID	ID
	19:00	9.8	3.3	0.558	5.1	1.1	0.2	ID	ID	ID	ID
	20:00	9.4	3.2	0.528	2.6	0.7	0.2	ID	ID	ID	ID
	21:00	9.6	3.2	0.546	4.5	1.1	0.4	ID	ID	ID	ID
	22:00	12.1	3.5	0.584	8.0	1.6	1.6	ID	ID	ID	ID
	23:00	13.0	4.0	0.568	4.7	1.4	1.4	ID	ID	ID	ID
	0:00	11.9	3.9	0.475	1.0	0.7	1.5	ID	ID	ID	ID
Min		**9.4**	**3.2**	**0.475**	**-0.2**	**0.7**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**26.5**	**10.2**	**0.667**	**8.0**	**2.2**	**47.1**	**ID**	**ID**	**ID**	**ID**
Average		**13.1**	**4.9**	**0.560**	**2.4**	**1.3**	**11.6**	**ID**	**ID**	**ID**	**ID**
21/05/2019	1:00	11.1	3.6	0.486	1.3	0.7	2.8	ID	ID	ID	ID
	2:00	13.7	4.1	0.502	1.2	1.0	1.3	ID	ID	ID	ID
	3:00	12.8	3.9	0.473	0.4	0.9	5.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	4:00	12.3	3.7	0.461	0.5	1.0	2.6	ID	ID	ID	ID
	5:00	12.3	4.2	0.465	0.5	1.4	22.0	ID	ID	ID	ID
	6:00	9.6	3.5	0.440	0.0	0.9	4.0	ID	ID	ID	ID
	7:00	9.0	3.0	0.429	-0.2	0.6	0.2	ID	ID	ID	ID
	8:00	6.4	2.6	0.486	0.3	1.2	18.9	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	10:00	7.0	3.3	PO	PO	PO	PO	ID	ID	ID	ID
	11:00	9.6	4.5	0.669	4.8	2.2	1.7	ID	ID	ID	ID
	12:00	10.4	4.4	0.621	0.4	1.2	2.8	ID	ID	ID	ID
	13:00	11.6	4.4	0.699	0.2	0.7	3.1	ID	ID	ID	ID
	14:00	13.8	5.2	0.696	-0.2	0.9	1.9	ID	ID	ID	ID
	15:00	14.2	5.3	0.574	0.3	0.8	1.2	ID	ID	ID	ID
	16:00	18.1	5.8	0.733	1.3	0.9	0.9	ID	ID	ID	ID
	17:00	19.3	5.7	0.697	1.9	1.0	1.3	ID	ID	ID	ID
	18:00	19.9	7.0	0.607	2.3	0.9	2.9	ID	ID	ID	ID
	19:00	21.0	8.7	0.597	2.5	0.9	2.6	ID	ID	ID	ID
	20:00	22.3	8.5	0.579	2.1	1.0	2.1	ID	ID	ID	ID
	21:00	22.1	9.0	0.575	1.6	0.8	2.1	ID	ID	ID	ID
	22:00	20.4	8.2	0.559	2.0	0.9	1.6	ID	ID	ID	ID
	23:00	20.2	7.9	0.555	1.4	0.9	1.5	ID	ID	ID	ID
	0:00	18.4	7.5	0.522	0.6	1.2	11.3	ID	ID	ID	ID
Min		**6.4**	**2.6**	**0.429**	**-0.2**	**0.6**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**22.3**	**9.0**	**0.733**	**4.8**	**2.2**	**22.0**	**ID**	**ID**	**ID**	**ID**
Average		**14.6**	**5.4**	**0.565**	**1.2**	**1.0**	**4.3**	**ID**	**ID**	**ID**	**ID**
22/05/2019	1:00	17.1	6.9	0.530	1.0	0.8	5.9	ID	ID	ID	ID
	2:00	21.7	8.4	0.556	1.4	1.0	5.7	ID	ID	ID	ID
	3:00	21.3	8.3	0.520	1.4	0.9	4.4	ID	ID	ID	ID
	4:00	21.9	8.7	0.527	1.4	1.1	2.6	ID	ID	ID	ID
	5:00	22.4	8.9	0.508	1.4	0.8	0.7	ID	ID	ID	ID
	6:00	24.2	9.2	0.513	2.0	0.9	0.5	ID	ID	ID	ID
	7:00	23.6	9.3	0.545	2.1	1.2	0.1	ID	ID	ID	ID
	7:00	23.3	9.3	0.625	1.8	1.1	0.5	ID	ID	ID	ID
	9:00	27.5	10.1	0.615	2.4	0.8	0.5	ID	ID	ID	ID
	10:00	26.4	10.1	0.524	1.2	0.8	0.1	ID	ID	ID	ID
	11:00	26.0	10.0	0.512	1.0	0.7	0.5	ID	ID	ID	ID
	12:00	23.6	9.3	0.540	2.2	0.8	1.2	ID	ID	ID	ID
	13:00	29.5	10.1	0.588	1.0	1.0	1.1	ID	ID	ID	ID
	14:00	28.9	9.4	0.573	1.3	1.0	1.4	ID	ID	ID	ID
	15:00	26.1	9.4	0.485	0.3	1.0	1.4	ID	ID	ID	ID
	16:00	31.2	9.9	0.606	1.3	1.0	1.8	ID	ID	ID	ID
	17:00	34.9	10.0	0.595	1.7	0.7	2.0	ID	ID	ID	ID
	18:00	35.2	11.6	0.562	2.0	0.7	1.7	ID	ID	ID	ID
	19:00	27.9	10.8	0.552	2.4	0.9	1.8	ID	ID	ID	ID
	20:00	25.8	9.7	0.541	2.2	0.5	2.0	ID	ID	ID	ID
	21:00	18.0	7.2	0.527	1.6	0.8	1.5	ID	ID	ID	ID
	22:00	16.4	6.5	0.537	1.9	0.7	1.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	23:00	17.2	6.5	0.503	1.1	0.7	1.6	ID	ID	ID	ID
	0:00	18.9	6.9	0.522	1.7	0.8	1.3	ID	ID	ID	ID
Min		**16.4**	**6.5**	**0.485**	**0.3**	**0.5**	**0.1**	**ID**	**ID**	**ID**	**ID**
Max		**35.2**	**11.6**	**0.625**	**2.4**	**1.2**	**5.9**	**ID**	**ID**	**ID**	**ID**
Average		**24.5**	**9.0**	**0.546**	**1.6**	**0.9**	**1.7**	**ID**	**ID**	**ID**	**ID**
23/05/2019	1:00	17.3	6.6	0.504	1.2	0.7	0.6	ID	ID	ID	ID
	2:00	16.8	7.0	0.487	0.9	0.6	0.6	ID	ID	ID	ID
	3:00	13.8	5.8	0.479	0.4	0.3	0.6	ID	ID	ID	ID
	4:00	14.4	5.7	0.512	1.3	0.4	0.6	ID	ID	ID	ID
	5:00	14.3	5.3	0.466	-0.4	0.6	6.5	ID	ID	ID	ID
	6:00	16.4	5.3	0.474	0.3	0.3	2.8	ID	ID	ID	ID
	7:00	12.9	4.5	0.490	-0.2	0.5	0.8	ID	ID	ID	ID
	8:00	11.9	4.5	0.499	-0.1	0.4	-0.7	ID	ID	ID	ID
	9:00	12.3	4.8	0.504	-0.3	0.4	-0.8	ID	ID	ID	ID
	10:00	11.3	4.4	0.482	-0.4	0.3	-0.7	ID	ID	ID	ID
	11:00	10.5	4.3	0.489	0.0	0.5	-0.3	ID	ID	ID	ID
	12:00	9.8	3.8	0.505	0.8	0.6	-0.2	ID	ID	ID	ID
	13:00	12.8	3.9	0.634	1.7	1.1	2.1	ID	ID	ID	ID
	14:00	18.4	4.7	0.686	0.9	0.9	3.2	ID	ID	ID	ID
	15:00	14.7	4.4	0.512	0.4	0.8	1.4	ID	ID	ID	ID
	16:00	16.2	4.3	0.552	1.4	0.9	0.8	ID	ID	ID	ID
	17:00	25.8	5.4	0.759	1.8	1.1	0.8	ID	ID	ID	ID
	18:00	18.8	6.2	0.562	2.3	0.8	2.3	ID	ID	ID	ID
	19:00	20.5	7.1	0.586	3.6	1.0	2.2	ID	ID	ID	ID
	20:00	17.4	5.7	0.582	3.2	1.0	2.5	ID	ID	ID	ID
	21:00	16.5	5.4	0.553	2.0	0.9	2.7	ID	ID	ID	ID
	22:00	15.3	5.5	0.538	1.6	0.8	2.4	ID	ID	ID	ID
	23:00	14.6	5.2	0.523	1.2	0.9	1.4	ID	ID	ID	ID
	0:00	12.7	4.6	0.489	2.1	0.5	1.5	ID	ID	ID	ID
Min		**9.8**	**3.8**	**0.466**	**-0.4**	**0.3**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**25.8**	**7.1**	**0.759**	**3.6**	**1.1**	**6.5**	**ID**	**ID**	**ID**	**ID**
Average		**15.2**	**5.2**	**0.536**	**1.1**	**0.7**	**1.4**	**ID**	**ID**	**ID**	**ID**
24/05/2019	1:00	11.9	4.4	0.496	2.7	0.7	0.6	ID	ID	ID	ID
	2:00	9.7	3.6	0.474	1.3	0.8	-0.2	ID	ID	ID	ID
	3:00	10.4	4.2	0.505	1.2	0.6	0.0	ID	ID	ID	ID
	4:00	9.9	4.1	0.509	0.9	1.0	12.3	ID	ID	ID	ID
	5:00	8.2	3.1	0.511	1.0	0.8	5.2	ID	ID	ID	ID
	6:00	7.3	2.8	0.552	3.3	1.1	6.8	ID	ID	ID	ID
	7:00	12.1	4.6	0.642	4.0	1.2	2.9	ID	ID	ID	ID
	7:00	9.5	4.0	0.640	3.0	1.3	2.9	ID	ID	ID	ID
	9:00	9.6	3.5	0.592	1.2	1.0	3.4	ID	ID	ID	ID
	10:00	6.5	2.7	0.524	0.6	0.7	0.8	ID	ID	ID	ID
	11:00	8.9	3.6	0.533	1.5	1.1	1.5	ID	ID	ID	ID
	12:00	11.3	4.2	0.549	3.9	2.0	39.1	ID	ID	ID	ID
	13:00	8.6	3.5	0.565	5.9	2.0	1.5	ID	ID	ID	ID
	14:00	6.6	2.4	0.558	6.8	1.5	11.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	15:00	11.9	6.4	0.694	12.2	11.7	17.4	ID	ID	ID	ID
	16:00	9.3	4.4	1.198	11.4	4.0	6.1	ID	ID	ID	ID
	17:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	18:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	19:00	9.4	3.5	0.772	6.6	1.4	1.0	ID	ID	ID	ID
	20:00	11.0	3.6	0.676	2.6	0.9	-0.4	ID	ID	ID	ID
	21:00	12.1	4.0	0.697	3.7	1.1	0.0	ID	ID	ID	ID
	22:00	12.2	3.6	0.636	1.2	0.9	1.0	ID	ID	ID	ID
	23:00	12.0	3.7	0.626	3.4	1.0	1.0	ID	ID	ID	ID
	0:00	10.5	3.5	ZS	ZS	1.0	0.9	ID	ID	ID	ID
Min		**6.5**	**2.4**	**0.474**	**0.6**	**0.6**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**12.2**	**6.4**	**1.198**	**12.2**	**11.7**	**39.1**	**ID**	**ID**	**ID**	**ID**
Average		**9.9**	**3.8**	**0.617**	**3.7**	**1.7**	**5.2**	**ID**	**ID**	**ID**	**ID**
25/05/2019	1:00	14.4	4.1	0.639	4.5	ZS	ZS	ID	ID	ID	ID
	2:00	13.4	3.9	0.607	4.2	1.0	1.3	ID	ID	ID	ID
	3:00	15.5	4.3	0.590	6.2	1.3	0.5	ID	ID	ID	ID
	4:00	14.8	4.2	0.578	3.5	1.0	0.3	ID	ID	ID	ID
	5:00	14.7	4.5	0.590	3.7	0.8	0.5	ID	ID	ID	ID
	6:00	14.6	4.1	0.592	5.6	0.9	0.1	ID	ID	ID	ID
	7:00	13.0	3.8	0.608	4.7	1.2	-0.5	ID	ID	ID	ID
	8:00	12.2	4.3	0.628	4.5	1.2	-0.7	ID	ID	ID	ID
	9:00	10.7	4.0	0.592	1.8	0.9	-0.5	ID	ID	ID	ID
	10:00	10.3	4.0	0.562	0.6	0.9	-0.4	ID	ID	ID	ID
	11:00	5.8	2.1	0.553	-0.1	0.6	-0.3	ID	ID	ID	ID
	12:00	9.6	3.8	0.553	0.0	0.6	-0.2	ID	ID	ID	ID
	13:00	11.3	4.6	0.557	0.1	0.5	0.1	ID	ID	ID	ID
	14:00	13.7	5.2	0.559	0.2	0.5	0.4	ID	ID	ID	ID
	15:00	15.5	5.4	0.559	0.2	0.5	1.6	ID	ID	ID	ID
	16:00	17.2	6.9	0.572	0.6	0.9	1.0	ID	ID	ID	ID
	17:00	20.1	7.8	0.571	0.7	0.8	0.7	ID	ID	ID	ID
	18:00	21.8	8.3	0.582	1.1	0.7	0.9	ID	ID	ID	ID
	19:00	24.2	9.2	0.588	1.9	0.5	1.5	ID	ID	ID	ID
	20:00	25.6	10.2	0.591	2.1	0.8	0.8	ID	ID	ID	ID
	21:00	25.3	10.3	0.566	1.4	0.7	1.1	ID	ID	ID	ID
	22:00	24.1	10.0	0.567	1.6	0.8	1.3	ID	ID	ID	ID
	23:00	24.7	9.9	0.558	1.3	0.8	1.3	ID	ID	ID	ID
	0:00	23.9	9.6	0.543	1.1	ZS	ZS	ID	ID	ID	ID
Min		**5.8**	**2.1**	**0.543**	**-0.1**	**0.5**	**-0.7**	**ID**	**ID**	**ID**	**ID**
Max		**25.6**	**10.3**	**0.639**	**6.2**	**1.3**	**1.6**	**ID**	**ID**	**ID**	**ID**
Average		**16.5**	**6.0**	**0.579**	**2.1**	**0.8**	**0.5**	**ID**	**ID**	**ID**	**ID**
26/05/2019	1:00	23.1	9.3	0.529	0.7	0.8	0.7	ID	ID	ID	ID
	2:00	23.0	9.2	0.521	ZS	0.4	0.6	ID	ID	ID	ID
	3:00	23.2	9.4	0.518	0.7	0.5	0.8	ID	ID	ID	ID
	4:00	24.0	9.2	0.533	1.3	0.5	0.7	ID	ID	ID	ID
	5:00	23.4	9.2	0.532	1.1	0.6	0.3	ID	ID	ID	ID
	6:00	22.1	9.1	0.522	0.7	0.6	0.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	7:00	21.4	8.4	0.529	0.8	0.7	0.7	ID	ID	ID	ID
	7:00	16.5	6.4	0.535	0.4	0.6	0.2	ID	ID	ID	ID
	9:00	14.3	5.8	0.534	0.2	0.8	-0.1	ID	ID	ID	ID
	10:00	15.3	5.9	0.530	0.2	0.6	-0.1	ID	ID	ID	ID
	11:00	15.5	5.7	0.535	0.1	0.6	-0.2	ID	ID	ID	ID
	12:00	11.0	4.3	0.531	0.0	0.4	-0.7	ID	ID	ID	ID
	13:00	11.0	3.7	0.543	0.2	0.4	-0.5	ID	ID	ID	ID
	14:00	12.2	4.6	0.545	0.2	0.3	-0.4	ID	ID	ID	ID
	15:00	11.4	4.5	0.541	0.2	0.4	-0.5	ID	ID	ID	ID
	16:00	11.1	4.4	0.556	0.5	0.2	0.0	ID	ID	ID	ID
	17:00	12.2	4.8	0.555	0.6	0.5	-0.3	ID	ID	ID	ID
	18:00	13.2	4.9	0.570	1.1	0.4	0.2	ID	ID	ID	ID
	19:00	15.6	5.9	0.604	2.4	0.6	0.4	ID	ID	ID	ID
	20:00	30.0	13.4	0.635	3.8	1.2	0.7	ID	ID	ID	ID
	21:00	18.6	6.7	0.611	2.4	1.1	0.3	ID	ID	ID	ID
	22:00	15.0	5.3	0.580	2.0	0.8	0.7	ID	ID	ID	ID
	23:00	12.8	5.0	0.550	1.3	0.6	1.0	ID	ID	ID	ID
	0:00	13.7	5.0	ZS	ZS	0.3	1.2	ID	ID	ID	ID
Min		**11.0**	**3.7**	**0.518**	**0.0**	**0.2**	**-0.7**	**ID**	**ID**	**ID**	**ID**
Max		**30.0**	**13.4**	**0.635**	**3.8**	**1.2**	**1.2**	**ID**	**ID**	**ID**	**ID**
Average		**17.1**	**6.7**	**0.549**	**1.0**	**0.6**	**0.3**	**ID**	**ID**	**ID**	**ID**
27/05/2019	1:00	13.8	4.7	0.535	0.8	ZS	ZS	ID	ID	ID	ID
	2:00	13.8	5.6	0.537	0.9	0.4	1.6	ID	ID	ID	ID
	3:00	14.7	5.7	0.528	0.5	0.6	2.5	ID	ID	ID	ID
	4:00	14.6	5.6	0.528	0.9	0.4	3.0	ID	ID	ID	ID
	5:00	15.9	5.7	0.529	1.0	0.5	2.4	ID	ID	ID	ID
	6:00	14.0	5.2	0.517	0.1	0.2	3.8	ID	ID	ID	ID
	7:00	14.6	5.3	0.527	0.2	0.3	2.4	ID	ID	ID	ID
	8:00	10.7	4.3	0.516	-0.4	0.2	0.5	ID	ID	ID	ID
	9:00	11.4	4.5	0.515	-0.4	0.3	-0.8	ID	ID	ID	ID
	10:00	9.6	3.9	0.504	-0.4	0.1	-0.3	ID	ID	ID	ID
	11:00	9.4	3.8	0.508	-0.4	0.2	-0.2	ID	ID	ID	ID
	12:00	9.9	3.7	0.507	-0.3	0.1	0.2	ID	ID	ID	ID
	13:00	11.6	4.4	0.532	0.0	0.2	0.4	ID	ID	ID	ID
	14:00	9.7	4.2	0.524	0.0	0.5	0.7	ID	ID	ID	ID
	15:00	9.7	4.1	PO	PO	PO	PO	ID	ID	ID	ID
	16:00	12.1	4.2	0.664	0.2	0.4	1.2	ID	ID	ID	ID
	17:00	12.9	4.5	0.654	0.8	0.7	1.2	ID	ID	ID	ID
	18:00	13.7	5.4	0.670	2.5	1.1	1.2	ID	ID	ID	ID
	19:00	21.1	8.4	0.714	3.3	1.1	1.6	ID	ID	ID	ID
	20:00	21.1	7.2	0.698	2.7	0.9	1.0	ID	ID	ID	ID
	21:00	21.2	7.3	0.690	2.8	1.0	0.6	ID	ID	ID	ID
	22:00	19.4	6.6	0.666	2.0	0.9	0.2	ID	ID	ID	ID
	23:00	15.9	6.4	0.626	1.5	0.8	0.2	ID	ID	ID	ID
	0:00	15.6	5.8	0.618	1.1	0.7	0.4	ID	ID	ID	ID
Min		**9.4**	**3.7**	**0.504**	**-0.4**	**0.1**	**-0.8**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Max		**21.2**	**8.4**	**0.714**	**3.3**	**1.1**	**3.8**	**ID**	**ID**	**ID**	**ID**
Average		**14.0**	**5.3**	**0.579**	**0.9**	**0.5**	**1.1**	**ID**	**ID**	**ID**	**ID**
28/05/2019	1:00	13.6	5.1	0.607	0.8	0.8	0.2	ID	ID	ID	ID
	2:00	13.6	5.5	0.590	0.2	0.5	0.5	ID	ID	ID	ID
	3:00	12.3	4.8	0.576	-0.3	0.5	1.2	ID	ID	ID	ID
	4:00	14.1	5.5	0.567	-0.3	0.4	0.6	ID	ID	ID	ID
	5:00	16.5	4.5	0.557	-0.6	0.5	3.2	ID	ID	ID	ID
	6:00	19.8	5.8	0.563	-0.6	0.4	5.3	ID	ID	ID	ID
	7:00	19.3	7.2	0.583	-0.5	0.7	2.3	ID	ID	ID	ID
	7:00	19.3	7.6	0.603	0.2	0.5	0.9	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	10:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	11:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	12:00	21.5	8.7	0.691	-0.1	0.4	0.7	ID	ID	ID	ID
	13:00	36.3	12.1	0.699	-0.2	0.2	-0.2	ID	ID	ID	ID
	14:00	42.7	13.0	0.701	0.1	0.8	0.2	ID	ID	ID	ID
	15:00	42.1	13.4	0.677	0.7	0.8	-0.4	ID	ID	ID	ID
	16:00	44.7	14.1	0.735	2.0	0.9	-0.8	ID	ID	ID	ID
	17:00	47.9	15.2	0.837	4.1	1.1	-0.7	ID	ID	ID	ID
	18:00	54.8	17.3	0.720	3.4	0.9	-0.3	ID	ID	ID	ID
	19:00	52.6	17.5	0.732	4.0	0.9	0.1	ID	ID	ID	ID
	20:00	45.2	16.2	0.684	2.0	1.0	-0.4	ID	ID	ID	ID
	21:00	48.6	16.3	0.690	2.6	0.8	0.2	ID	ID	ID	ID
	22:00	49.4	16.9	0.669	1.8	0.9	0.4	ID	ID	ID	ID
	23:00	41.9	15.7	0.643	0.6	0.5	1.6	ID	ID	ID	ID
	0:00	43.8	16.2	0.620	0.4	0.7	1.3	ID	ID	ID	ID
Min		**12.3**	**4.5**	**0.557**	**-0.6**	**0.2**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**54.8**	**17.5**	**0.837**	**4.1**	**1.1**	**5.3**	**ID**	**ID**	**ID**	**ID**
Average		**33.3**	**11.4**	**0.655**	**1.0**	**0.7**	**0.8**	**ID**	**ID**	**ID**	**ID**
29/05/2019	1:00	43.4	15.6	0.618	-0.1	0.9	2.2	ID	ID	ID	ID
	2:00	43.7	15.6	0.588	-0.1	0.8	0.9	ID	ID	ID	ID
	3:00	41.2	14.7	0.578	-0.1	0.8	0.5	ID	ID	ID	ID
	4:00	39.4	14.0	0.590	0.5	0.7	1.0	ID	ID	ID	ID
	5:00	36.9	13.3	0.578	0.0	0.6	1.0	ID	ID	ID	ID
	6:00	39.3	13.7	0.592	-0.1	0.7	4.3	ID	ID	ID	ID
	7:00	39.6	14.1	0.592	0.2	0.7	3.0	ID	ID	ID	ID
	8:00	39.9	15.0	0.729	3.1	1.0	1.8	ID	ID	ID	ID
	9:00	37.7	14.2	0.682	2.2	1.0	0.8	ID	ID	ID	ID
	10:00	38.4	14.1	0.598	0.4	0.7	1.4	ID	ID	ID	ID
	11:00	35.0	12.8	0.583	0.2	0.9	2.4	ID	ID	ID	ID
	12:00	23.7	9.4	0.546	0.0	0.8	0.1	ID	ID	ID	ID
	13:00	30.7	12.4	0.602	0.7	0.9	1.1	ID	ID	ID	ID
	14:00	33.3	13.1	0.924	2.1	1.2	1.6	ID	ID	ID	ID
	15:00	35.6	13.5	0.768	2.0	1.5	1.2	ID	ID	ID	ID
	16:00	35.2	13.4	0.709	1.9	1.2	0.0	ID	ID	ID	ID
	17:00	37.7	13.6	0.659	2.3	0.9	0.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	18:00	32.9	12.6	0.612	2.2	1.1	1.5	ID	ID	ID	ID
	19:00	31.6	12.4	0.613	2.7	0.9	3.0	ID	ID	ID	ID
	20:00	32.8	12.6	0.609	2.4	1.0	2.2	ID	ID	ID	ID
	21:00	32.4	11.9	0.582	1.4	1.1	3.7	ID	ID	ID	ID
	22:00	28.3	10.8	0.559	0.4	0.8	4.9	ID	ID	ID	ID
	23:00	27.6	10.5	0.550	0.2	0.6	3.8	ID	ID	ID	ID
	0:00	31.1	11.4	0.550	0.0	0.7	4.0	ID	ID	ID	ID
Min		**23.7**	**9.4**	**0.546**	**-0.1**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**43.7**	**15.6**	**0.924**	**3.1**	**1.5**	**4.9**	**ID**	**ID**	**ID**	**ID**
Average		**35.3**	**13.1**	**0.625**	**1.0**	**0.9**	**2.0**	**ID**	**ID**	**ID**	**ID**
30/05/2019	1:00	32.1	12.7	0.553	-0.2	0.7	7.8	ID	ID	ID	ID
	2:00	34.7	13.1	0.556	-0.2	0.8	7.9	ID	ID	ID	ID
	3:00	34.0	13.1	0.553	0.0	0.9	7.8	ID	ID	ID	ID
	4:00	28.9	10.9	0.539	-0.5	0.7	8.0	ID	ID	ID	ID
	5:00	33.7	13.0	0.547	-0.2	0.9	9.2	ID	ID	ID	ID
	6:00	35.6	13.1	0.555	0.2	0.9	10.5	ID	ID	ID	ID
	7:00	35.7	13.5	0.611	2.2	0.8	5.7	ID	ID	ID	ID
	7:00	35.5	13.5	0.686	2.0	1.2	5.2	ID	ID	ID	ID
	9:00	32.7	12.1	0.635	0.9	1.2	6.5	ID	ID	ID	ID
	10:00	35.3	12.9	0.575	0.9	1.0	4.1	ID	ID	ID	ID
	11:00	28.8	11.4	0.591	1.1	1.1	5.0	ID	ID	ID	ID
	12:00	25.3	11.7	0.594	2.6	1.1	11.1	ID	ID	ID	ID
	13:00	25.0	10.5	0.703	1.9	1.1	1.5	ID	ID	ID	ID
	14:00	27.8	10.4	0.689	0.1	0.7	1.4	ID	ID	ID	ID
	15:00	27.1	9.7	0.549	1.0	0.6	1.3	ID	ID	ID	ID
	16:00	29.9	10.4	0.671	2.1	0.6	2.5	ID	ID	ID	ID
	17:00	30.5	10.5	0.730	2.0	0.7	2.6	ID	ID	ID	ID
	18:00	23.7	8.9	0.580	2.1	0.9	2.3	ID	ID	ID	ID
	19:00	27.6	10.8	0.621	4.3	0.8	2.6	ID	ID	ID	ID
	20:00	29.8	11.3	0.631	3.2	1.1	2.0	ID	ID	ID	ID
	21:00	31.1	11.6	0.590	2.1	0.9	2.1	ID	ID	ID	ID
	22:00	29.1	11.5	0.556	1.3	1.0	2.8	ID	ID	ID	ID
	23:00	27.1	10.5	0.556	1.5	0.6	2.4	ID	ID	ID	ID
	0:00	27.1	10.3	ZS	0.8	0.6	1.7	ID	ID	ID	ID
Min		**23.7**	**8.9**	**0.539**	**-0.5**	**0.6**	**1.3**	**ID**	**ID**	**ID**	**ID**
Max		**35.7**	**13.5**	**0.730**	**4.3**	**1.2**	**11.1**	**ID**	**ID**	**ID**	**ID**
Average		**30.3**	**11.6**	**0.603**	**1.3**	**0.9**	**4.7**	**ID**	**ID**	**ID**	**ID**
31/05/2019	1:00	24.6	9.2	0.543	0.6	0.4	1.3	ID	ID	ID	ID
	2:00	23.4	8.7	0.517	0.1	0.8	0.5	ID	ID	ID	ID
	3:00	21.2	8.3	0.515	-0.2	0.9	3.1	ID	ID	ID	ID
	4:00	15.2	6.0	0.533	-0.6	1.0	10.0	ID	ID	ID	ID
	5:00	15.3	6.0	0.508	-0.6	1.1	7.7	ID	ID	ID	ID
	6:00	15.3	6.0	0.518	1.1	0.7	3.6	ID	ID	ID	ID
	7:00	17.8	7.2	0.659	5.3	1.2	3.9	ID	ID	ID	ID
	8:00	19.9	7.6	0.695	2.6	1.3	2.5	ID	ID	ID	ID
	9:00	20.7	8.0	0.588	0.3	1.1	2.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	10:00	21.6	8.3	0.552	0.5	0.9	1.7	ID	ID	ID	ID
	11:00	20.5	8.0	0.549	0.7	1.0	1.1	ID	ID	ID	ID
	12:00	21.1	8.0	0.556	0.6	1.0	1.3	ID	ID	ID	ID
	13:00	22.6	7.7	0.622	1.5	0.7	1.4	ID	ID	ID	ID
	14:00	24.1	7.3	0.697	0.9	0.8	1.6	ID	ID	ID	ID
	15:00	20.4	6.9	0.562	0.5	0.9	0.7	ID	ID	ID	ID
	16:00	23.8	7.1	0.680	1.9	0.9	1.4	ID	ID	ID	ID
	17:00	34.9	8.1	0.715	3.4	1.3	2.3	ID	ID	ID	ID
	18:00	23.8	7.6	0.592	2.2	1.2	3.6	ID	ID	ID	ID
	19:00	21.6	8.6	0.661	5.1	1.2	4.0	ID	ID	ID	ID
	20:00	23.0	9.0	0.646	5.0	1.3	1.3	ID	ID	ID	ID
	21:00	19.9	7.3	0.582	2.9	1.1	1.3	ID	ID	ID	ID
	22:00	20.4	7.5	0.612	3.2	1.0	2.1	ID	ID	ID	ID
	23:00	17.1	6.8	0.558	1.3	0.9	3.4	ID	ID	ID	ID
	0:00	15.7	5.1	0.513	-0.4	0.9	3.8	ID	ID	ID	ID
Min		**15.2**	**5.1**	**0.508**	**-0.6**	**0.4**	**0.5**	**ID**	**ID**	**ID**	**ID**
Max		**34.9**	**9.2**	**0.715**	**5.3**	**1.3**	**10.0**	**ID**	**ID**	**ID**	**ID**
Average		**21.0**	**7.5**	**0.591**	**1.6**	**1.0**	**2.8**	**ID**	**ID**	**ID**	**ID**
01/06/2019	1:00	16.8	5.2	0.523	-0.4	0.8	5.2	ID	ID	ID	ID
	2:00	14.2	4.5	0.530	0.1	1.0	5.8	ID	ID	ID	ID
	3:00	17.6	4.7	0.535	-0.3	0.9	9.0	ID	ID	ID	ID
	4:00	16.9	5.2	0.535	-0.1	1.2	10.3	ID	ID	ID	ID
	5:00	17.7	5.9	0.541	0.2	1.0	6.0	ID	ID	ID	ID
	6:00	17.8	5.3	0.541	0.8	0.8	6.1	ID	ID	ID	ID
	7:00	14.0	5.4	0.576	1.1	1.0	3.4	ID	ID	ID	ID
	7:00	13.5	5.5	0.554	0.2	0.9	1.0	ID	ID	ID	ID
	9:00	12.2	4.7	0.540	0.3	0.7	1.1	ID	ID	ID	ID
	10:00	9.5	3.7	0.534	0.0	0.7	2.4	ID	ID	ID	ID
	11:00	10.2	3.7	0.548	0.3	0.8	2.9	ID	ID	ID	ID
	12:00	12.3	3.8	0.542	0.1	0.7	3.4	ID	ID	ID	ID
	13:00	9.7	3.5	0.549	0.0	0.9	2.8	ID	ID	ID	ID
	14:00	11.5	4.3	0.571	0.4	0.7	3.1	ID	ID	ID	ID
	15:00	11.2	4.6	0.564	0.5	0.8	2.5	ID	ID	ID	ID
	16:00	12.1	4.1	0.564	0.6	0.8	2.3	ID	ID	ID	ID
	17:00	16.2	6.2	0.577	1.0	0.8	2.4	ID	ID	ID	ID
	18:00	12.9	4.5	0.596	1.5	0.8	1.9	ID	ID	ID	ID
	19:00	13.1	5.0	0.598	1.9	1.1	2.2	ID	ID	ID	ID
	20:00	14.8	5.2	0.631	2.9	0.7	2.3	ID	ID	ID	ID
	21:00	14.0	4.4	0.632	2.7	0.9	0.4	ID	ID	ID	ID
	22:00	11.4	4.2	0.591	2.1	1.1	1.0	ID	ID	ID	ID
	23:00	12.1	3.9	0.558	1.0	0.8	0.4	ID	ID	ID	ID
	0:00	11.5	4.2	0.553	0.6	0.7	0.5	ID	ID	ID	ID
Min		**9.5**	**3.5**	**0.523**	**-0.4**	**0.7**	**0.4**	**ID**	**ID**	**ID**	**ID**
Max		**17.8**	**6.2**	**0.632**	**2.9**	**1.2**	**10.3**	**ID**	**ID**	**ID**	**ID**
Average		**13.5**	**4.7**	**0.562**	**0.7**	**0.9**	**3.3**	**ID**	**ID**	**ID**	**ID**
02/06/2019	1:00	11.3	4.1	0.542	0.3	0.8	0.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	2:00	11.6	4.2	0.537	0.3	0.9	-0.2	ID	ID	ID	ID
	3:00	12.0	4.3	0.536	0.0	0.7	0.0	ID	ID	ID	ID
	4:00	11.5	4.1	0.539	0.1	0.8	-0.1	ID	ID	ID	ID
	5:00	11.1	4.3	0.531	0.2	0.7	0.1	ID	ID	ID	ID
	6:00	12.0	4.2	0.542	0.4	0.9	0.6	ID	ID	ID	ID
	7:00	14.3	5.2	0.555	0.3	0.7	0.0	ID	ID	ID	ID
	8:00	18.6	7.0	0.545	-0.1	0.7	0.4	ID	ID	ID	ID
	9:00	18.6	6.8	0.537	-0.3	0.5	1.5	ID	ID	ID	ID
	10:00	14.4	5.0	0.539	-0.3	0.8	1.3	ID	ID	ID	ID
	11:00	14.0	5.4	0.534	-0.3	0.6	1.6	ID	ID	ID	ID
	12:00	14.0	6.3	0.546	-0.2	0.5	0.8	ID	ID	ID	ID
	13:00	9.5	4.0	0.533	0.0	0.7	0.6	ID	ID	ID	ID
	14:00	23.2	8.8	0.555	0.2	0.8	1.9	ID	ID	ID	ID
	15:00	27.6	9.8	0.554	-0.2	0.7	2.6	ID	ID	ID	ID
	16:00	26.0	10.1	0.554	-0.1	0.5	2.1	ID	ID	ID	ID
	17:00	27.6	10.6	0.570	0.2	0.9	1.9	ID	ID	ID	ID
	18:00	29.2	11.3	0.585	0.8	0.5	2.1	ID	ID	ID	ID
	19:00	32.2	12.3	0.633	2.4	0.7	1.6	ID	ID	ID	ID
	20:00	30.5	12.0	0.641	4.1	1.2	0.3	ID	ID	ID	ID
	21:00	25.8	9.3	0.633	3.5	1.2	-0.2	ID	ID	ID	ID
	22:00	28.0	9.9	0.639	3.0	0.8	0.4	ID	ID	ID	ID
	23:00	28.2	9.9	0.626	2.9	1.0	0.3	ID	ID	ID	ID
	0:00	24.1	9.3	0.608	2.3	1.0	0.3	ID	ID	ID	ID
Min		**9.5**	**4.0**	**0.531**	**-0.3**	**0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**32.2**	**12.3**	**0.641**	**4.1**	**1.2**	**2.6**	**ID**	**ID**	**ID**	**ID**
Average		**19.8**	**7.4**	**0.567**	**0.8**	**0.8**	**0.8**	**ID**	**ID**	**ID**	**ID**
03/06/2019	1:00	22.5	8.3	0.592	1.7	0.9	0.0	ID	ID	ID	ID
	2:00	17.6	7.3	0.576	0.9	0.6	0.2	ID	ID	ID	ID
	3:00	15.1	5.9	0.560	0.2	0.7	0.6	ID	ID	ID	ID
	4:00	15.6	5.2	0.561	0.1	0.9	5.4	ID	ID	ID	ID
	5:00	15.4	5.5	0.584	1.3	1.0	4.8	ID	ID	ID	ID
	6:00	14.5	5.5	0.576	0.8	0.9	2.1	ID	ID	ID	ID
	7:00	13.2	4.6	0.572	0.0	0.9	4.2	ID	ID	ID	ID
	7:00	21.7	5.5	0.703	1.9	0.8	-0.2	ID	ID	ID	ID
	9:00	19.6	5.3	0.659	0.8	0.8	3.3	ID	ID	ID	ID
	10:00	11.1	4.2	0.555	-0.4	0.4	2.9	ID	ID	ID	ID
	11:00	14.1	4.8	0.559	-0.3	0.5	2.6	ID	ID	ID	ID
	12:00	15.2	5.1	0.580	-0.3	0.3	1.9	ID	ID	ID	ID
	13:00	16.9	5.7	0.667	-0.1	0.4	1.3	ID	ID	ID	ID
	14:00	24.1	8.2	0.623	0.1	0.4	2.8	ID	ID	ID	ID
	15:00	24.8	9.5	0.585	-0.1	0.4	2.2	ID	ID	ID	ID
	16:00	25.6	9.2	0.645	0.4	0.6	2.0	ID	ID	ID	ID
	17:00	31.2	11.3	0.621	MM	0.6	2.3	ID	ID	ID	ID
	18:00	35.5	13.0	MM	MM	0.6	1.5	ID	ID	ID	ID
	19:00	42.1	15.7	MM	2.6	0.4	1.5	ID	ID	ID	ID
	20:00	40.5	16.3	0.663	3.0	0.7	0.8	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	21:00	36.2	13.9	0.625	1.4	0.4	0.1	ID	ID	ID	ID
	22:00	36.3	13.9	0.631	2.5	0.6	0.4	ID	ID	ID	ID
	23:00	33.6	12.6	0.583	0.3	0.6	1.2	ID	ID	ID	ID
	0:00	34.5	12.6	0.582	0.2	0.6	0.2	ID	ID	ID	ID
Min		**11.1**	**4.2**	**0.555**	**-0.4**	**0.3**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**42.1**	**16.3**	**0.703**	**3.0**	**1.0**	**5.4**	**ID**	**ID**	**ID**	**ID**
Average		**24.0**	**8.7**	**0.605**	**0.8**	**0.6**	**1.8**	**ID**	**ID**	**ID**	**ID**
04/06/2019	1:00	26.8	10.4	0.571	ZS	0.6	0.5	ID	ID	ID	ID
	2:00	19.2	7.7	0.561	0.2	ZS	ZS	ID	ID	ID	ID
	3:00	16.2	6.3	0.563	-0.1	0.5	-0.1	ID	ID	ID	ID
	4:00	18.9	6.9	0.557	0.0	0.4	0.0	ID	ID	ID	ID
	5:00	22.6	7.8	0.553	-0.1	0.5	-0.1	ID	ID	ID	ID
	6:00	21.7	7.7	0.559	-0.1	0.3	0.0	ID	ID	ID	ID
	7:00	22.0	7.7	0.566	0.0	0.5	-0.1	ID	ID	ID	ID
	8:00	30.7	9.0	0.659	1.2	0.3	0.2	ID	ID	ID	ID
	9:00	26.1	7.9	0.615	0.1	0.5	1.8	ID	ID	ID	ID
	10:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	11:00	19.0	6.3	0.697	-0.2	0.5	1.3	ID	ID	ID	ID
	12:00	18.1	6.0	0.683	0.2	0.5	2.5	ID	ID	ID	ID
	13:00	17.7	5.9	0.702	0.4	0.4	1.1	ID	ID	ID	ID
	14:00	25.1	7.2	0.747	0.7	0.7	1.4	ID	ID	ID	ID
	15:00	22.4	7.4	0.694	0.2	0.5	1.6	ID	ID	ID	ID
	16:00	26.7	7.6	0.733	1.1	0.5	2.0	ID	ID	ID	ID
	17:00	27.0	8.4	0.758	1.0	0.8	2.1	ID	ID	ID	ID
	18:00	25.8	8.6	0.714	1.4	0.6	2.2	ID	ID	ID	ID
	19:00	29.1	10.4	0.677	1.5	0.5	1.4	ID	ID	ID	ID
	20:00	25.6	10.1	0.669	1.0	0.5	2.8	ID	ID	ID	ID
	21:00	23.5	8.7	0.673	1.1	0.7	2.0	ID	ID	ID	ID
	22:00	21.8	8.2	0.651	0.5	0.7	1.5	ID	ID	ID	ID
	23:00	23.6	8.5	0.629	0.0	0.6	2.5	ID	ID	ID	ID
	0:00	23.8	8.8	0.629	0.1	0.5	1.1	ID	ID	ID	ID
Min		**16.2**	**5.9**	**0.553**	**-0.2**	**0.3**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**30.7**	**10.4**	**0.758**	**1.5**	**0.8**	**2.8**	**ID**	**ID**	**ID**	**ID**
Average		**23.2**	**8.0**	**0.646**	**0.5**	**0.5**	**1.3**	**ID**	**ID**	**ID**	**ID**
05/06/2019	1:00	23.9	8.5	0.614	0.1	0.4	0.8	ID	ID	ID	ID
	2:00	27.0	9.0	0.614	-0.2	0.5	0.8	ID	ID	ID	ID
	3:00	28.0	9.8	0.609	-0.1	0.7	0.4	ID	ID	ID	ID
	4:00	31.0	10.1	0.606	-0.2	0.5	0.2	ID	ID	ID	ID
	5:00	30.3	9.9	0.603	0.0	0.5	1.4	ID	ID	ID	ID
	6:00	29.1	9.7	0.607	0.4	0.8	2.2	ID	ID	ID	ID
	7:00	33.8	11.3	0.641	1.2	0.9	2.1	ID	ID	ID	ID
	7:00	36.9	11.4	0.733	0.9	0.9	2.3	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	10:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	11:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	12:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	13:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	14:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	15:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	16:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	17:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	18:00	27.3	8.5	0.950	2.7	1.5	1.0	ID	ID	ID	ID
	19:00	25.9	8.5	0.864	3.4	1.3	1.4	ID	ID	ID	ID
	20:00	31.3	10.8	0.855	4.0	1.4	1.2	ID	ID	ID	ID
	21:00	36.4	12.9	0.816	3.2	1.3	0.7	ID	ID	ID	ID
	22:00	34.3	12.2	0.783	2.1	1.2	2.2	ID	ID	ID	ID
	23:00	29.6	10.6	0.758	1.4	1.1	3.6	ID	ID	ID	ID
	0:00	30.7	10.3	0.732	1.1	1.0	2.8	ID	ID	ID	ID
Min		**23.9**	**8.5**	**0.603**	**-0.2**	**0.4**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**36.9**	**12.9**	**0.950**	**4.0**	**1.5**	**3.6**	**ID**	**ID**	**ID**	**ID**
Average		**30.4**	**10.2**	**0.719**	**1.3**	**0.9**	**1.5**	**ID**	**ID**	**ID**	**ID**
06/06/2019	1:00	29.0	10.0	ZS	1.3	1.1	1.3	ID	ID	ID	ID
	2:00	30.6	9.8	0.700	1.3	1.2	0.5	ID	ID	ID	ID
	3:00	30.7	10.1	0.687	1.0	1.1	0.3	ID	ID	ID	ID
	4:00	31.7	10.5	0.674	1.0	0.9	0.3	ID	ID	ID	ID
	5:00	33.7	11.3	0.677	2.0	1.1	0.3	ID	ID	ID	ID
	6:00	32.1	10.9	0.670	0.7	1.0	5.9	ID	ID	ID	ID
	7:00	30.6	10.5	0.670	0.2	0.8	4.6	ID	ID	ID	ID
	8:00	37.1	11.5	0.852	5.2	1.1	6.2	ID	ID	ID	ID
	9:00	20.2	8.6	0.908	2.6	1.2	6.9	ID	ID	ID	ID
	10:00	23.9	8.6	0.667	1.0	0.6	4.4	ID	ID	ID	ID
	11:00	32.9	10.7	0.661	0.7	0.3	6.0	ID	ID	ID	ID
	12:00	35.1	11.0	0.659	1.3	0.9	6.6	ID	ID	ID	ID
	13:00	37.2	10.6	0.699	1.4	1.1	4.6	ID	ID	ID	ID
	14:00	33.1	9.7	0.708	1.2	1.0	4.5	ID	ID	ID	ID
	15:00	26.6	9.0	0.672	0.3	0.6	2.2	ID	ID	ID	ID
	16:00	25.4	8.1	0.759	1.2	0.8	2.7	ID	ID	ID	ID
	17:00	33.5	9.3	0.783	2.0	1.2	4.2	ID	ID	ID	ID
	18:00	29.8	9.2	0.788	3.4	1.3	5.5	ID	ID	ID	ID
	19:00	20.1	8.0	0.702	2.7	1.3	6.0	ID	ID	ID	ID
	20:00	17.1	6.3	0.675	1.8	0.9	5.7	ID	ID	ID	ID
	21:00	20.6	7.3	0.653	1.8	0.7	5.5	ID	ID	ID	ID
	22:00	26.6	9.1	0.639	1.6	0.9	4.9	ID	ID	ID	ID
	23:00	21.4	7.9	ZS	0.9	0.6	4.0	ID	ID	ID	ID
	0:00	13.6	5.2	0.611	0.6	0.7	3.4	ID	ID	ID	ID
Min		**13.6**	**5.2**	**0.611**	**0.2**	**0.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
Max		**37.2**	**11.5**	**0.908**	**5.2**	**1.3**	**6.9**	**ID**	**ID**	**ID**	**ID**
Average		**28.0**	**9.3**	**0.705**	**1.6**	**0.9**	**4.0**	**ID**	**ID**	**ID**	**ID**
07/06/2019	1:00	17.9	6.8	0.616	0.5	0.8	15.1	ID	ID	ID	ID
	2:00	18.2	7.0	0.606	0.1	1.5	25.1	ID	ID	ID	ID
	3:00	16.6	6.7	0.607	0.4	1.3	8.5	ID	ID	ID	ID
	4:00	14.8	5.9	0.598	-0.1	1.0	9.9	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	5:00	10.6	3.6	0.597	0.2	0.8	9.4	ID	ID	ID	ID
	6:00	12.7	4.0	0.591	-0.2	0.9	6.3	ID	ID	ID	ID
	7:00	12.1	4.4	0.598	0.2	0.7	1.8	ID	ID	ID	ID
	7:00	11.4	4.0	0.653	0.0	0.6	-0.2	ID	ID	ID	ID
	9:00	11.4	4.3	0.647	-0.1	0.6	3.5	ID	ID	ID	ID
	10:00	10.3	4.0	0.582	-0.4	0.1	1.9	ID	ID	ID	ID
	11:00	6.7	2.1	0.583	-0.3	0.0	1.2	ID	ID	ID	ID
	12:00	13.0	3.7	0.599	-0.1	0.3	14.3	ID	ID	ID	ID
	13:00	11.6	4.1	0.665	0.4	0.6	7.3	ID	ID	ID	ID
	14:00	11.6	4.3	0.626	0.1	0.7	12.1	ID	ID	ID	ID
	15:00	12.1	4.6	0.583	0.1	0.9	8.4	ID	ID	ID	ID
	16:00	15.8	4.7	0.699	1.2	1.2	5.5	ID	ID	ID	ID
	17:00	15.9	4.8	0.677	0.8	1.2	6.3	ID	ID	ID	ID
	18:00	14.7	5.3	0.609	0.9	1.0	6.2	ID	ID	ID	ID
	19:00	18.5	6.5	0.656	3.6	0.9	6.6	ID	ID	ID	ID
	20:00	17.9	6.8	0.601	1.9	1.1	16.6	ID	ID	ID	ID
	21:00	13.3	5.2	0.632	1.1	1.0	13.0	ID	ID	ID	ID
	22:00	11.7	4.7	0.622	0.5	1.0	11.1	ID	ID	ID	ID
	23:00	13.7	4.9	ZS	0.4	0.8	11.2	ID	ID	ID	ID
	0:00	14.0	5.4	0.585	0.2	0.8	11.0	ID	ID	ID	ID
Min		**6.7**	**2.1**	**0.582**	**-0.4**	**0.0**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**18.5**	**7.0**	**0.699**	**3.6**	**1.5**	**25.1**	**ID**	**ID**	**ID**	**ID**
Average		**13.6**	**4.9**	**0.619**	**0.5**	**0.8**	**8.8**	**ID**	**ID**	**ID**	**ID**
08/06/2019	1:00	15.4	6.1	0.600	0.0	0.7	14.6	ID	ID	ID	ID
	2:00	17.3	6.6	0.583	-0.2	0.6	5.6	ID	ID	ID	ID
	3:00	19.7	6.9	0.574	-0.1	0.4	3.2	ID	ID	ID	ID
	4:00	11.7	4.1	0.549	-0.5	0.6	7.2	ID	ID	ID	ID
	5:00	14.6	5.0	0.561	-0.4	0.5	11.4	ID	ID	ID	ID
	6:00	14.4	5.0	0.579	-0.6	1.3	27.8	ID	ID	ID	ID
	7:00	8.5	2.6	0.576	-0.7	0.5	2.5	ID	ID	ID	ID
	8:00	6.1	2.1	0.566	-0.6	0.4	5.2	ID	ID	ID	ID
	9:00	7.2	2.8	0.594	0.4	1.1	28.3	ID	ID	ID	ID
	10:00	7.2	2.6	0.627	1.5	0.8	12.7	ID	ID	ID	ID
	11:00	7.9	2.6	0.619	0.8	0.3	2.0	ID	ID	ID	ID
	12:00	8.2	3.3	0.616	1.1	0.3	0.5	ID	ID	ID	ID
	13:00	9.2	3.8	0.642	1.5	0.7	9.0	ID	ID	ID	ID
	14:00	12.7	4.1	0.632	1.1	1.0	16.8	ID	ID	ID	ID
	15:00	12.0	3.9	0.610	1.0	1.2	18.7	ID	ID	ID	ID
	16:00	8.7	3.3	0.608	1.3	1.2	13.7	ID	ID	ID	ID
	17:00	8.8	3.2	0.606	2.2	1.1	5.7	ID	ID	ID	ID
	18:00	9.5	3.7	0.636	3.8	1.1	3.8	ID	ID	ID	ID
	19:00	11.2	3.9	0.697	3.9	0.9	1.6	ID	ID	ID	ID
	20:00	10.3	3.9	0.699	3.4	1.1	0.8	ID	ID	ID	ID
	21:00	11.7	4.4	0.975	2.8	2.2	0.0	ID	ID	ID	ID
	22:00	13.8	4.2	0.858	5.3	1.1	2.1	ID	ID	ID	ID
	23:00	14.9	4.0	0.791	4.3	0.9	4.8	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	0:00	14.1	4.3	0.796	3.4	1.2	2.3	ID	ID	ID	ID
Min		**6.1**	**2.1**	**0.549**	**-0.7**	**0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**19.7**	**6.9**	**0.975**	**5.3**	**2.2**	**28.3**	**ID**	**ID**	**ID**	**ID**
Average		**11.5**	**4.0**	**0.650**	**1.4**	**0.9**	**8.3**	**ID**	**ID**	**ID**	**ID**
09/06/2019	1:00	12.9	4.5	0.755	1.9	1.1	4.2	ID	ID	ID	ID
	2:00	12.4	4.2	0.724	1.4	1.0	6.2	ID	ID	ID	ID
	3:00	12.4	4.2	0.686	0.7	1.1	4.0	ID	ID	ID	ID
	4:00	12.1	4.4	0.681	0.7	0.8	1.9	ID	ID	ID	ID
	5:00	14.2	4.6	0.672	0.0	1.0	1.5	ID	ID	ID	ID
	6:00	17.6	4.9	0.646	-0.1	0.8	1.2	ID	ID	ID	ID
	7:00	17.2	5.1	0.647	-0.4	0.9	3.3	ID	ID	ID	ID
	7:00	11.5	4.2	0.637	-0.5	0.7	0.3	ID	ID	ID	ID
	9:00	9.4	3.5	0.627	-0.4	0.6	-0.4	ID	ID	ID	ID
	10:00	11.8	4.5	0.624	-0.3	0.4	0.2	ID	ID	ID	ID
	11:00	8.1	3.6	0.617	-0.3	0.5	-0.9	ID	ID	ID	ID
	12:00	9.9	4.0	0.622	-0.4	0.6	4.8	ID	ID	ID	ID
	13:00	9.7	3.9	0.618	-0.5	0.4	3.2	ID	ID	ID	ID
	14:00	10.3	4.2	0.646	-0.1	0.5	6.0	ID	ID	ID	ID
	15:00	13.3	5.2	0.656	0.0	1.1	7.8	ID	ID	ID	ID
	16:00	15.2	5.6	0.637	0.3	0.8	7.2	ID	ID	ID	ID
	17:00	15.7	5.8	0.642	0.8	0.7	4.2	ID	ID	ID	ID
	18:00	16.9	6.5	0.672	1.1	0.6	4.5	ID	ID	ID	ID
	19:00	18.8	7.4	0.712	2.3	0.6	3.2	ID	ID	ID	ID
	20:00	24.5	9.5	0.752	3.4	0.8	2.0	ID	ID	ID	ID
	21:00	21.0	7.2	0.766	4.3	1.0	1.3	ID	ID	ID	ID
	22:00	22.0	7.0	0.708	2.8	0.9	1.6	ID	ID	ID	ID
	23:00	18.9	6.5	0.704	2.6	0.7	1.3	ID	ID	ID	ID
	0:00	22.4	6.6	0.641	0.4	0.6	0.8	ID	ID	ID	ID
Min		**8.1**	**3.5**	**0.617**	**-0.5**	**0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**24.5**	**9.5**	**0.766**	**4.3**	**1.1**	**7.8**	**ID**	**ID**	**ID**	**ID**
Average		**14.9**	**5.3**	**0.671**	**0.8**	**0.8**	**2.9**	**ID**	**ID**	**ID**	**ID**
10/06/2019	1:00	24.2	8.7	0.645	0.9	0.8	3.7	ID	ID	ID	ID
	2:00	30.4	11.8	0.614	0.6	1.5	22.4	ID	ID	ID	ID
	3:00	28.4	10.8	0.580	-0.4	1.3	18.4	ID	ID	ID	ID
	4:00	33.1	11.2	0.579	-0.3	0.5	5.5	ID	ID	ID	ID
	5:00	34.8	10.8	0.585	-0.5	0.7	7.7	ID	ID	ID	ID
	6:00	42.8	15.5	0.597	0.9	0.9	5.6	ID	ID	ID	ID
	7:00	48.5	17.4	0.633	1.6	0.9	5.4	ID	ID	ID	ID
	8:00	48.6	17.8	0.714	1.3	1.0	5.6	ID	ID	ID	ID
	9:00	49.5	17.2	0.650	0.7	1.1	4.3	ID	ID	ID	ID
	10:00	49.8	17.3	0.611	0.3	0.8	4.0	ID	ID	ID	ID
	11:00	46.3	16.5	0.603	0.0	0.9	4.2	ID	ID	ID	ID
	12:00	45.6	16.7	0.598	0.3	0.8	4.1	ID	ID	ID	ID
	13:00	50.8	17.5	0.653	0.7	0.7	3.6	ID	ID	ID	ID
	14:00	52.0	17.5	0.664	0.9	0.9	2.6	ID	ID	ID	ID
	15:00	51.3	17.3	0.601	0.3	0.7	3.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	16:00	53.2	17.8	0.727	1.8	1.0	2.1	ID	ID	ID	ID
	17:00	58.4	18.3	0.703	1.6	1.2	2.0	ID	ID	ID	ID
	18:00	55.2	19.5	0.709	2.7	1.1	3.4	ID	ID	ID	ID
	19:00	54.3	19.6	0.668	3.0	1.2	3.4	ID	ID	ID	ID
	20:00	54.9	19.0	0.648	2.5	1.1	3.5	ID	ID	ID	ID
	21:00	54.8	18.9	0.652	1.5	0.9	4.3	ID	ID	ID	ID
	22:00	55.7	19.2	0.658	1.7	0.9	3.8	ID	ID	ID	ID
	23:00	56.3	19.2	0.612	0.7	0.9	3.0	ID	ID	ID	ID
	0:00	55.1	19.9	0.607	0.3	1.2	2.0	ID	ID	ID	ID
Min		**24.2**	**8.7**	**0.579**	**-0.5**	**0.5**	**2.0**	**ID**	**ID**	**ID**	**ID**
Max		**58.4**	**19.9**	**0.727**	**3.0**	**1.5**	**22.4**	**ID**	**ID**	**ID**	**ID**
Average		**47.3**	**16.5**	**0.638**	**1.0**	**1.0**	**5.3**	**ID**	**ID**	**ID**	**ID**
11/06/2019	1:00	50.7	18.6	0.599	0.0	0.9	2.2	ID	ID	ID	ID
	2:00	53.6	19.5	0.591	-0.2	0.5	2.2	ID	ID	ID	ID
	3:00	54.5	19.2	0.579	0.4	0.7	3.1	ID	ID	ID	ID
	4:00	55.6	18.9	0.564	0.7	1.0	3.1	ID	ID	ID	ID
	5:00	52.7	18.7	0.566	0.9	0.9	3.5	ID	ID	ID	ID
	6:00	53.5	18.9	0.597	0.7	0.8	4.6	ID	ID	ID	ID
	7:00	59.0	19.3	0.632	1.2	0.9	2.7	ID	ID	ID	ID
	7:00	61.2	19.1	0.715	2.1	1.0	2.0	ID	ID	ID	ID
	9:00	63.3	18.9	0.691	1.3	1.2	2.6	ID	ID	ID	ID
	10:00	56.9	18.5	0.620	0.7	1.1	2.3	ID	ID	ID	ID
	11:00	61.8	20.3	0.679	0.8	1.0	1.3	ID	ID	ID	ID
	12:00	63.8	19.8	0.683	1.4	1.2	1.9	ID	ID	ID	ID
	13:00	40.9	13.0	0.628	0.8	1.0	0.7	ID	ID	ID	ID
	14:00	18.4	7.6	0.596	0.0	0.8	0.0	ID	ID	ID	ID
	15:00	22.9	9.2	0.599	0.3	0.8	-0.8	ID	ID	ID	ID
	16:00	18.5	7.6	0.691	0.8	0.7	0.2	ID	ID	ID	ID
	17:00	22.3	9.3	0.821	4.4	1.1	4.9	ID	ID	ID	ID
	18:00	36.2	14.0	0.877	6.7	1.4	2.7	ID	ID	ID	ID
	19:00	46.3	16.8	0.742	6.0	1.7	0.5	ID	ID	ID	ID
	20:00	47.7	17.0	0.739	4.1	1.9	-0.5	ID	ID	ID	ID
	21:00	46.4	16.4	1.026	2.5	1.9	0.1	ID	ID	ID	ID
	22:00	45.7	15.8	0.792	3.9	1.9	-0.4	ID	ID	ID	ID
	23:00	45.5	15.5	0.762	2.3	1.4	0.4	ID	ID	ID	ID
	0:00	44.2	15.2	0.742	1.4	1.0	1.0	ID	ID	ID	ID
Min		**18.4**	**7.6**	**0.564**	**-0.2**	**0.5**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**63.8**	**20.3**	**1.026**	**6.7**	**1.9**	**4.9**	**ID**	**ID**	**ID**	**ID**
Average		**46.7**	**16.1**	**0.689**	**1.8**	**1.1**	**1.7**	**ID**	**ID**	**ID**	**ID**
12/06/2019	1:00	40.3	14.4	0.717	1.0	1.0	0.7	ID	ID	ID	ID
	2:00	26.8	10.6	0.698	-0.1	0.8	2.3	ID	ID	ID	ID
	3:00	30.9	11.8	0.693	0.6	0.9	2.2	ID	ID	ID	ID
	4:00	27.7	10.8	0.689	-0.1	1.1	9.8	ID	ID	ID	ID
	5:00	17.0	6.9	0.691	0.5	1.4	21.5	ID	ID	ID	ID
	6:00	20.0	6.9	0.683	-0.2	0.7	0.9	ID	ID	ID	ID
	7:00	21.0	7.2	0.676	-0.3	0.8	1.9	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	16.0	6.1	0.731	0.0	1.2	7.8	ID	ID	ID	ID
	9:00	12.6	4.9	0.792	1.8	1.3	10.7	ID	ID	ID	ID
	10:00	8.7	3.9	0.705	1.8	0.9	9.1	ID	ID	ID	ID
	11:00	11.0	5.6	0.797	4.9	1.1	0.6	ID	ID	ID	ID
	12:00	10.4	4.7	0.764	10.5	4.8	-0.6	ID	ID	ID	ID
	13:00	12.8	5.2	0.768	10.4	4.9	-1.0	ID	ID	ID	ID
	14:00	19.3	7.6	0.931	3.3	1.7	-0.4	ID	ID	ID	ID
	15:00	19.4	7.0	0.699	0.8	1.0	-0.7	ID	ID	ID	ID
	16:00	19.6	6.7	0.747	1.5	1.2	-1.0	ID	ID	ID	ID
	17:00	21.6	6.6	0.903	4.0	1.2	-0.7	ID	ID	ID	ID
	18:00	20.9	7.1	0.865	3.1	1.3	-0.6	ID	ID	ID	ID
	19:00	18.3	6.5	0.740	4.5	1.3	0.8	ID	ID	ID	ID
	20:00	14.9	5.8	0.717	2.8	1.3	0.5	ID	ID	ID	ID
	21:00	15.3	5.9	0.707	2.8	1.7	-0.4	ID	ID	ID	ID
	22:00	16.0	6.2	0.705	3.6	1.3	0.0	ID	ID	ID	ID
	23:00	15.7	5.9	0.696	2.1	1.2	-0.1	ID	ID	ID	ID
	0:00	15.0	5.7	0.691	1.8	1.2	0.1	ID	ID	ID	ID
Min		**8.7**	**3.9**	**0.676**	**-0.3**	**0.7**	**-1.0**	**ID**	**ID**	**ID**	**ID**
Max		**40.3**	**14.4**	**0.931**	**10.5**	**4.9**	**21.5**	**ID**	**ID**	**ID**	**ID**
Average		**18.8**	**7.1**	**0.742**	**2.5**	**1.5**	**2.6**	**ID**	**ID**	**ID**	**ID**

µg/m³ = microgram per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = insufficient data; IO = Instrument offline; MM = maintenance mode; NO_2 = nitrogen dioxide; PF = pump failure; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); PO = power outage; ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide; UM = unknown malfunction; ZS = nightly zero and span

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

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APPENDIX F

Onshore and Offshore Meteorological Data

Resubmitted without changes

March 2022

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Onshore Meteorological Data

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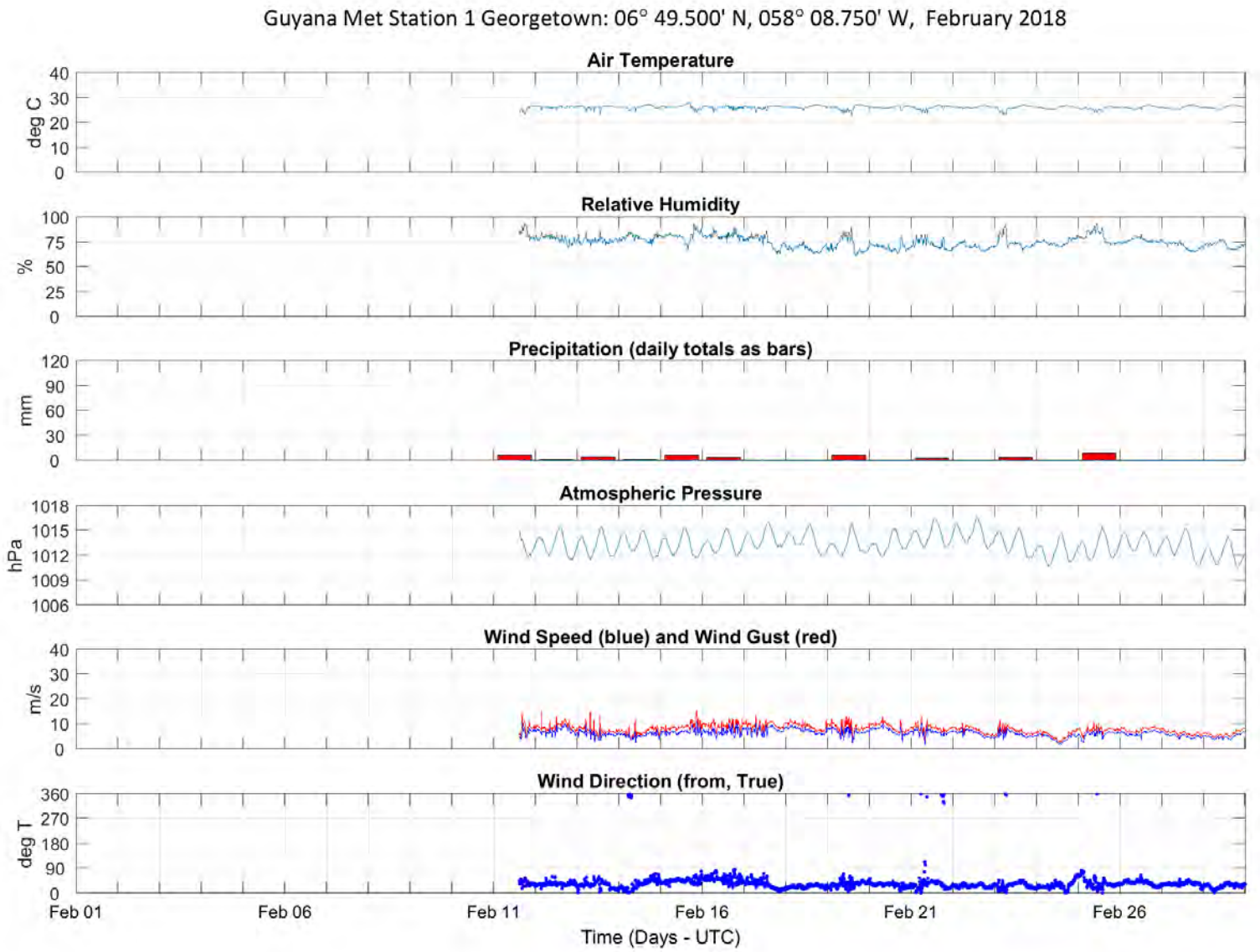

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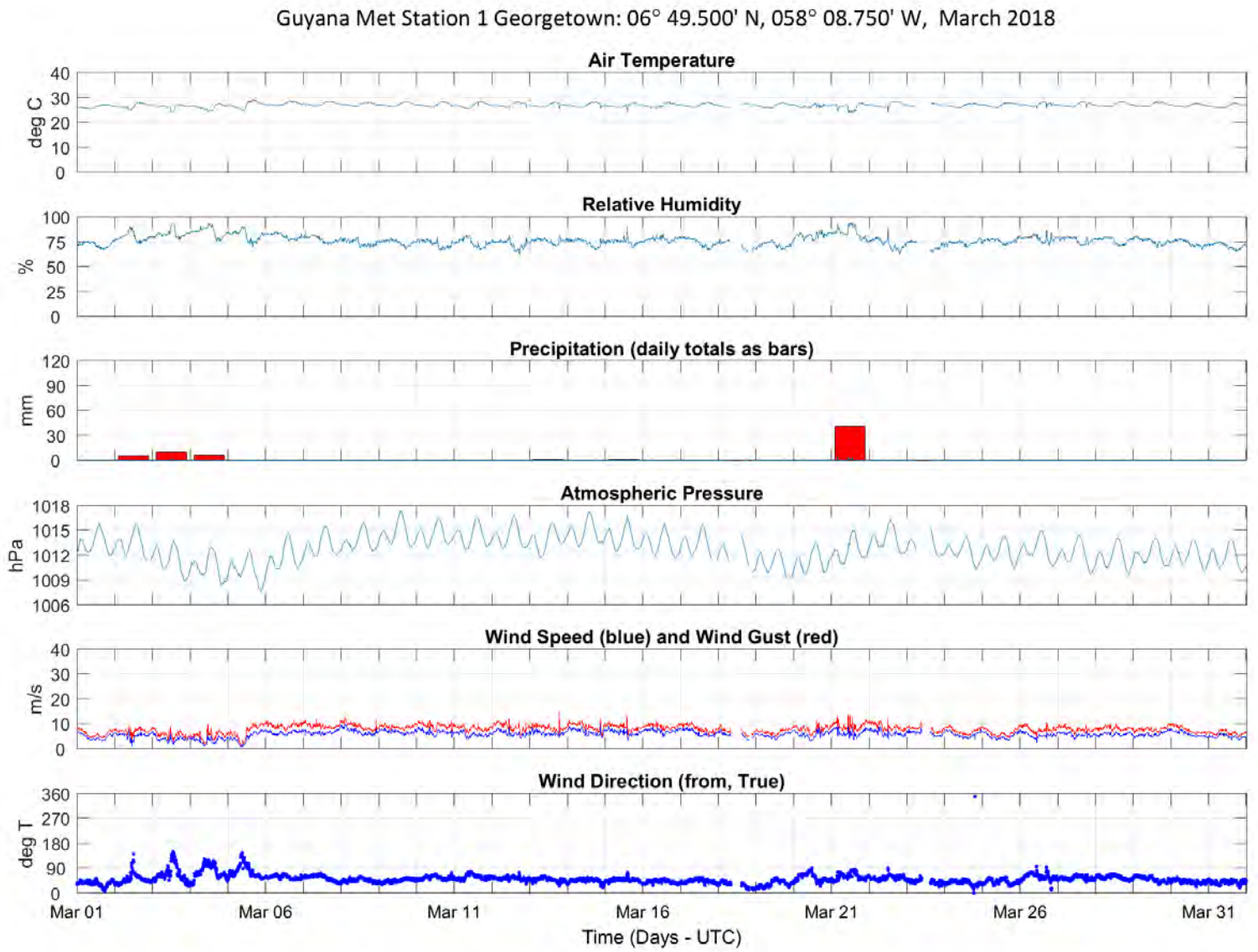

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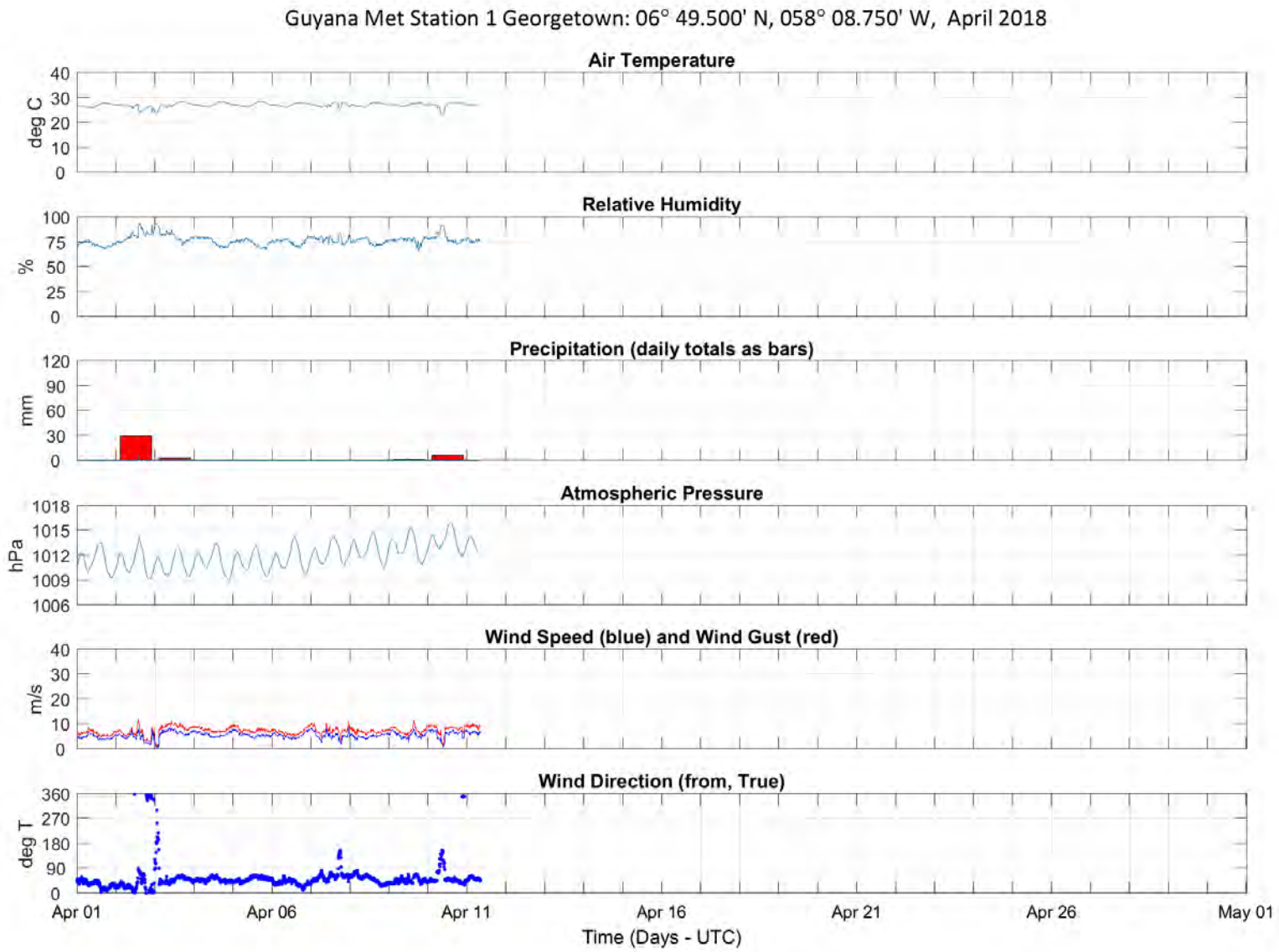

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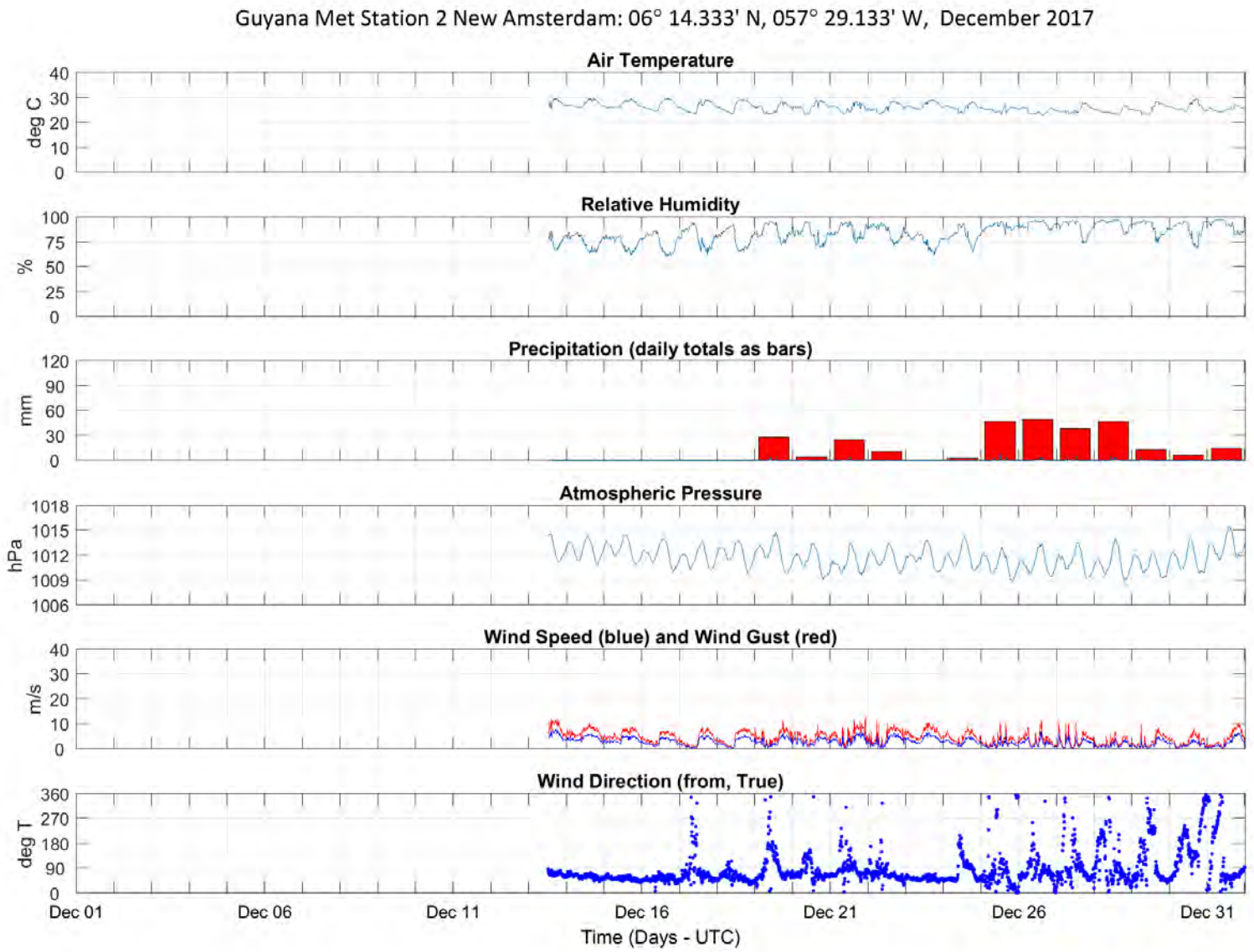

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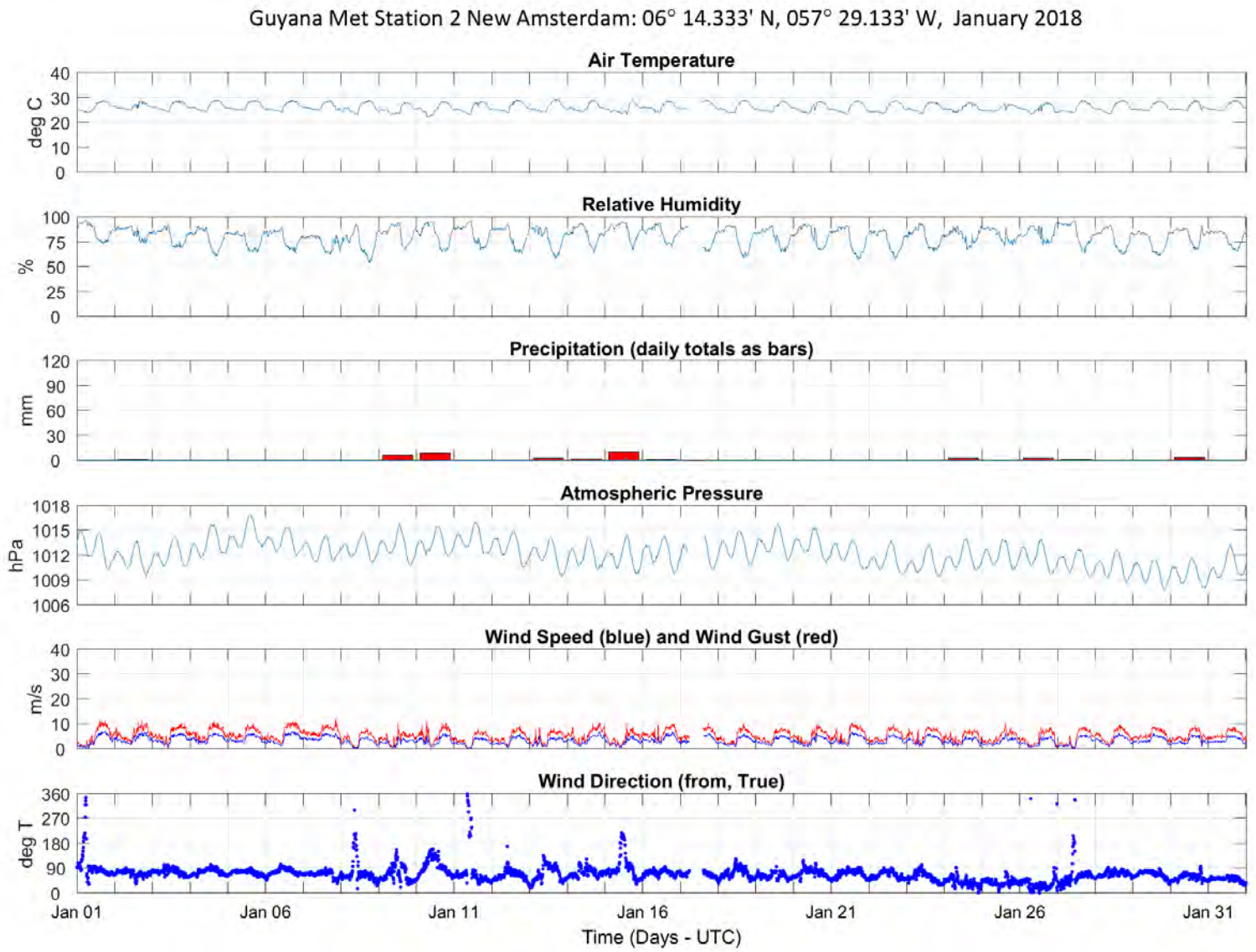

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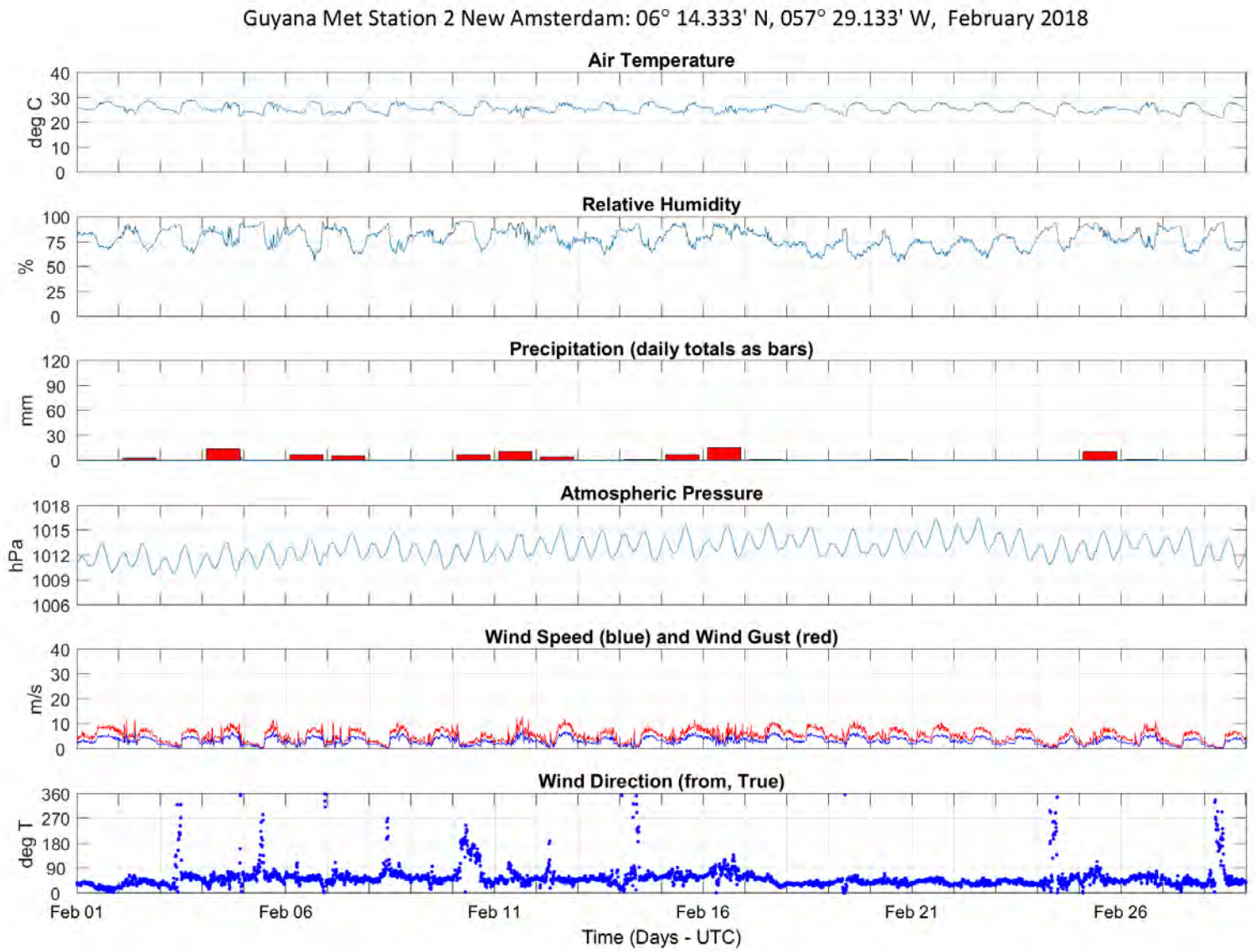

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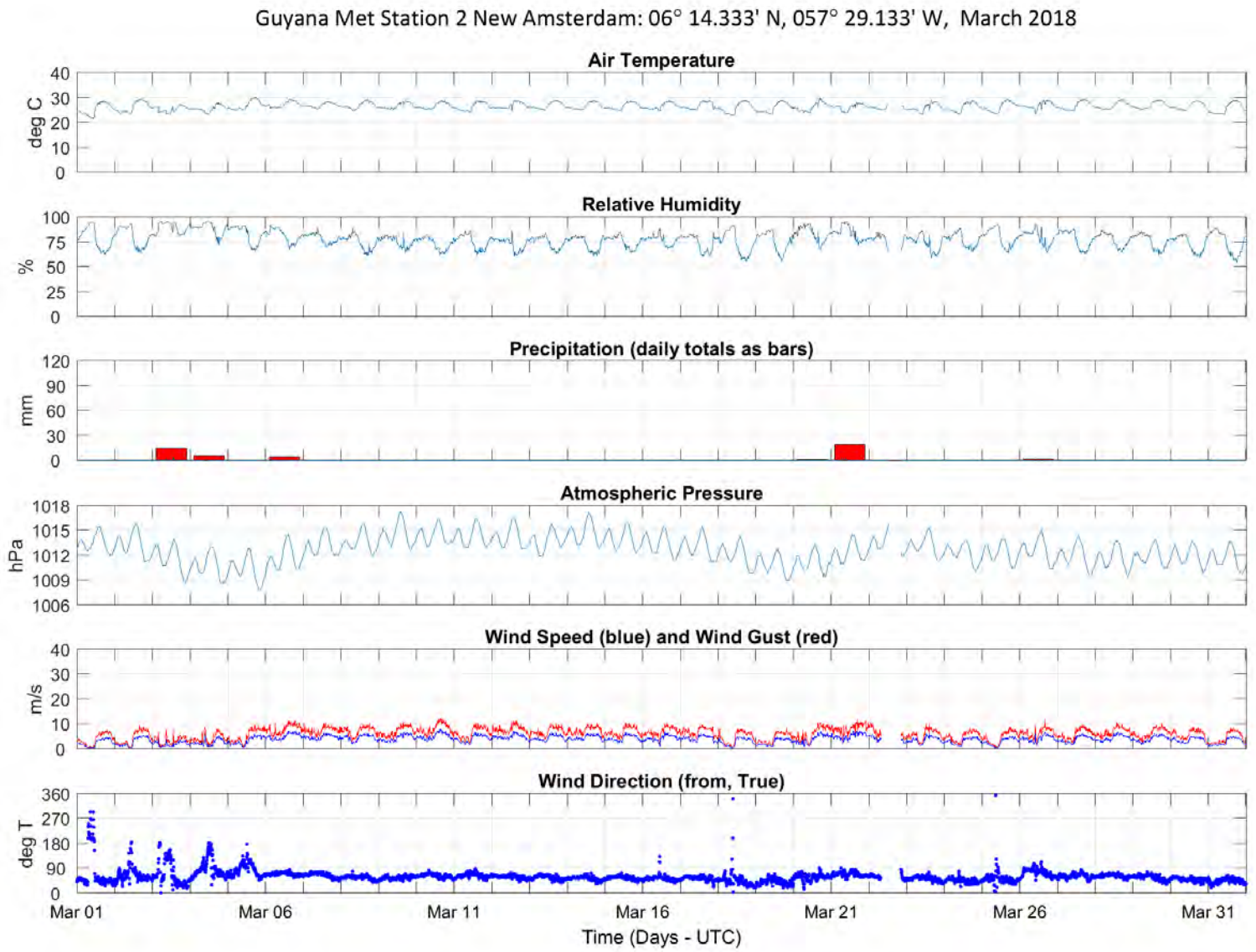

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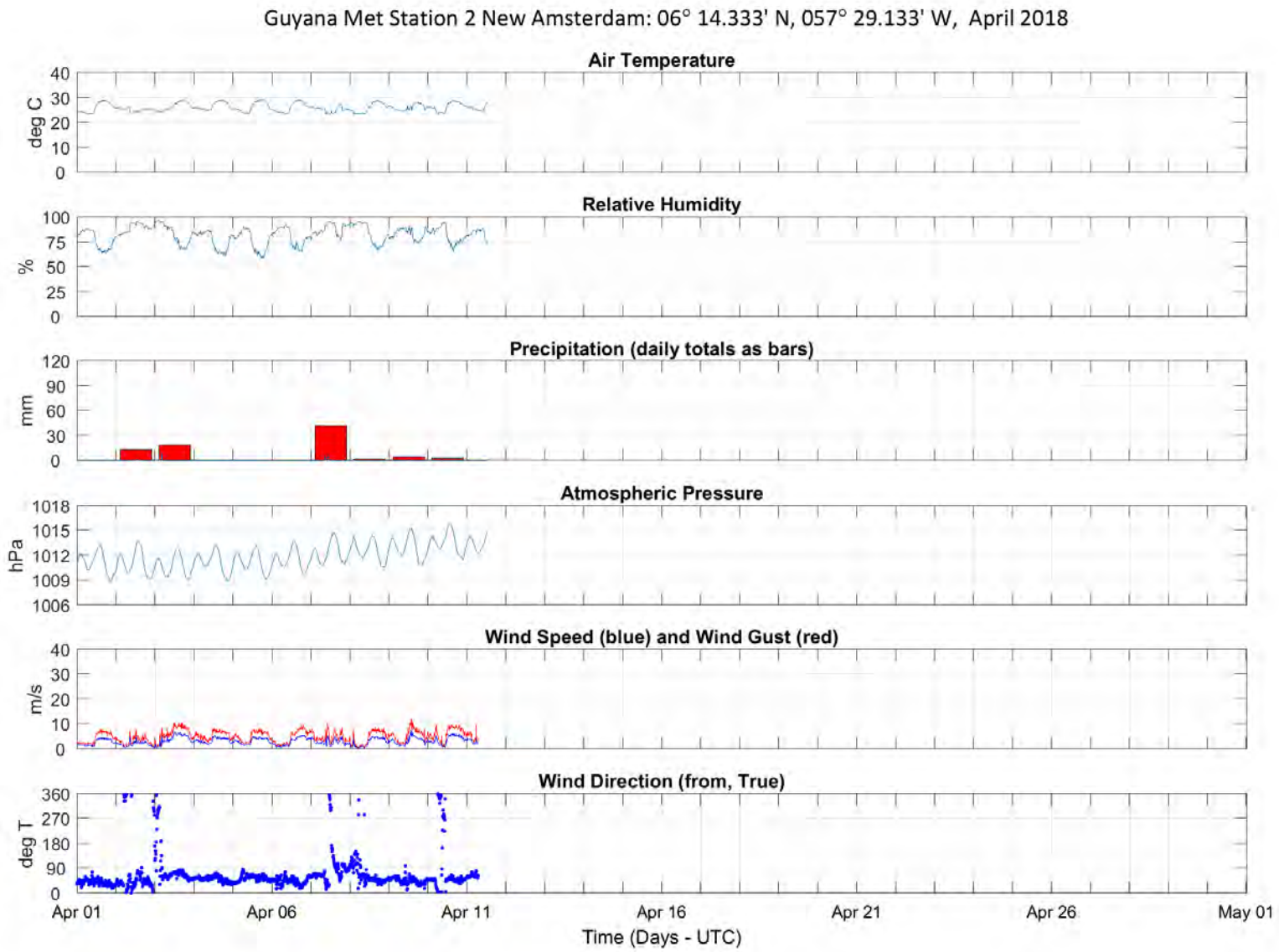

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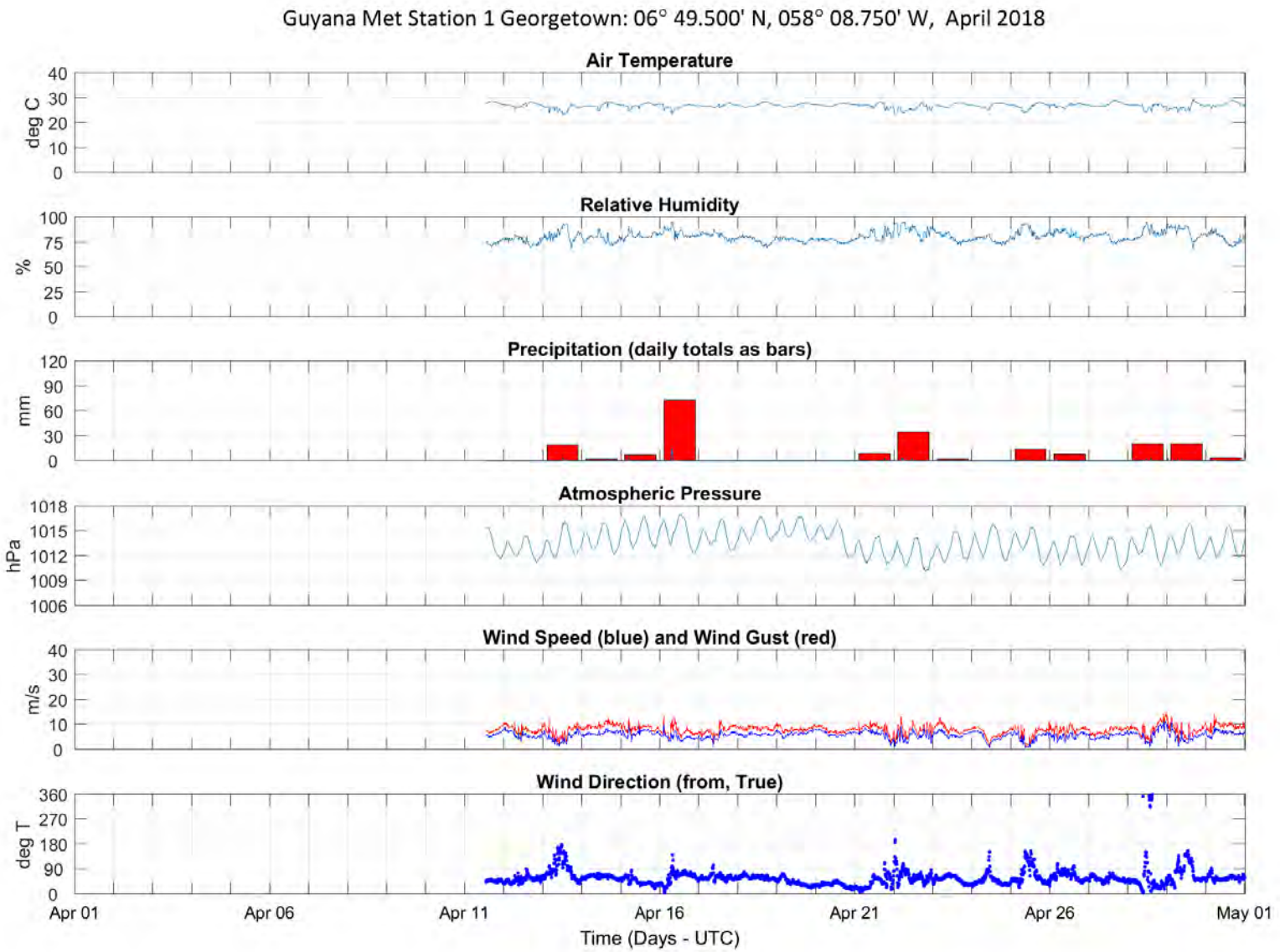

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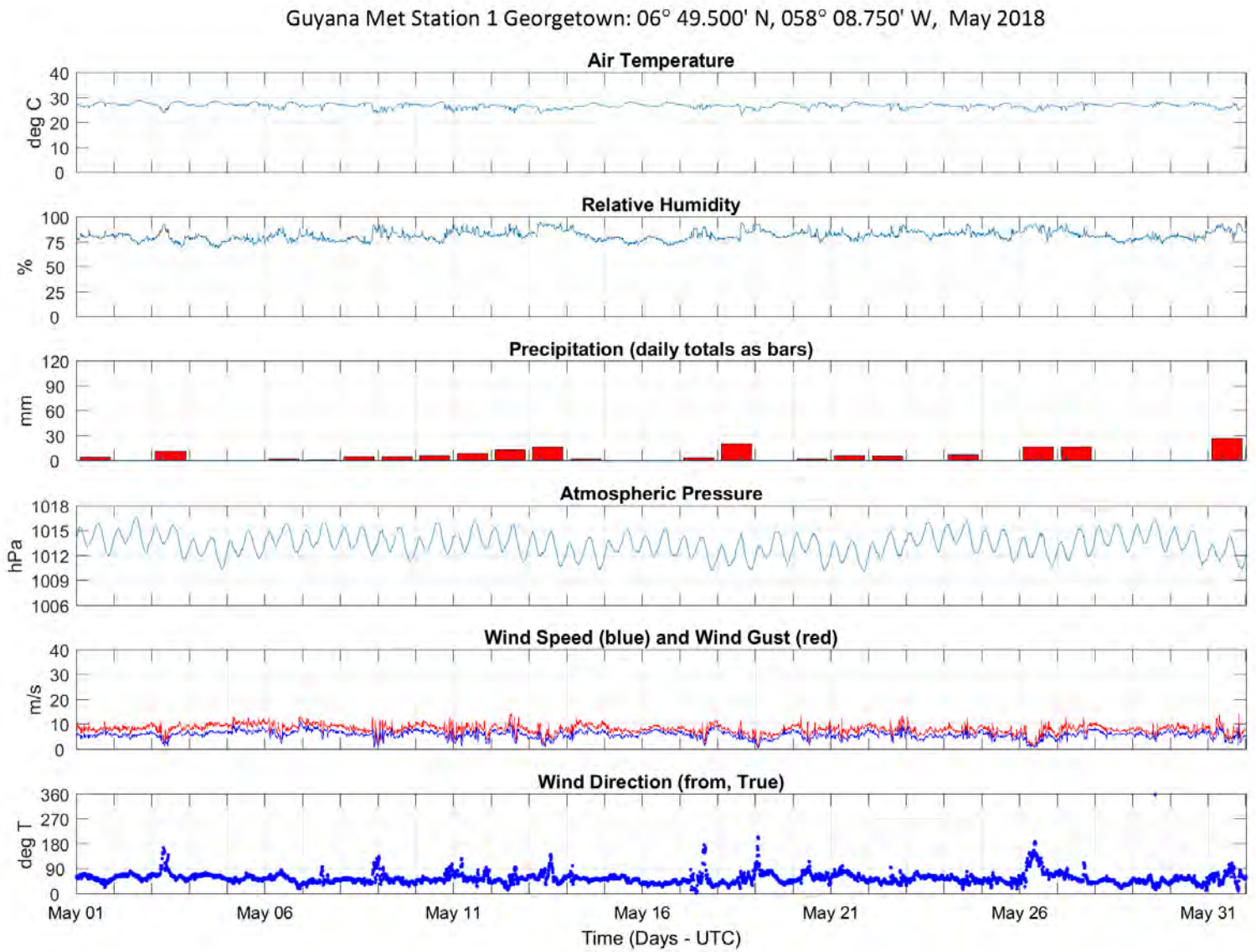

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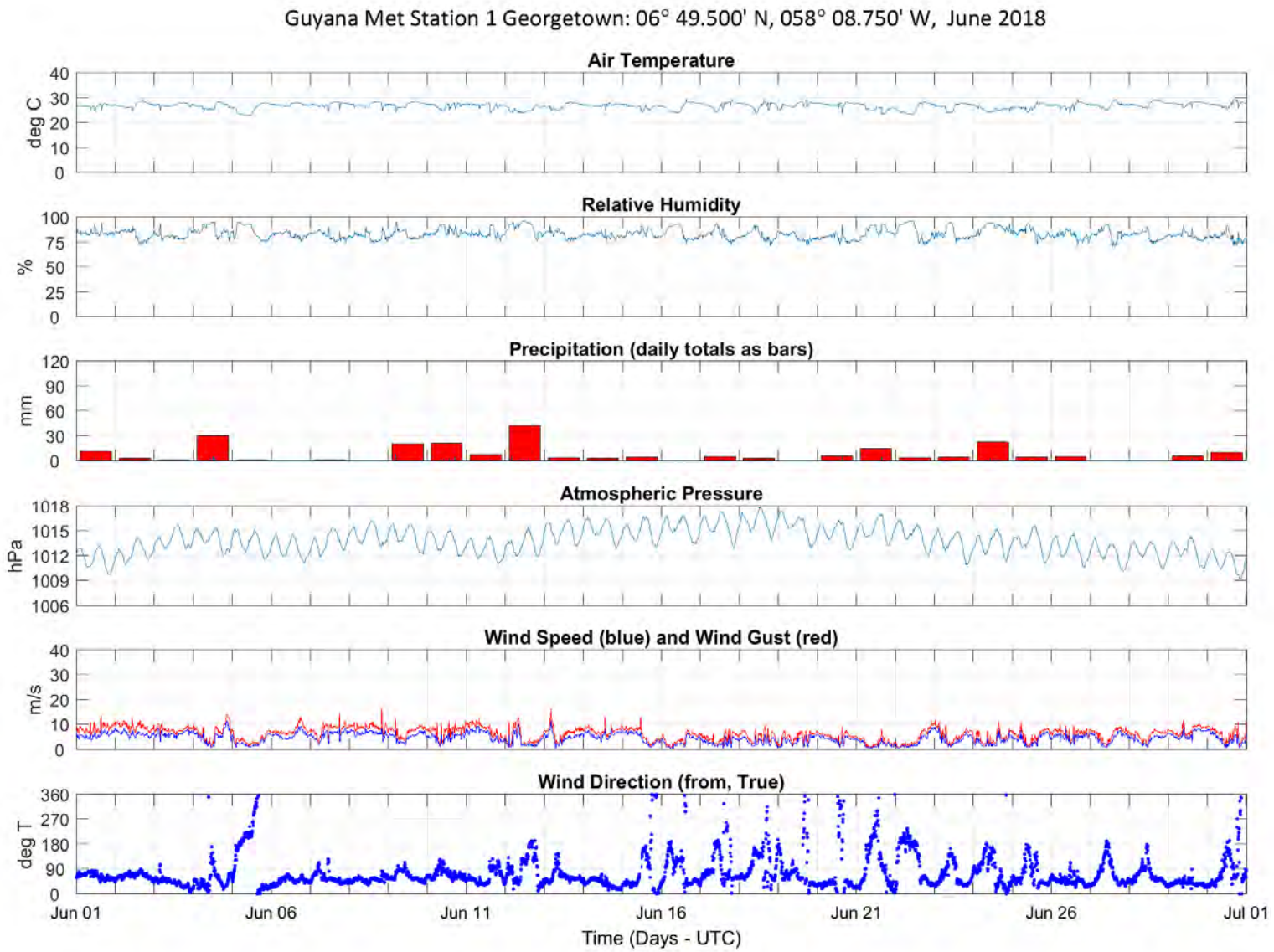

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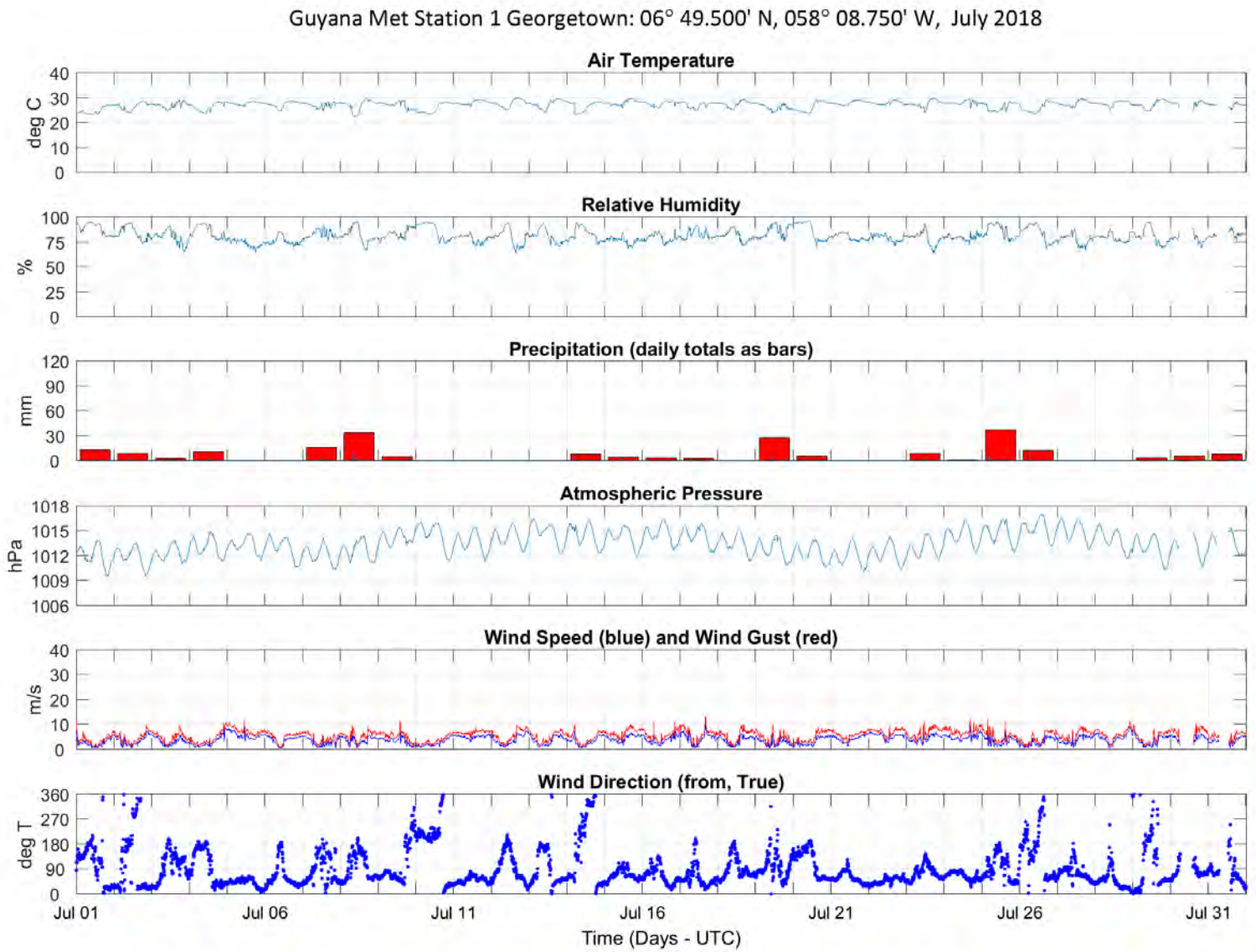

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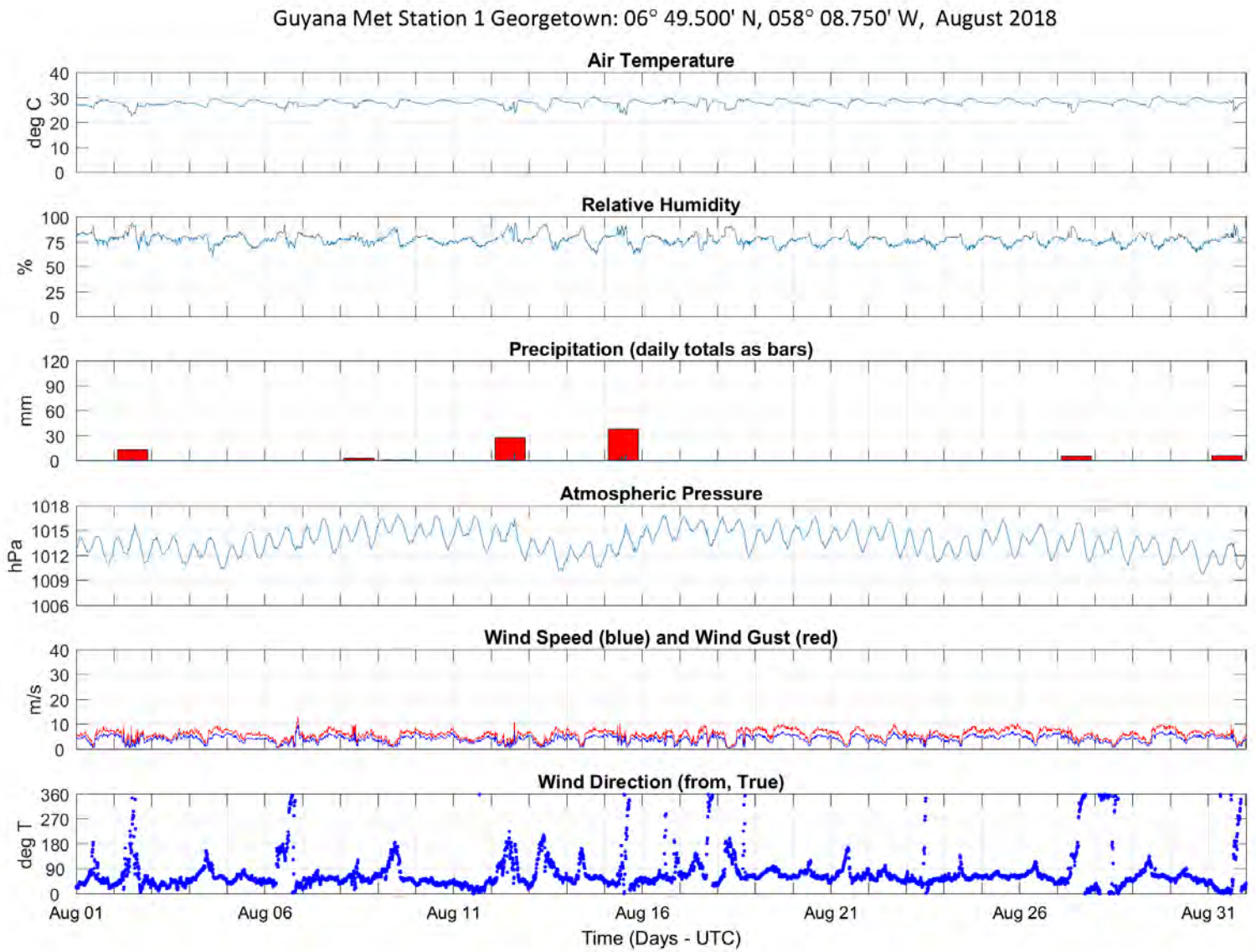

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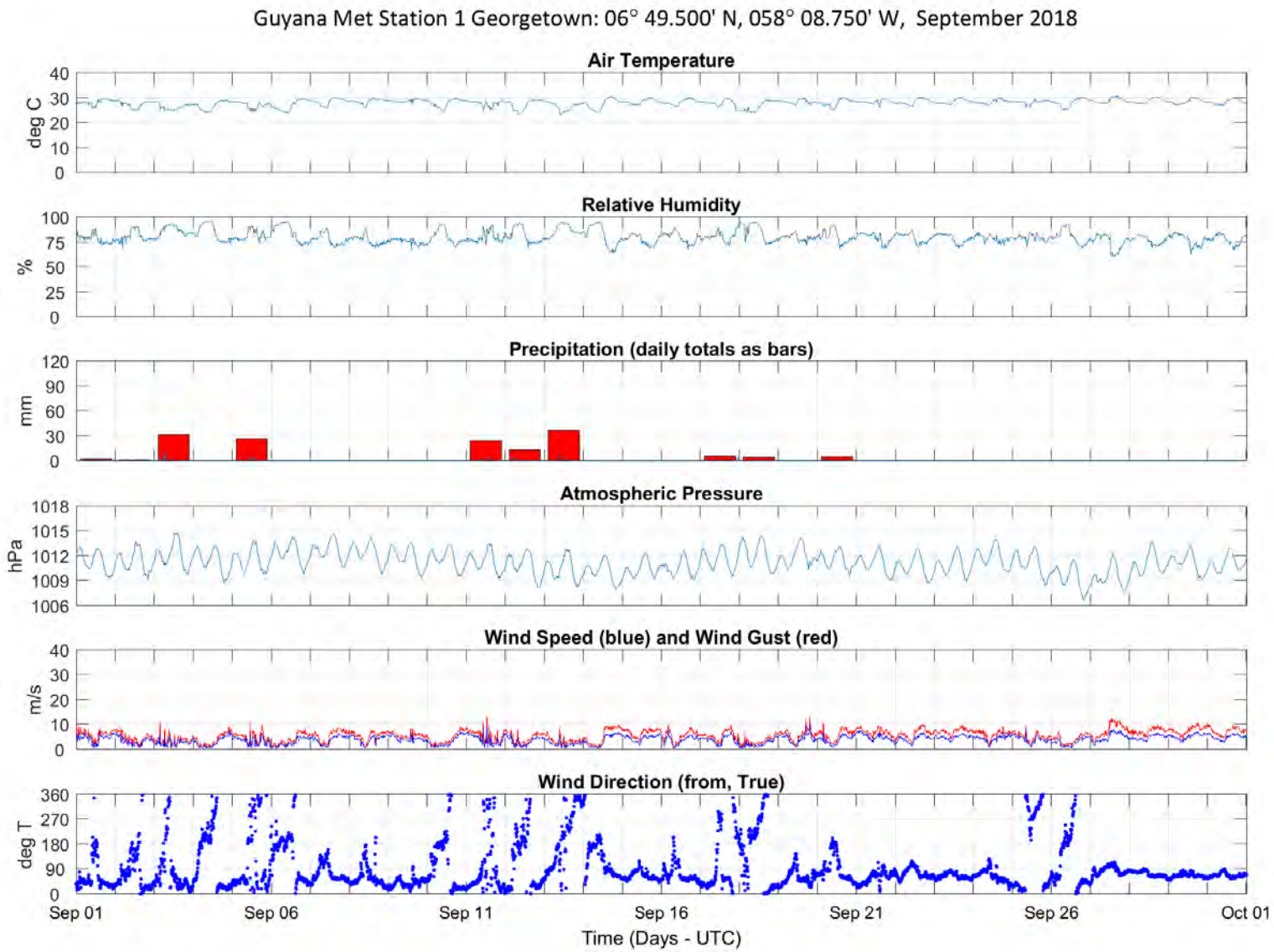

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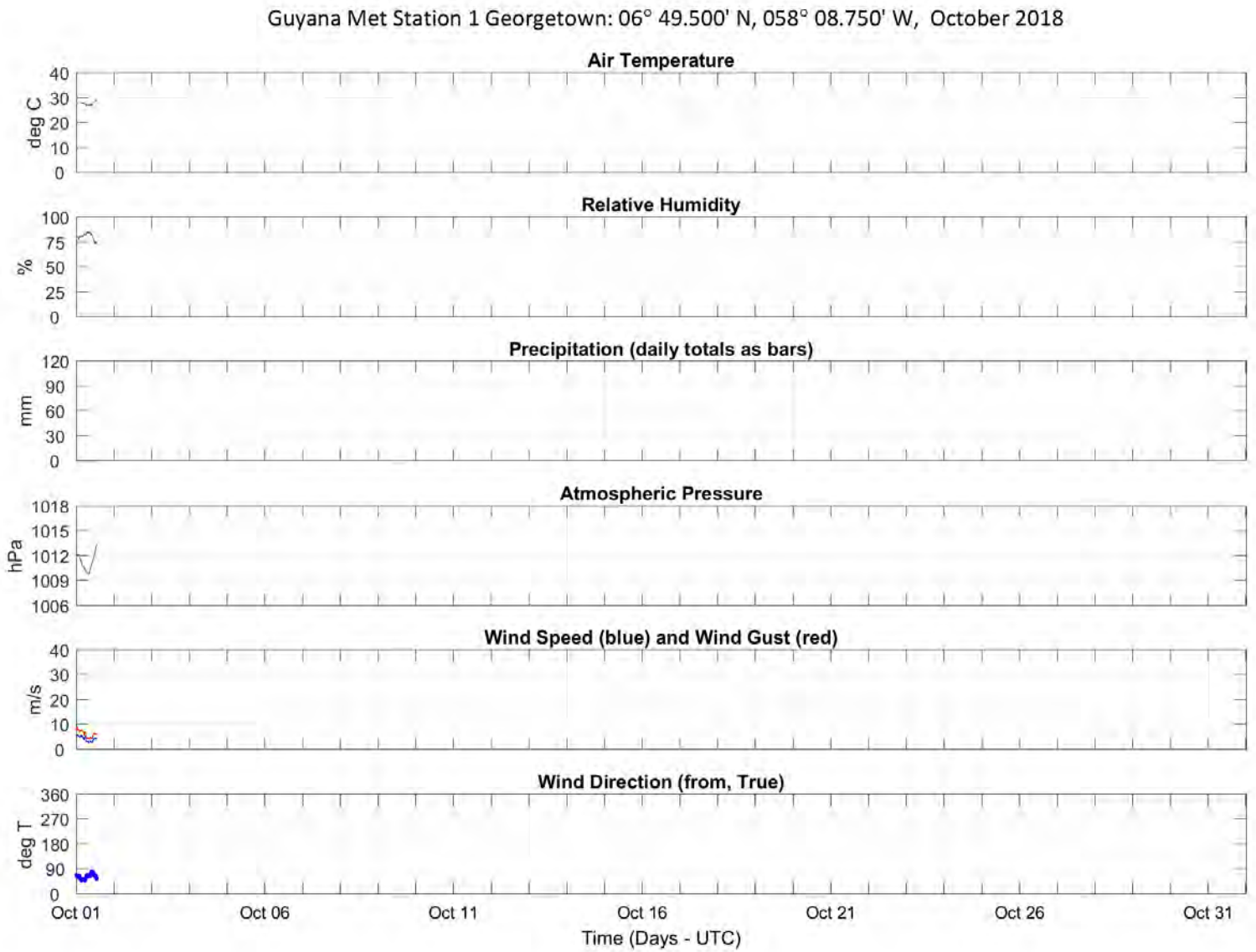

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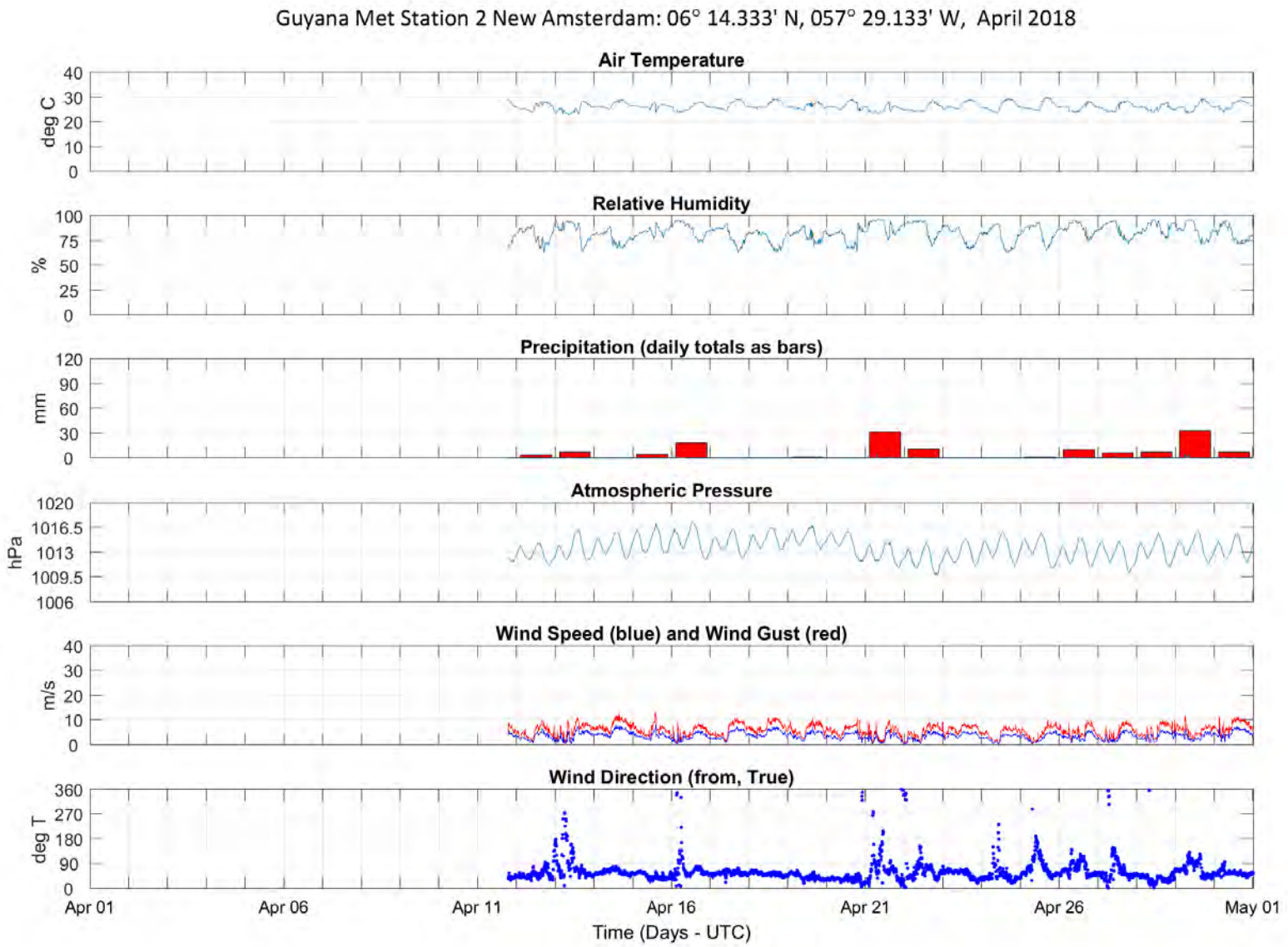

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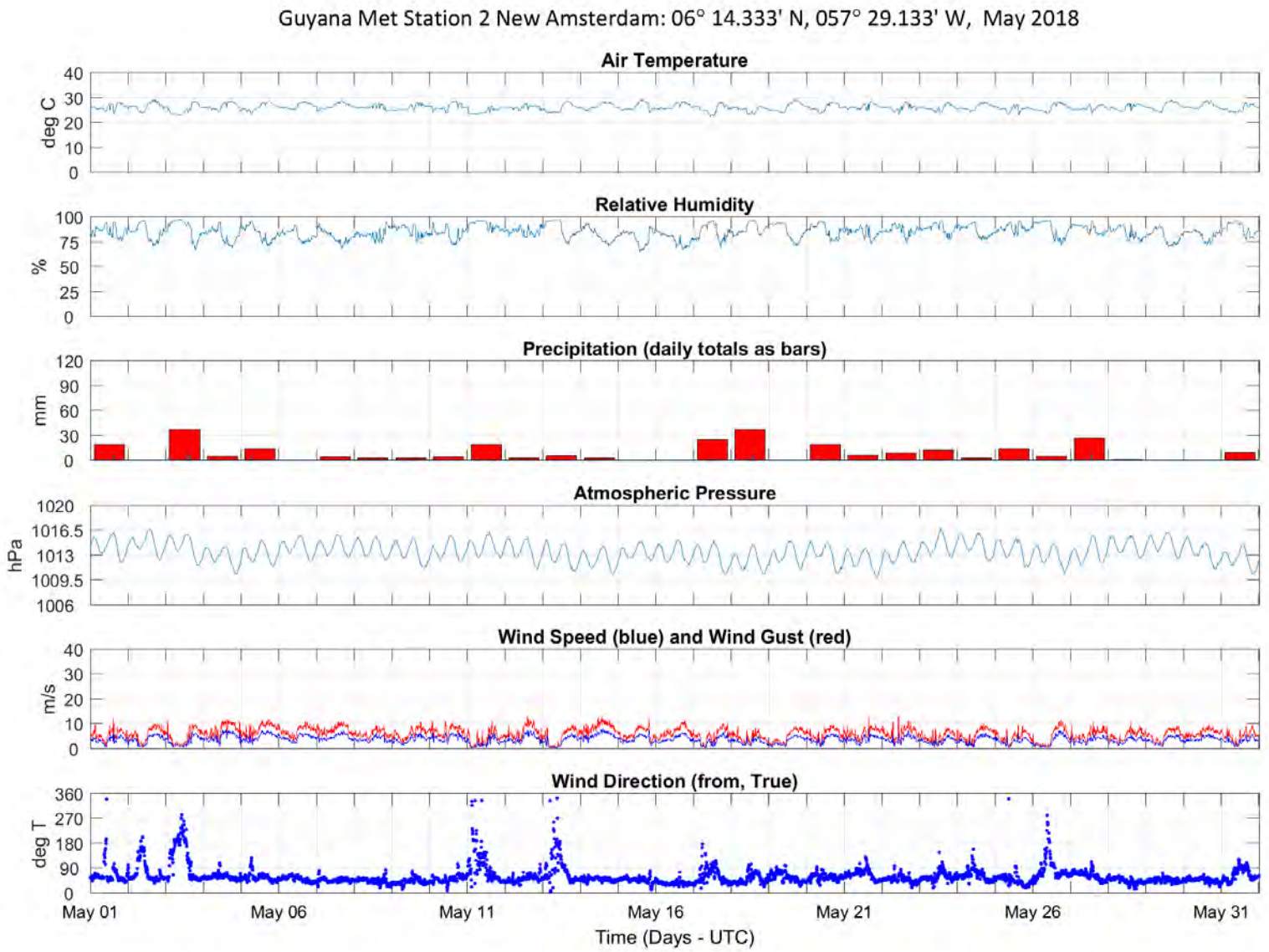

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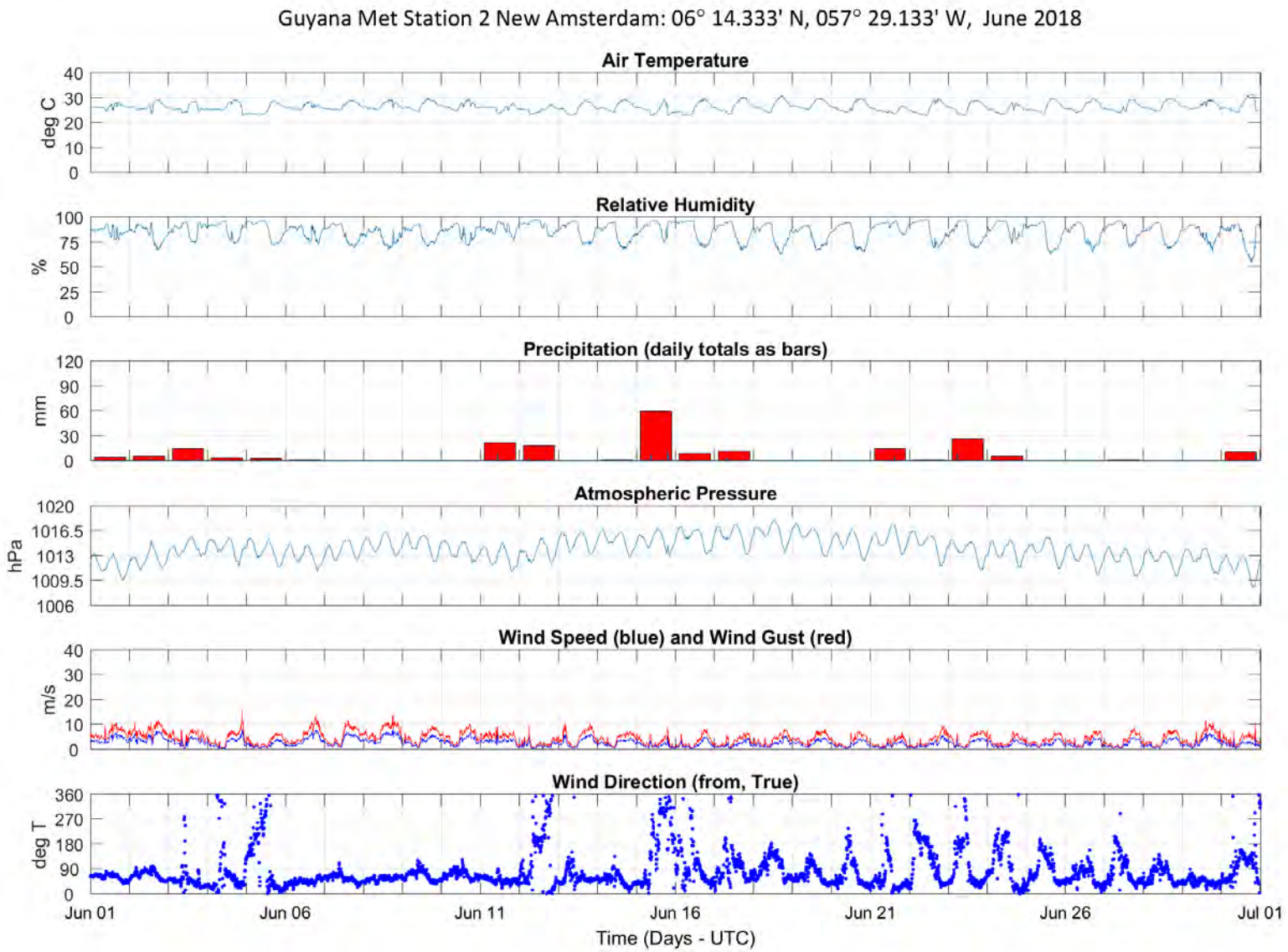

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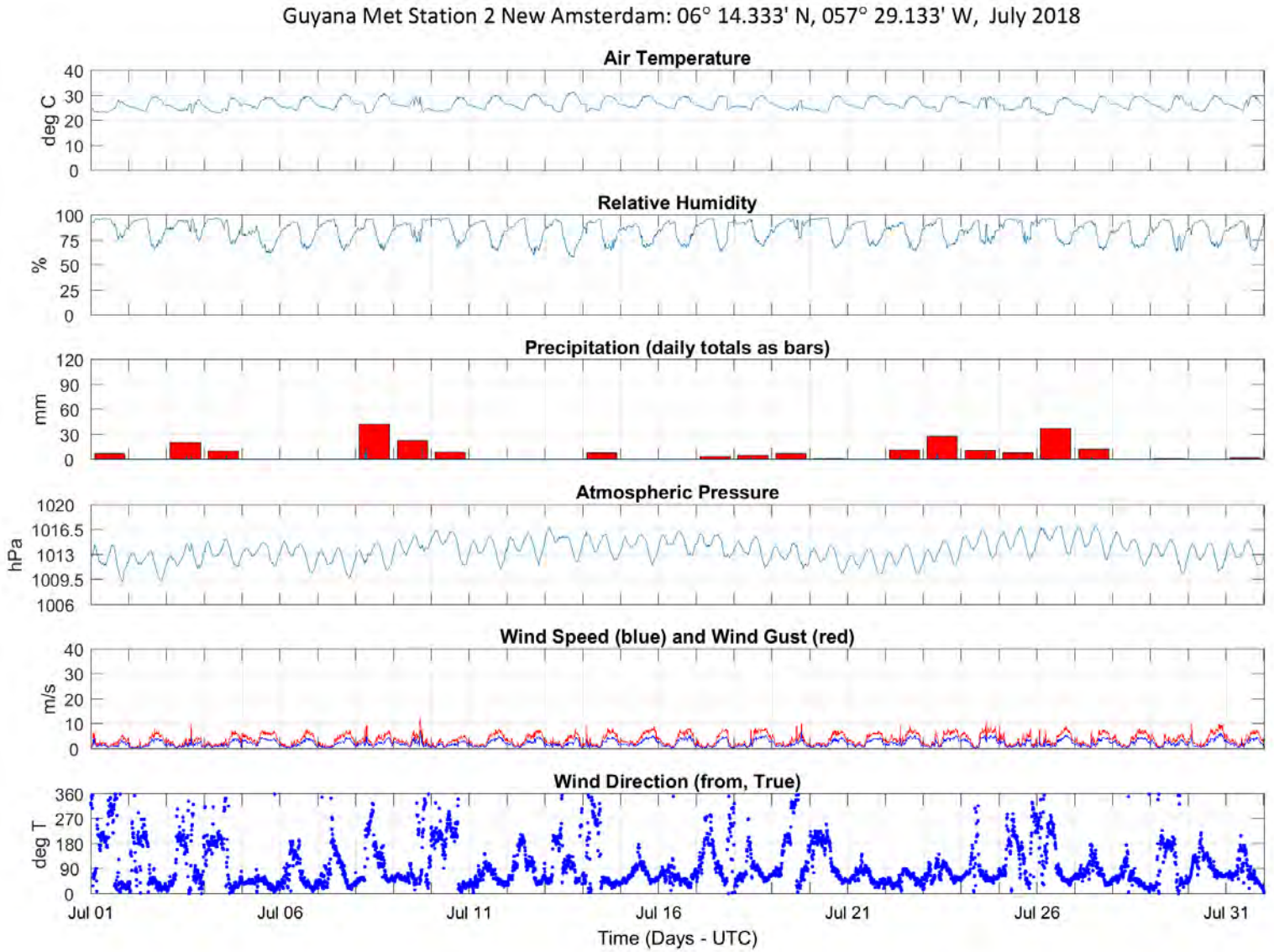

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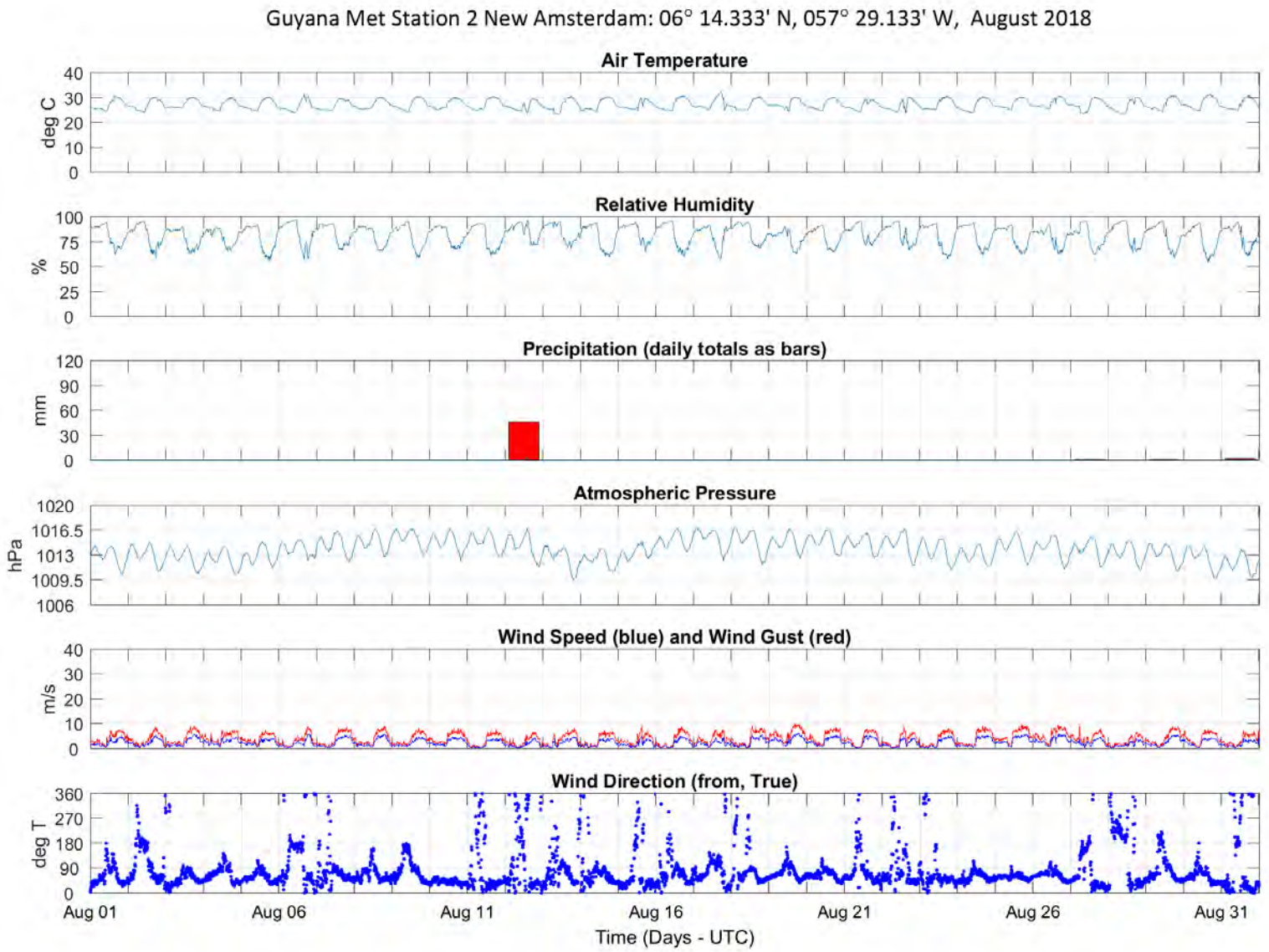

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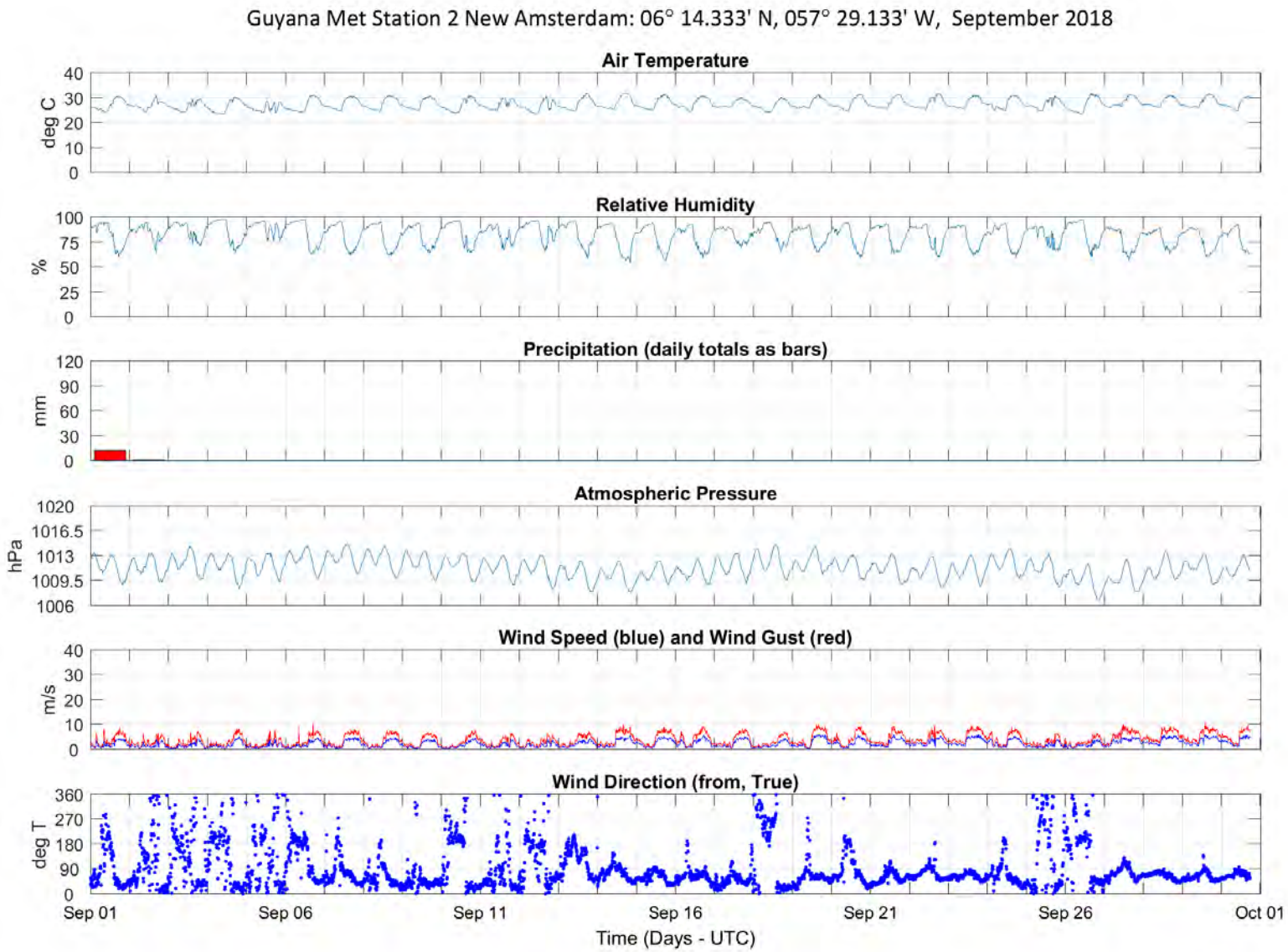

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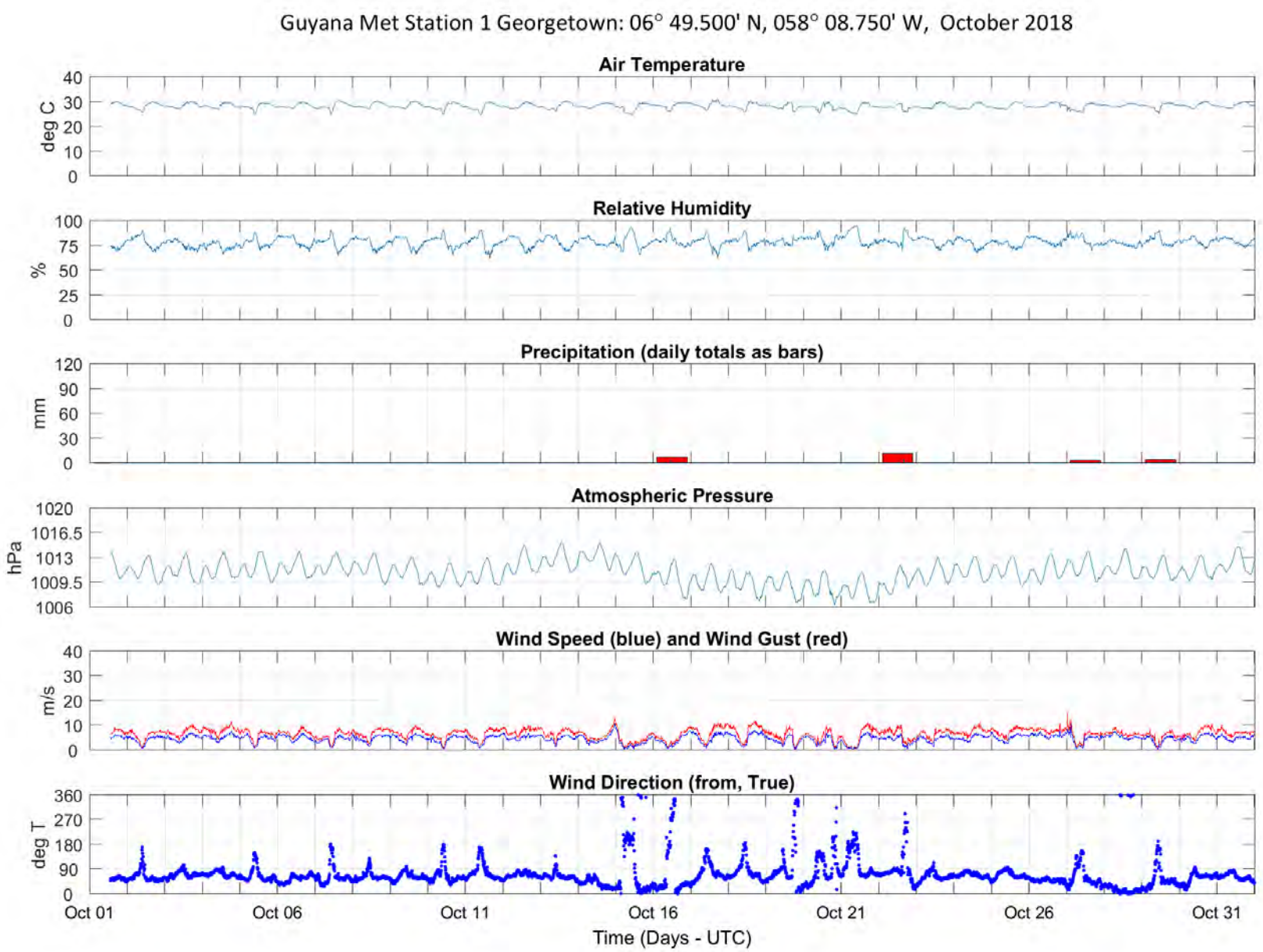
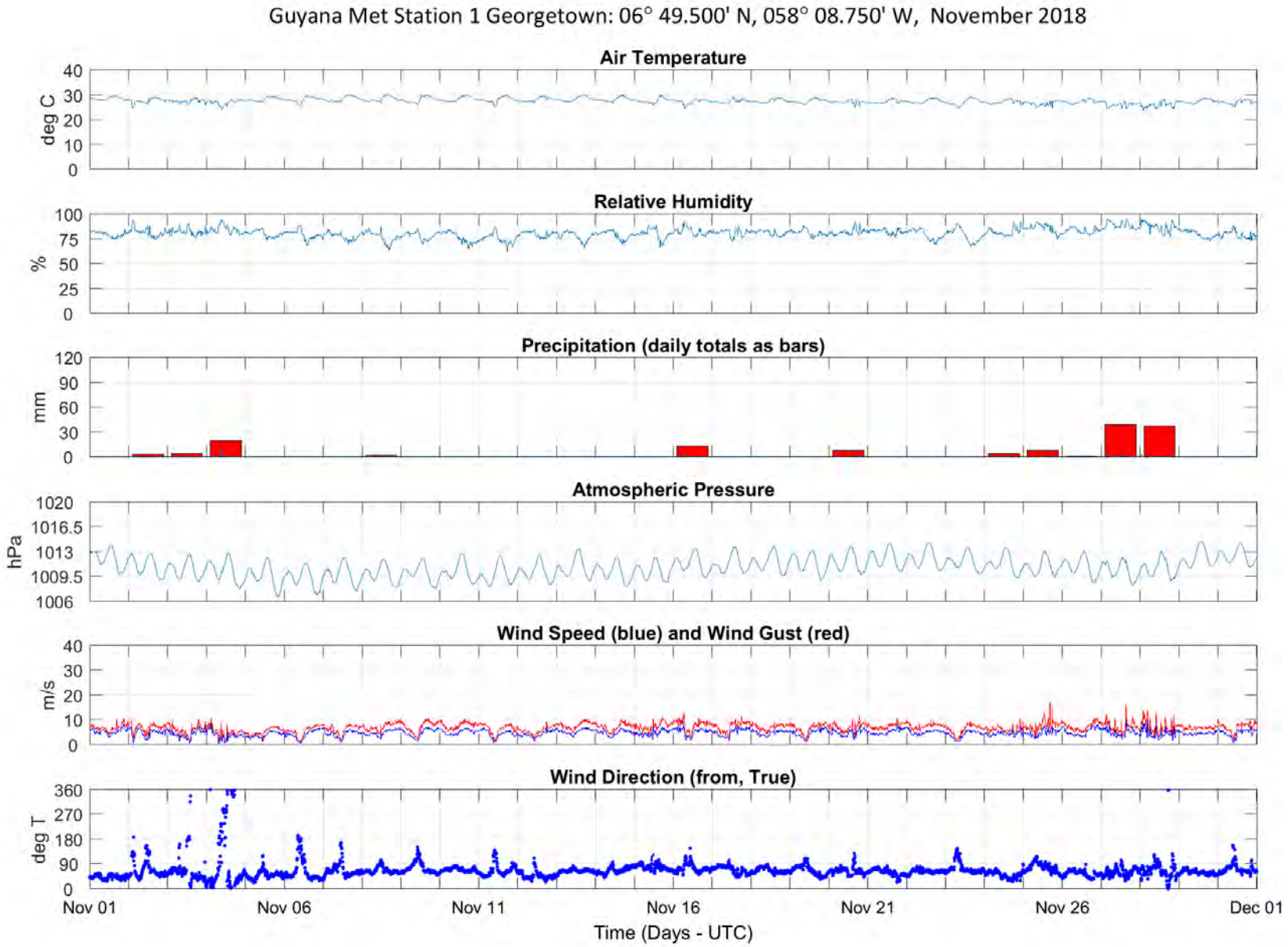
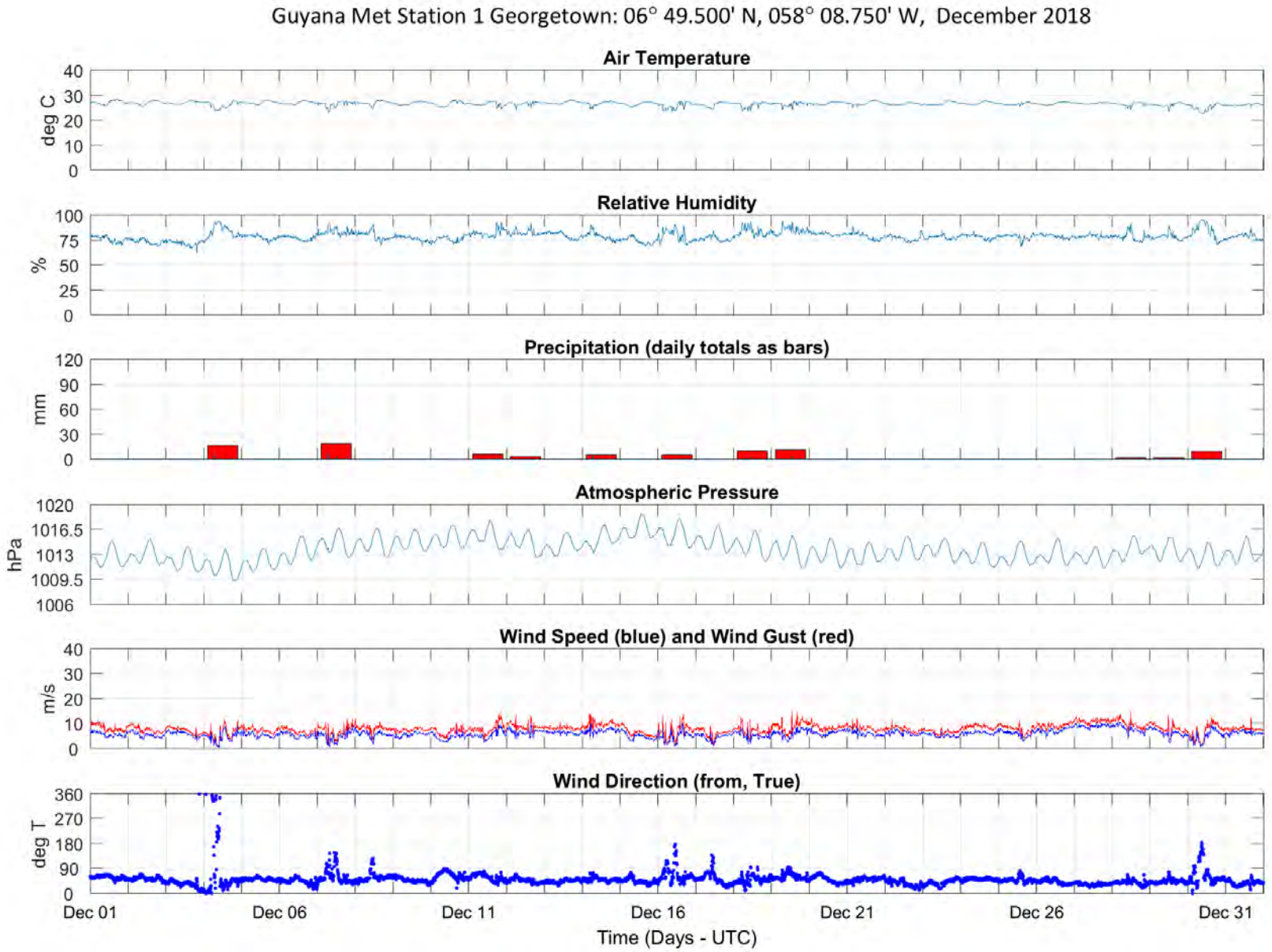
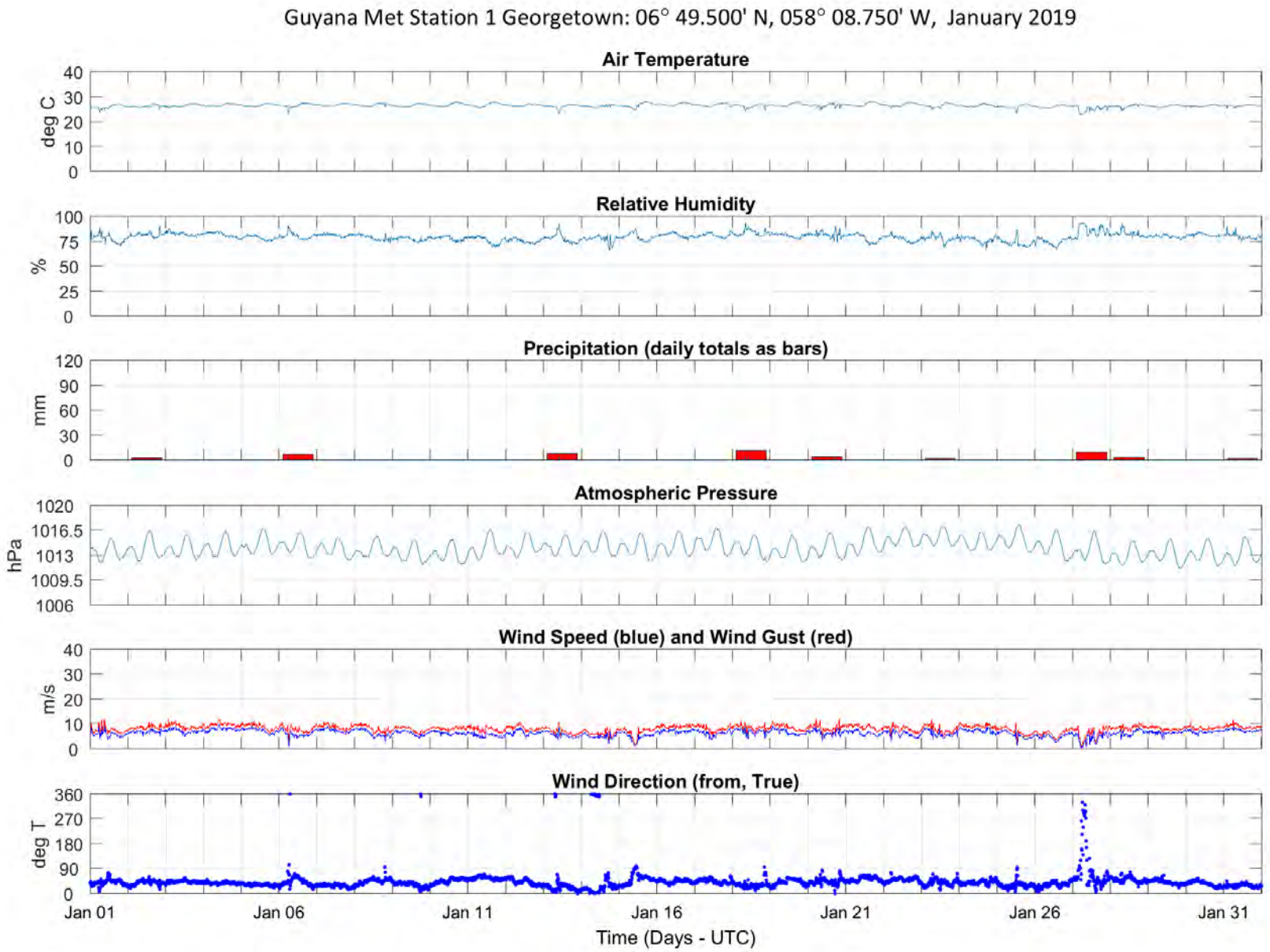
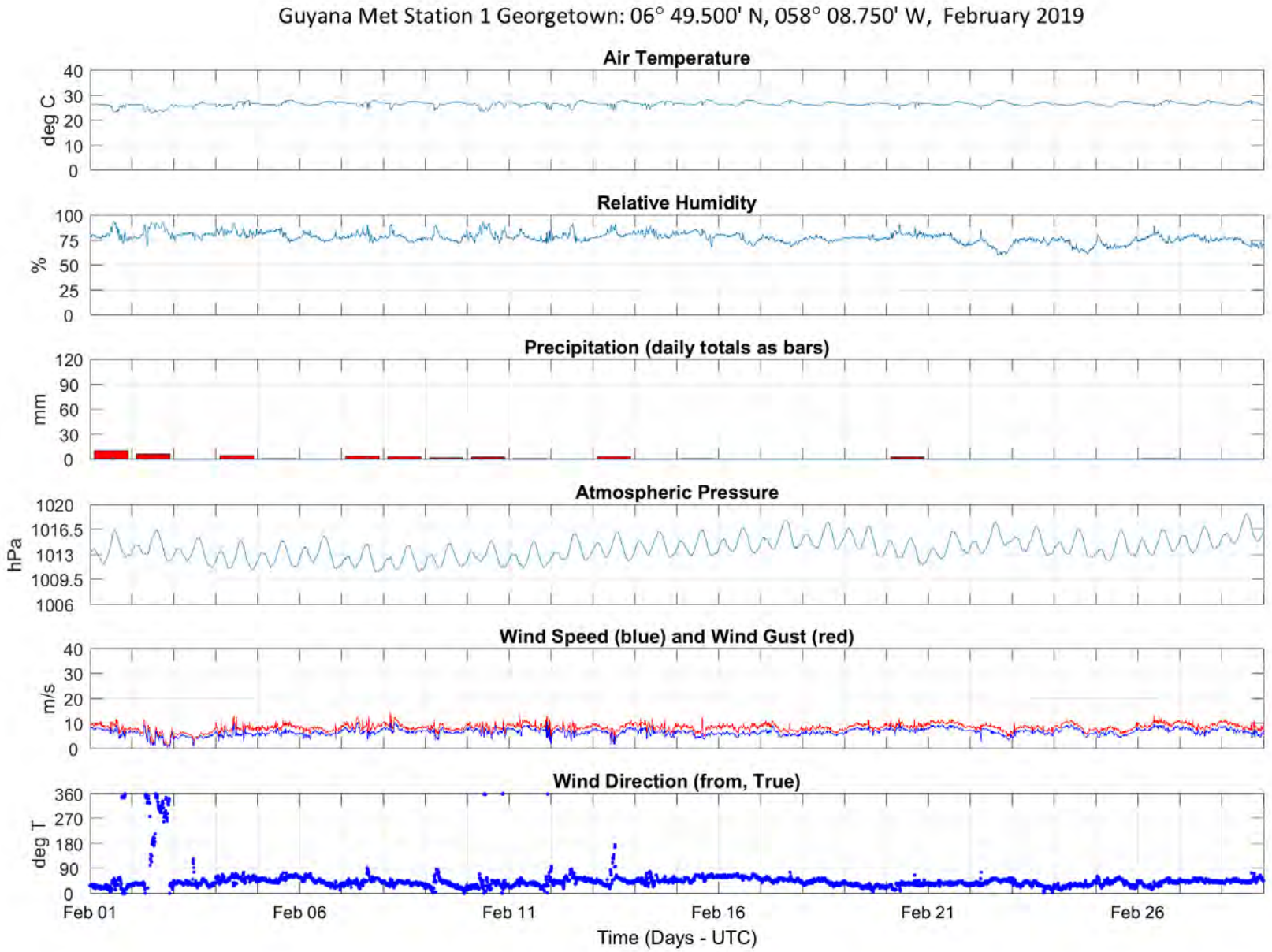
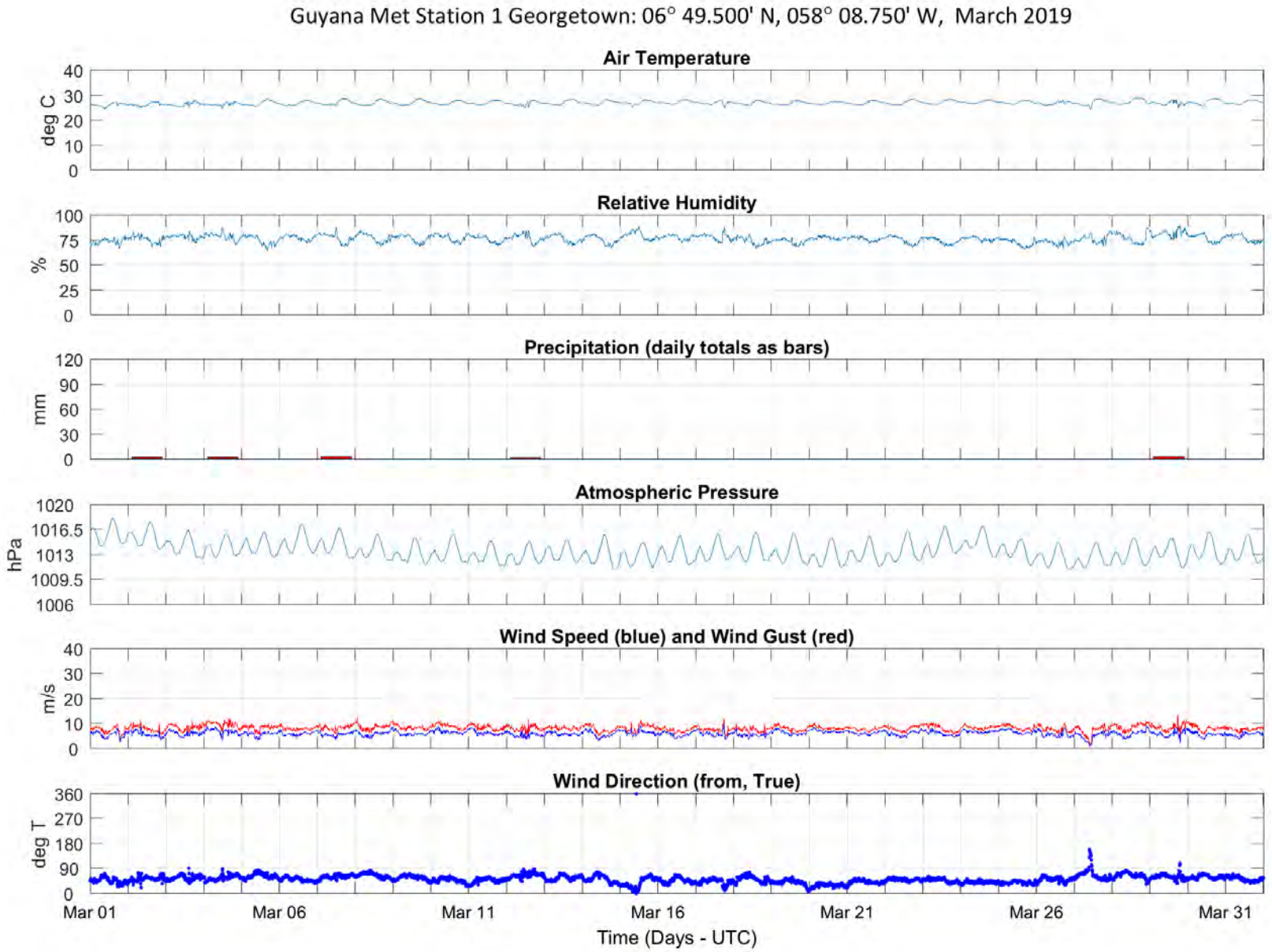

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, October 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)

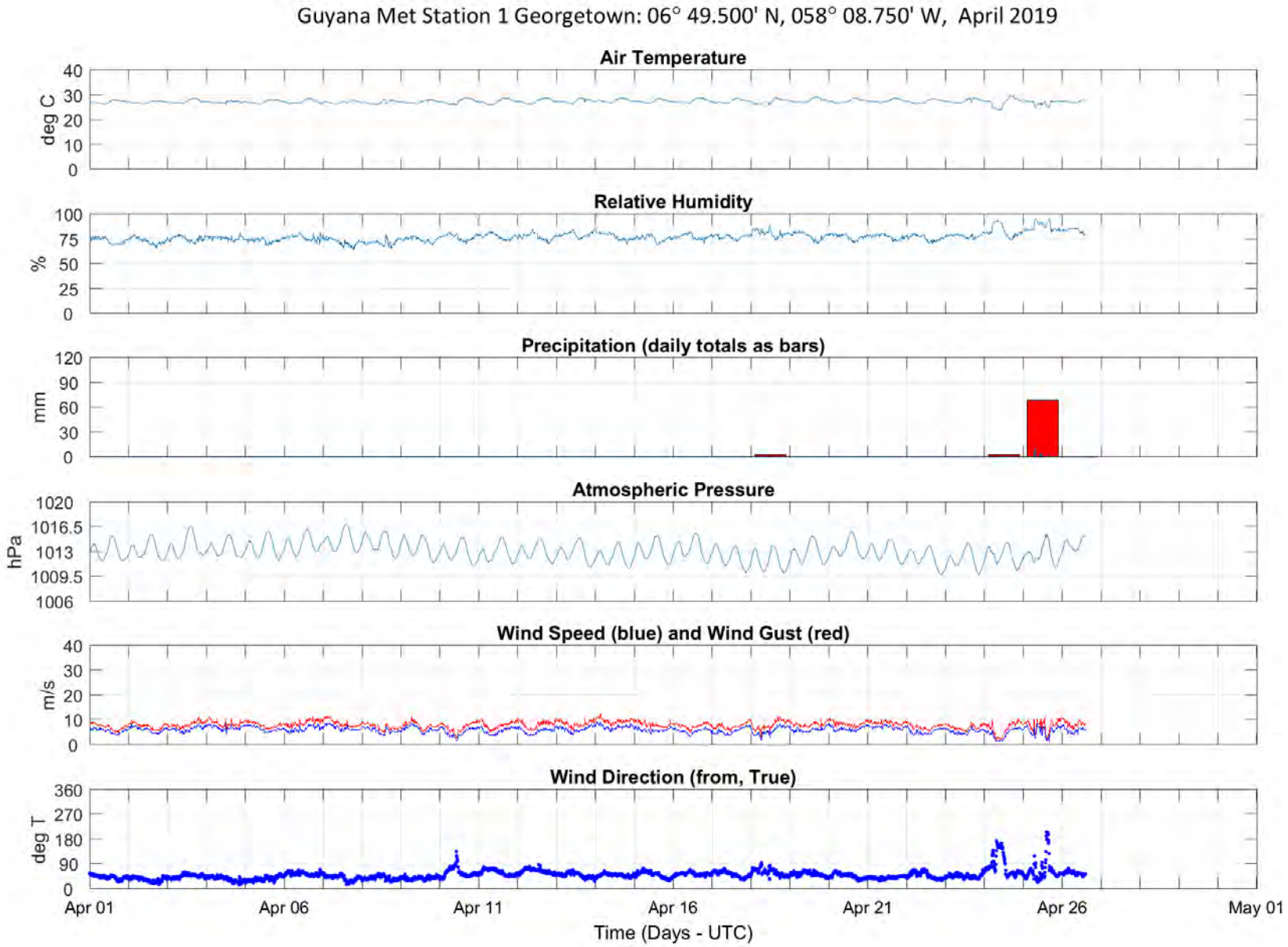

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, November 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

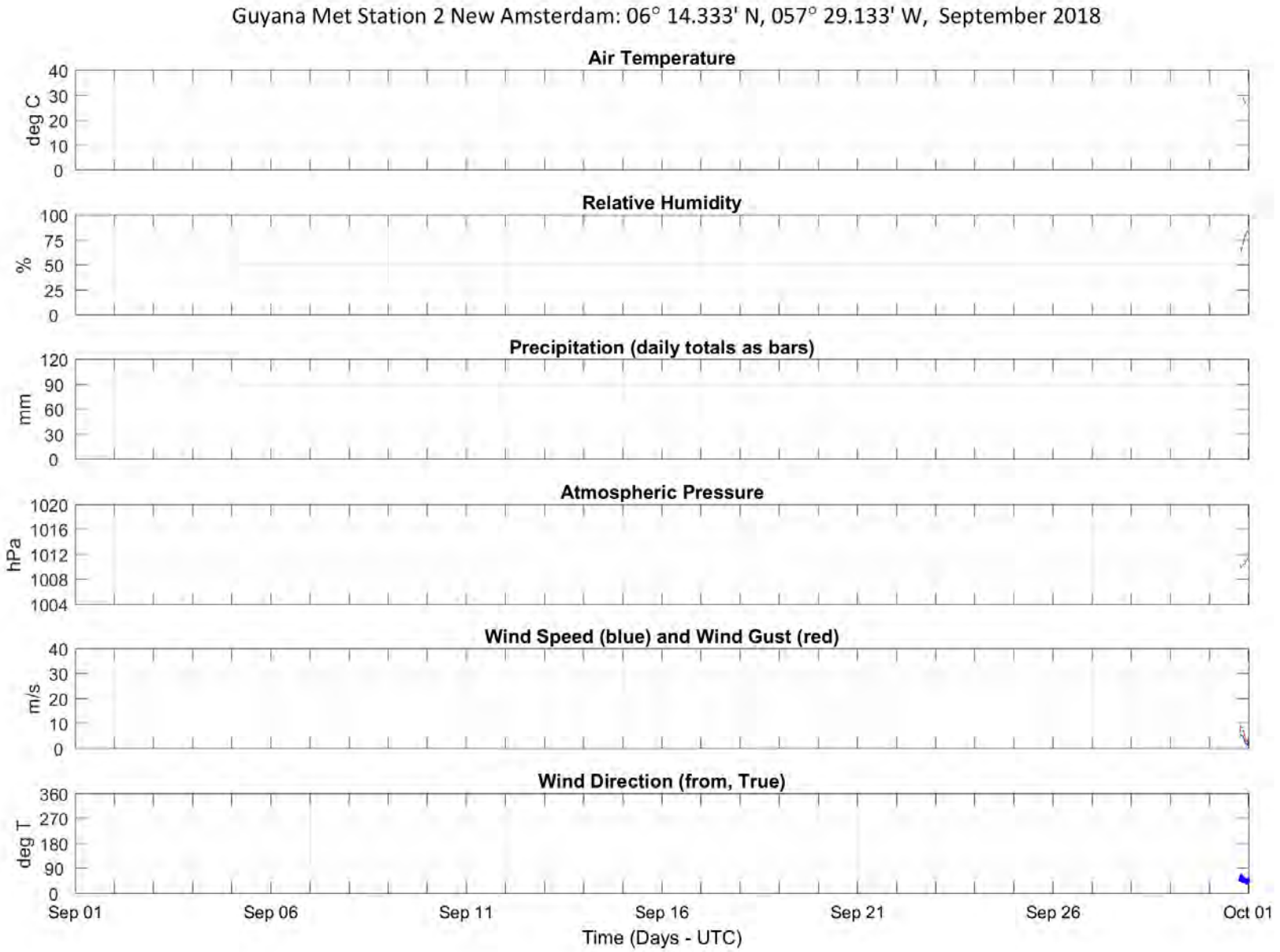

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, December 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Dec 01
Dec 06
Dec 11
Dec 16
Dec 21
Dec 26
Dec 31
Time (Days - UTC)

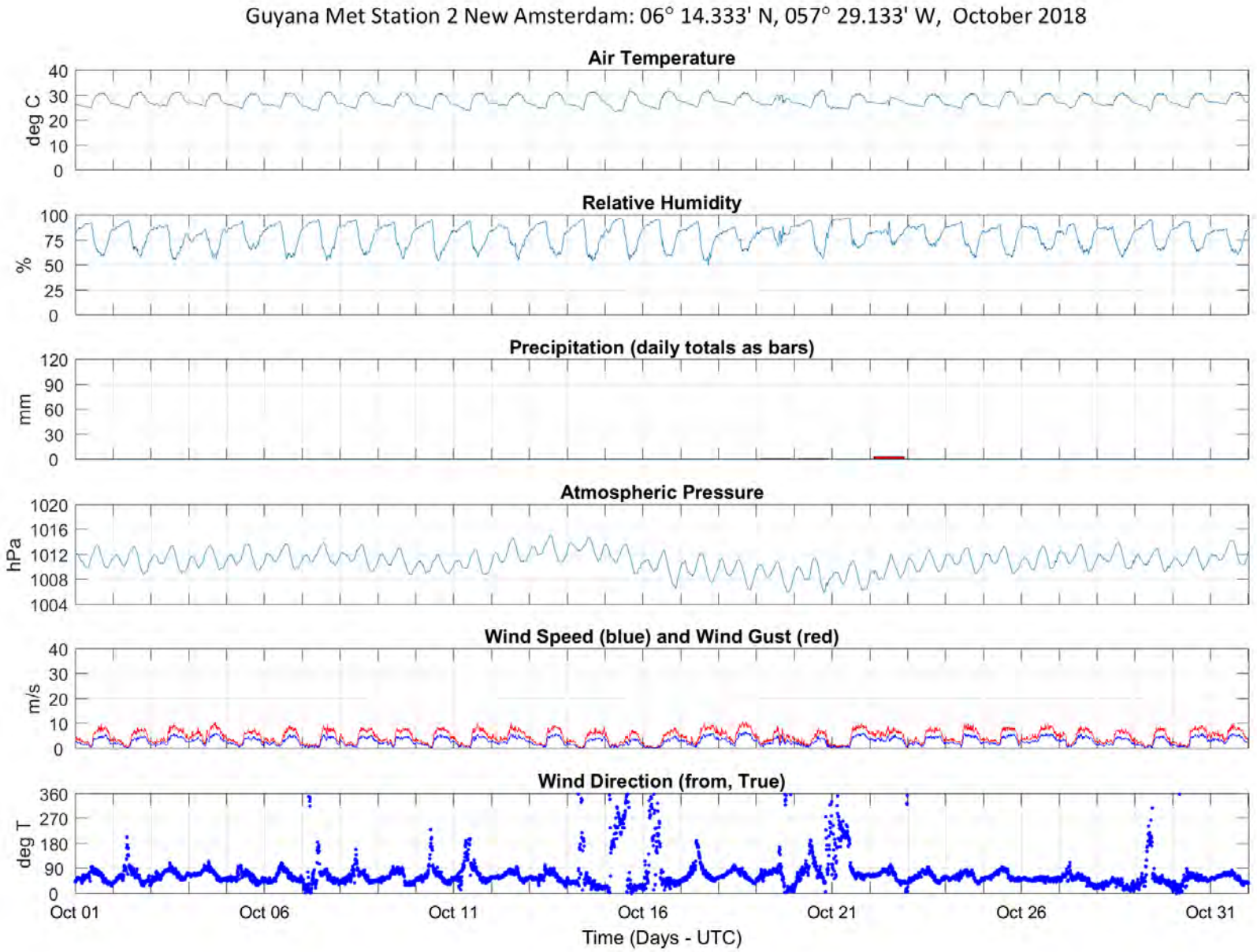

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, January 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Jan 01
Jan 06
Jan 11
Jan 16
Jan 21
Jan 26
Jan 31
Time (Days - UTC)

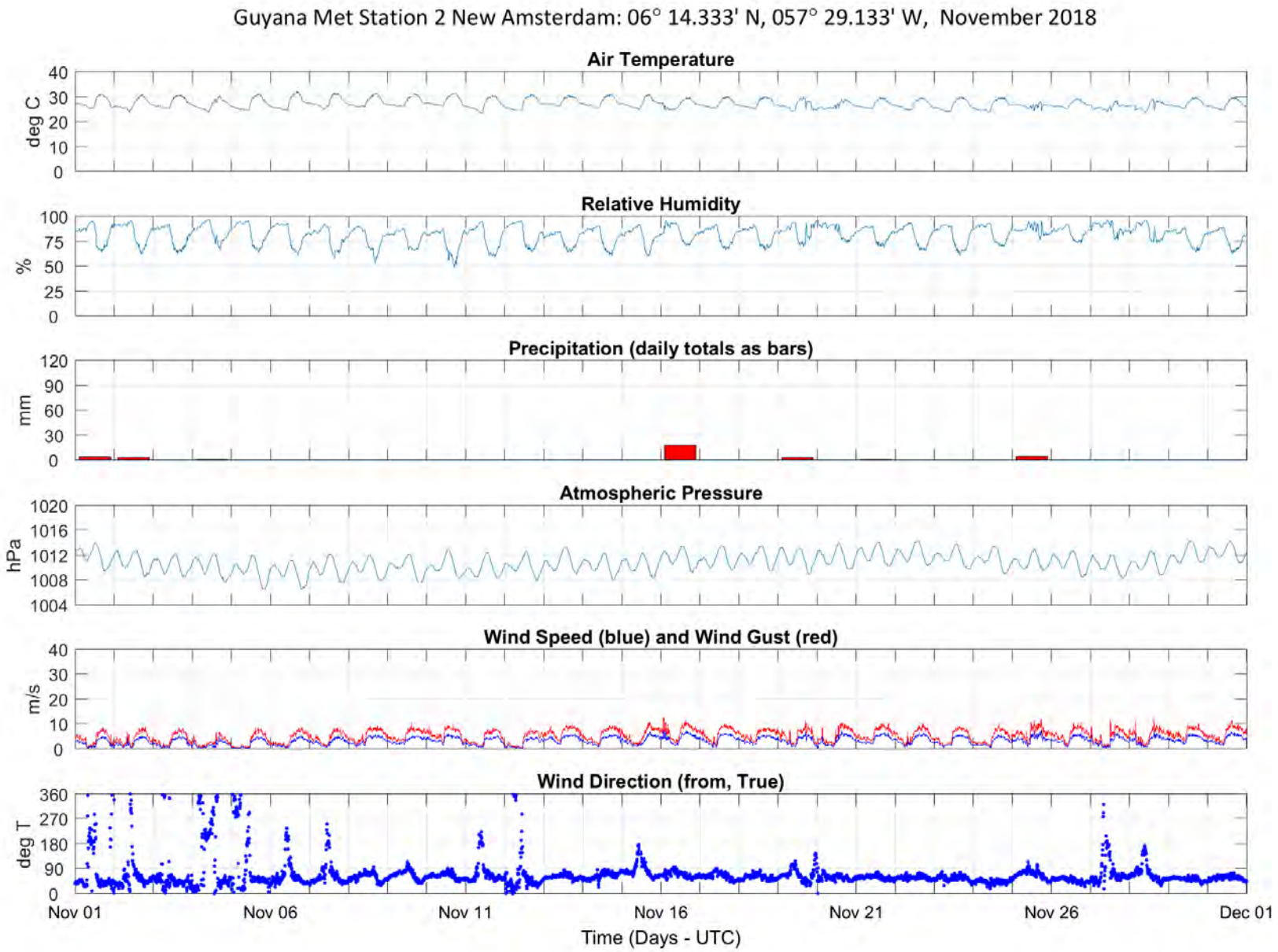

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, February 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Feb 01
Feb 06
Feb 11
Feb 16
Feb 21
Feb 26
Time (Days - UTC)

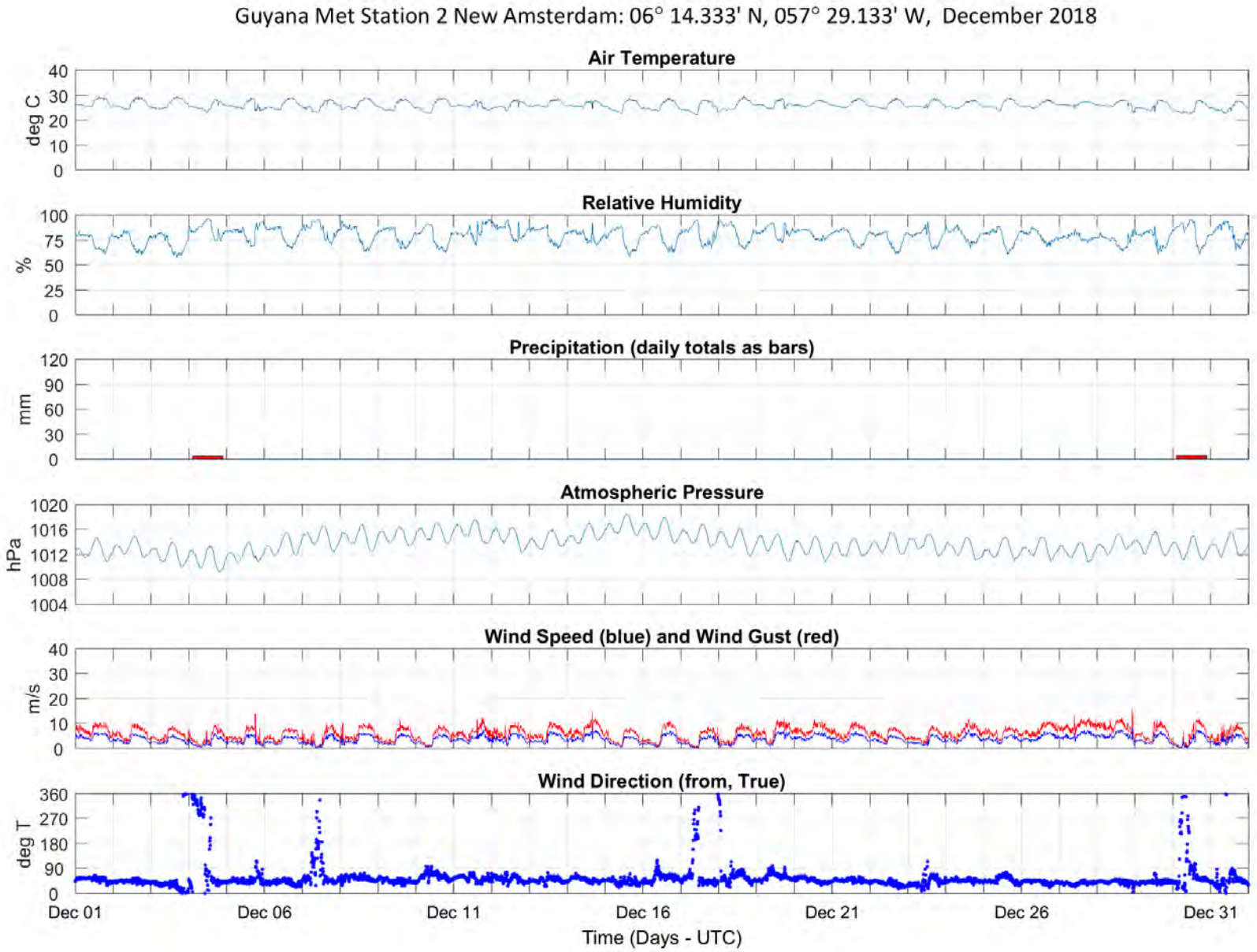

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, March 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Mar 01
Mar 06
Mar 11
Mar 16
Mar 21
Mar 26
Mar 31
Time (Days - UTC)

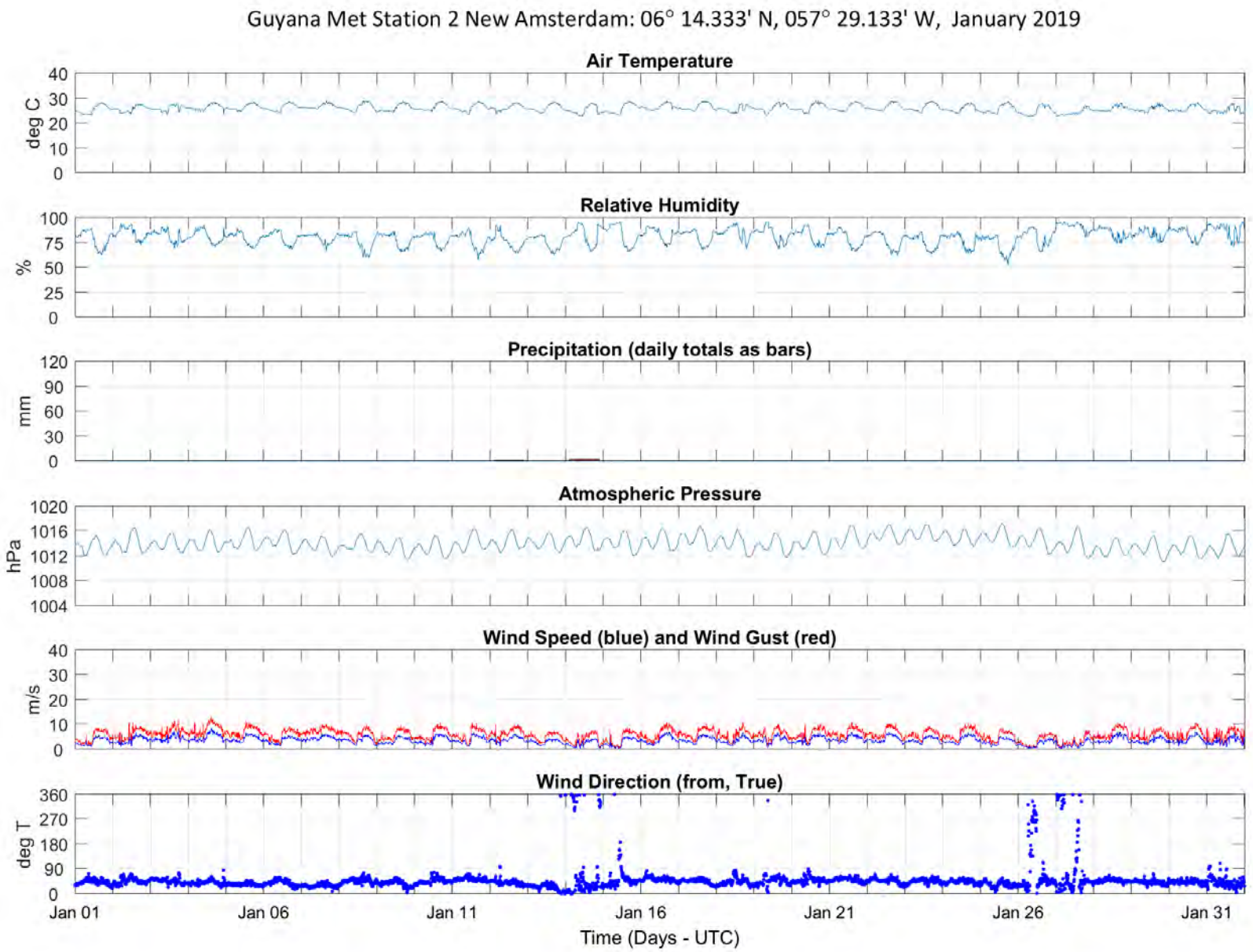

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, April 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Apr 01
Apr 06
Apr 11
Apr 16
Apr 21
Apr 26
May 01
Time (Days - UTC)

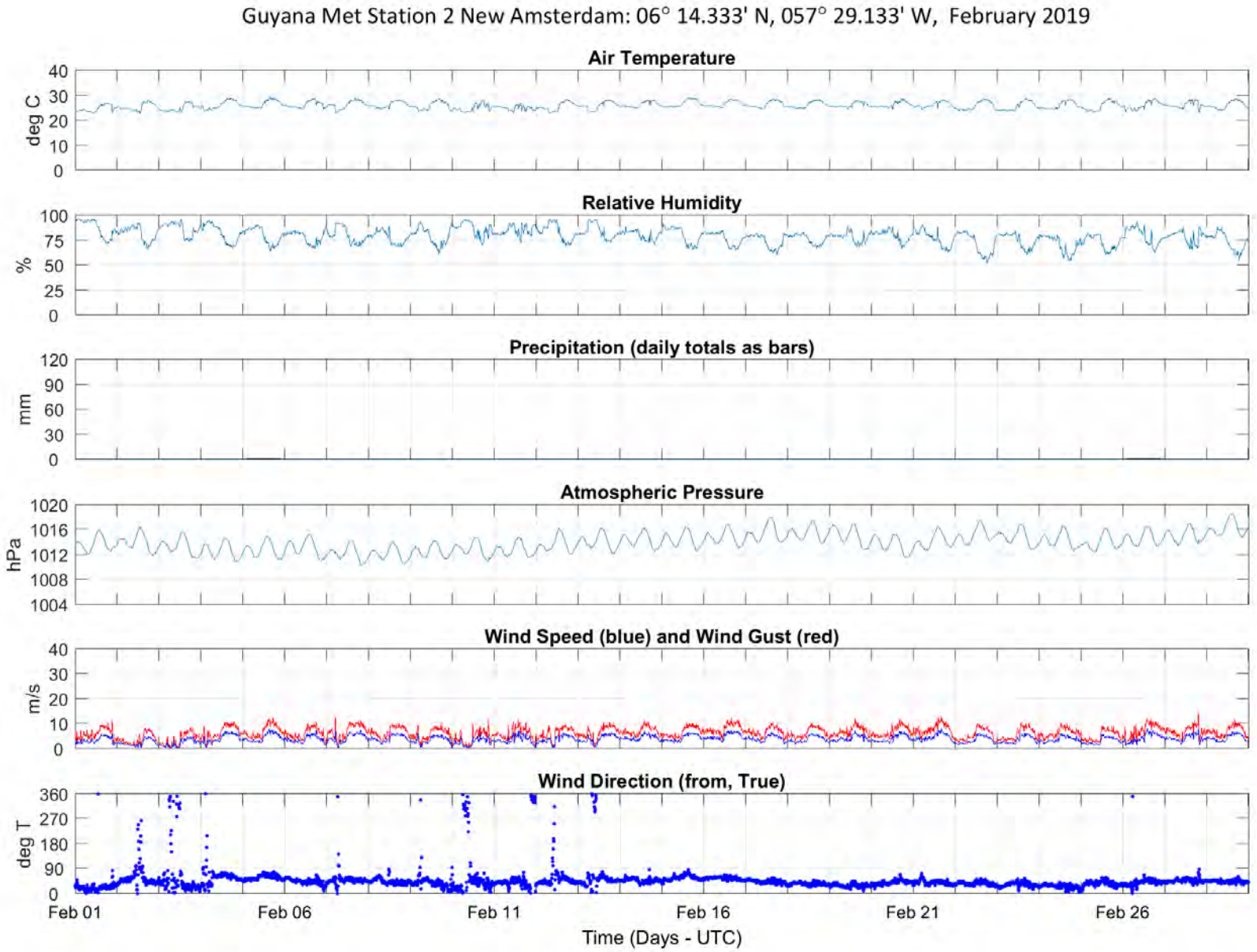

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, September 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Sep 01
Sep 06
Sep 11
Sep 16
Sep 21
Sep 26
Oct 01
Time (Days - UTC)

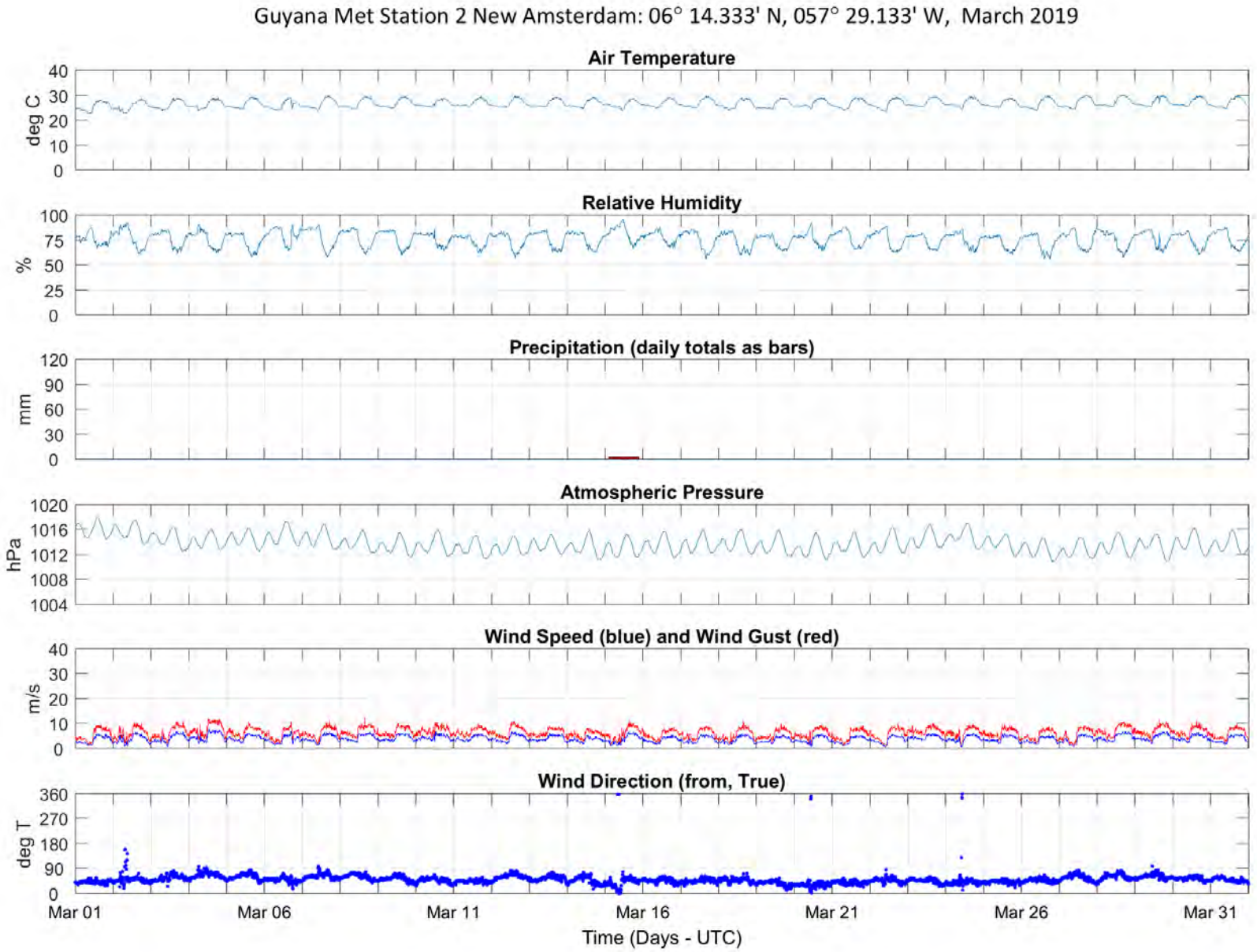

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, October 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)

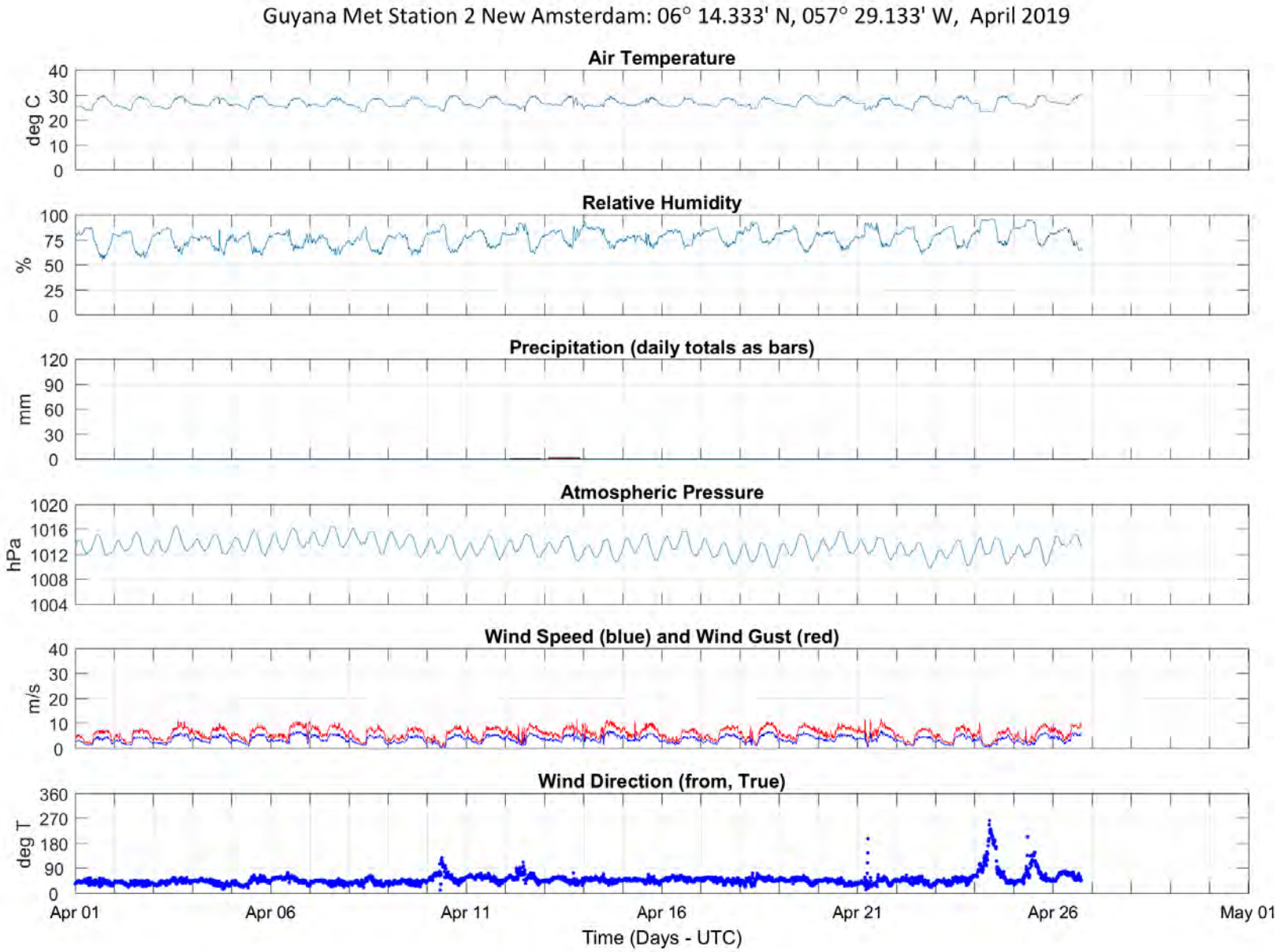

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, November 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, December 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Dec 01
Dec 06
Dec 11
Dec 16
Dec 21
Dec 26
Dec 31
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, January 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Jan 01
Jan 06
Jan 11
Jan 16
Jan 21
Jan 26
Jan 31
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, February 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Feb 01
Feb 06
Feb 11
Feb 16
Feb 21
Feb 26
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, March 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Mar 01
Mar 06
Mar 11
Mar 16
Mar 21
Mar 26
Mar 31
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, April 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Apr 01
Apr 06
Apr 11
Apr 16
Apr 21
Apr 26
May 01
Time (Days - UTC)

Offshore Meteorological Data

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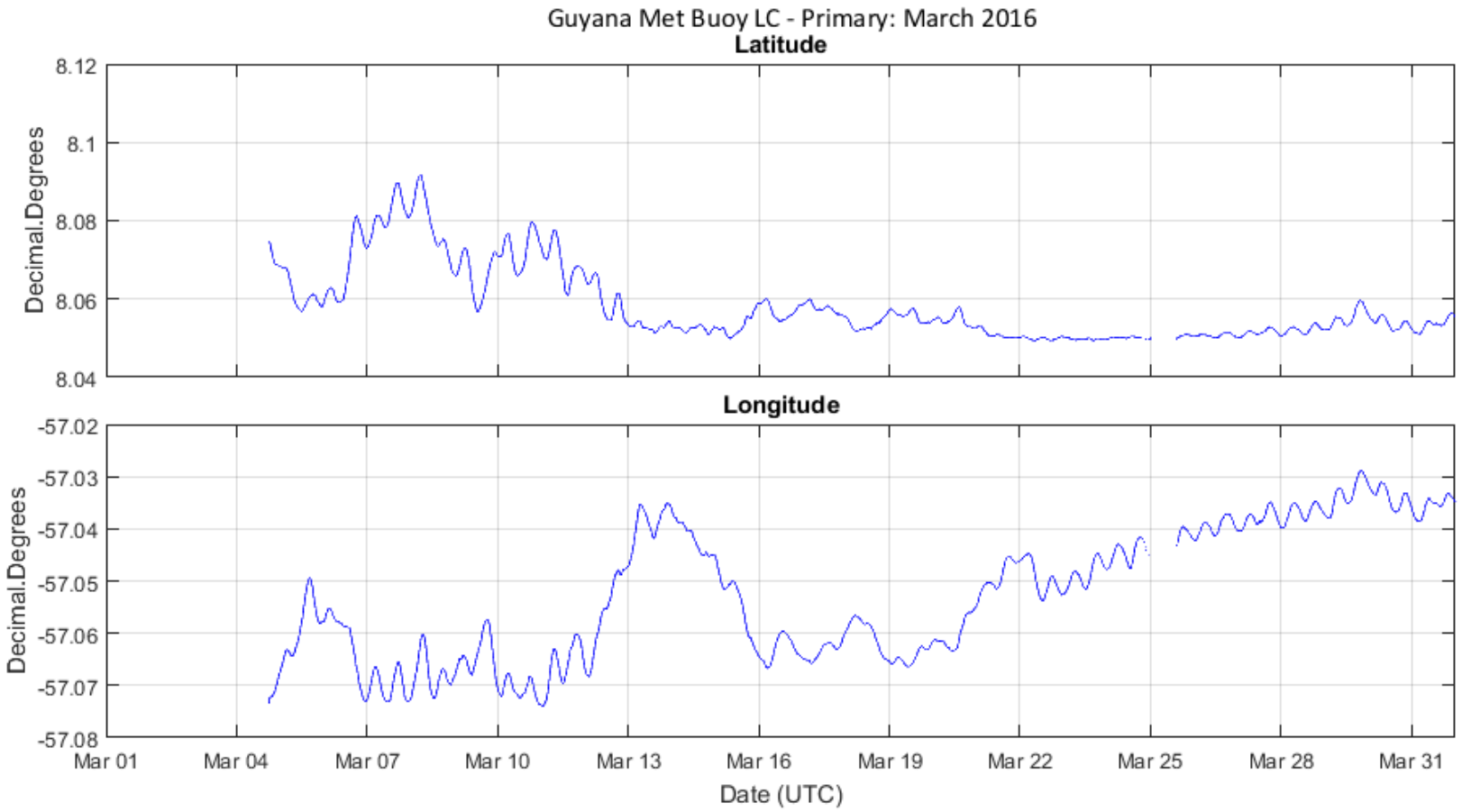

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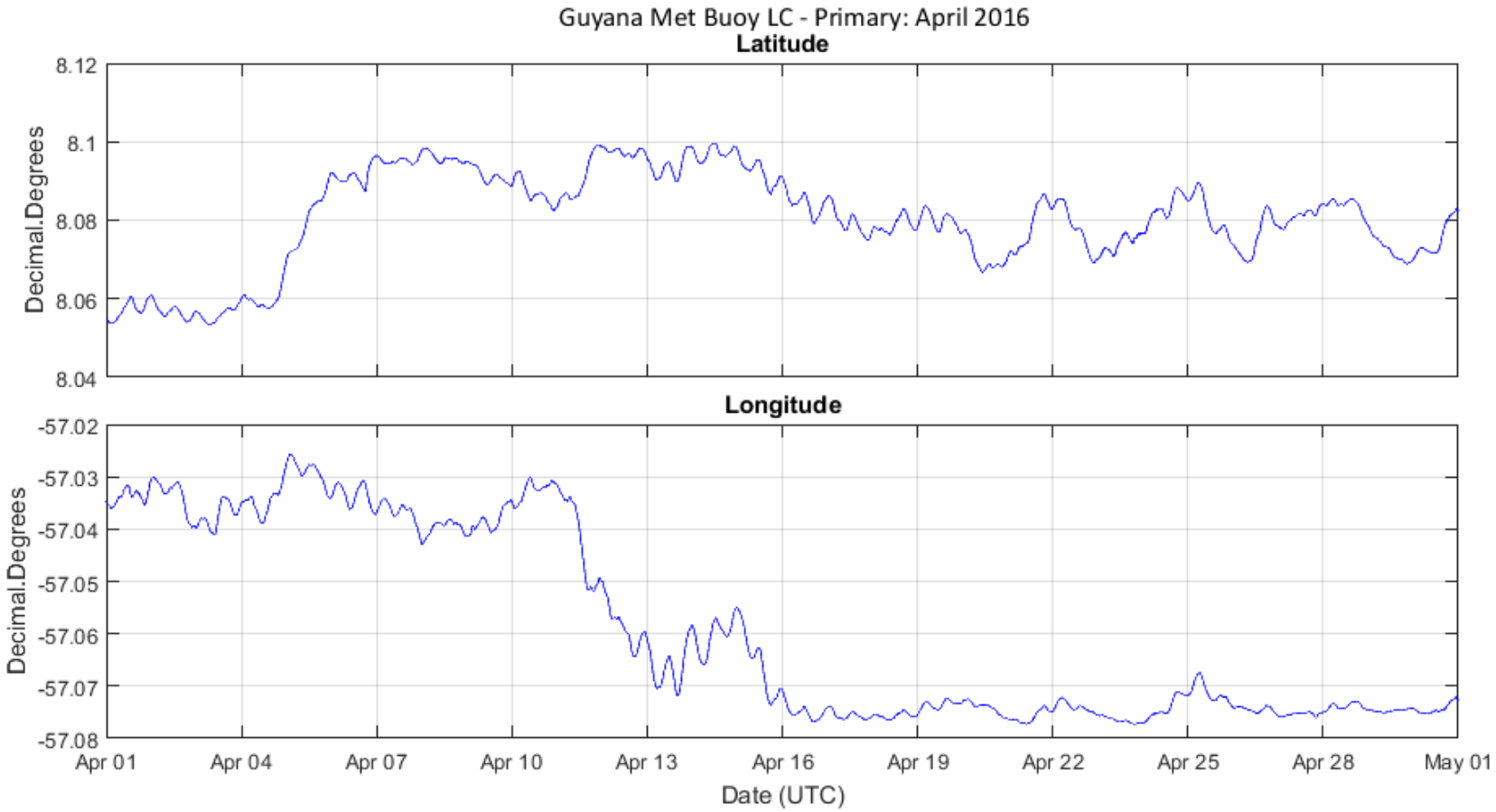

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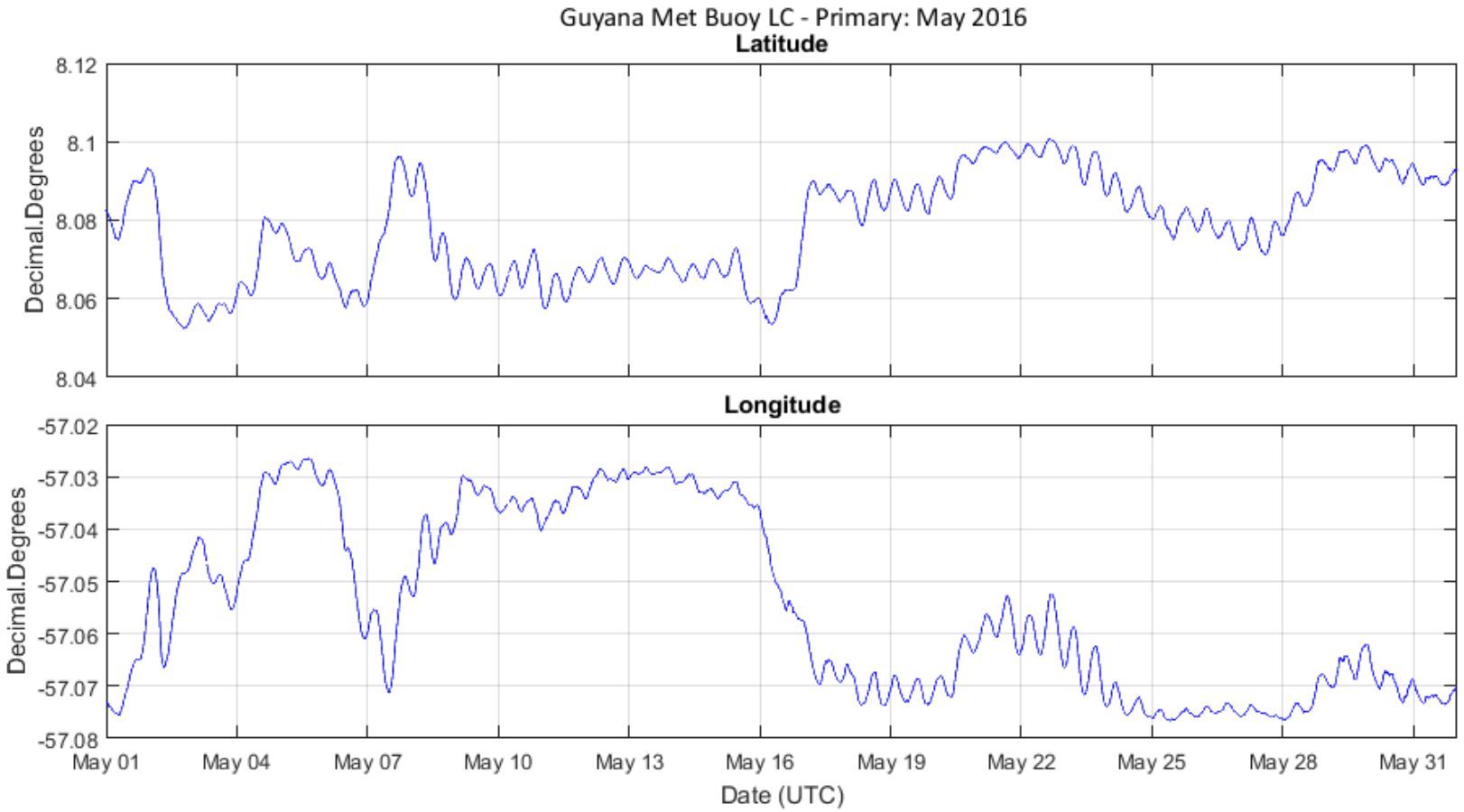

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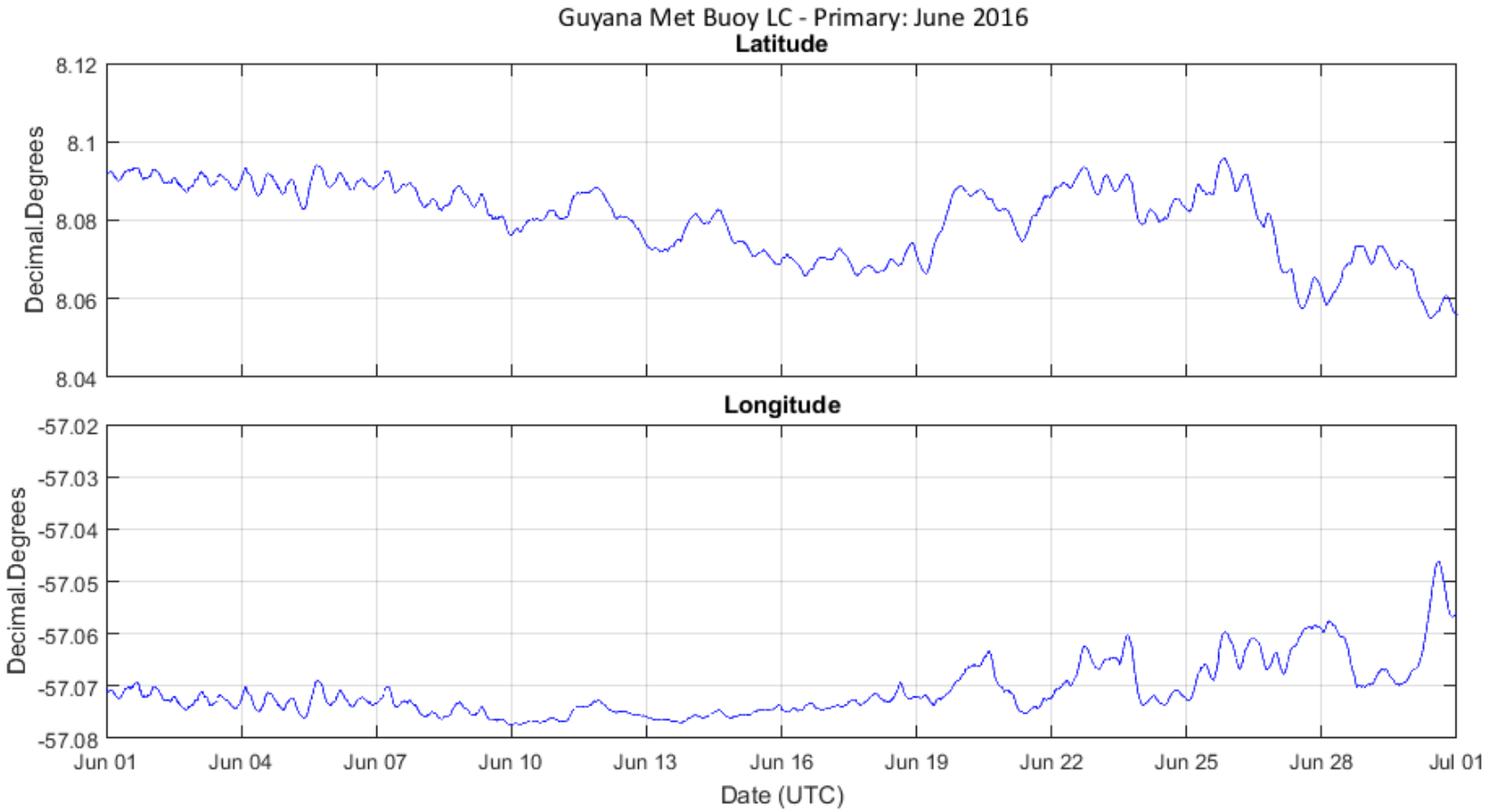

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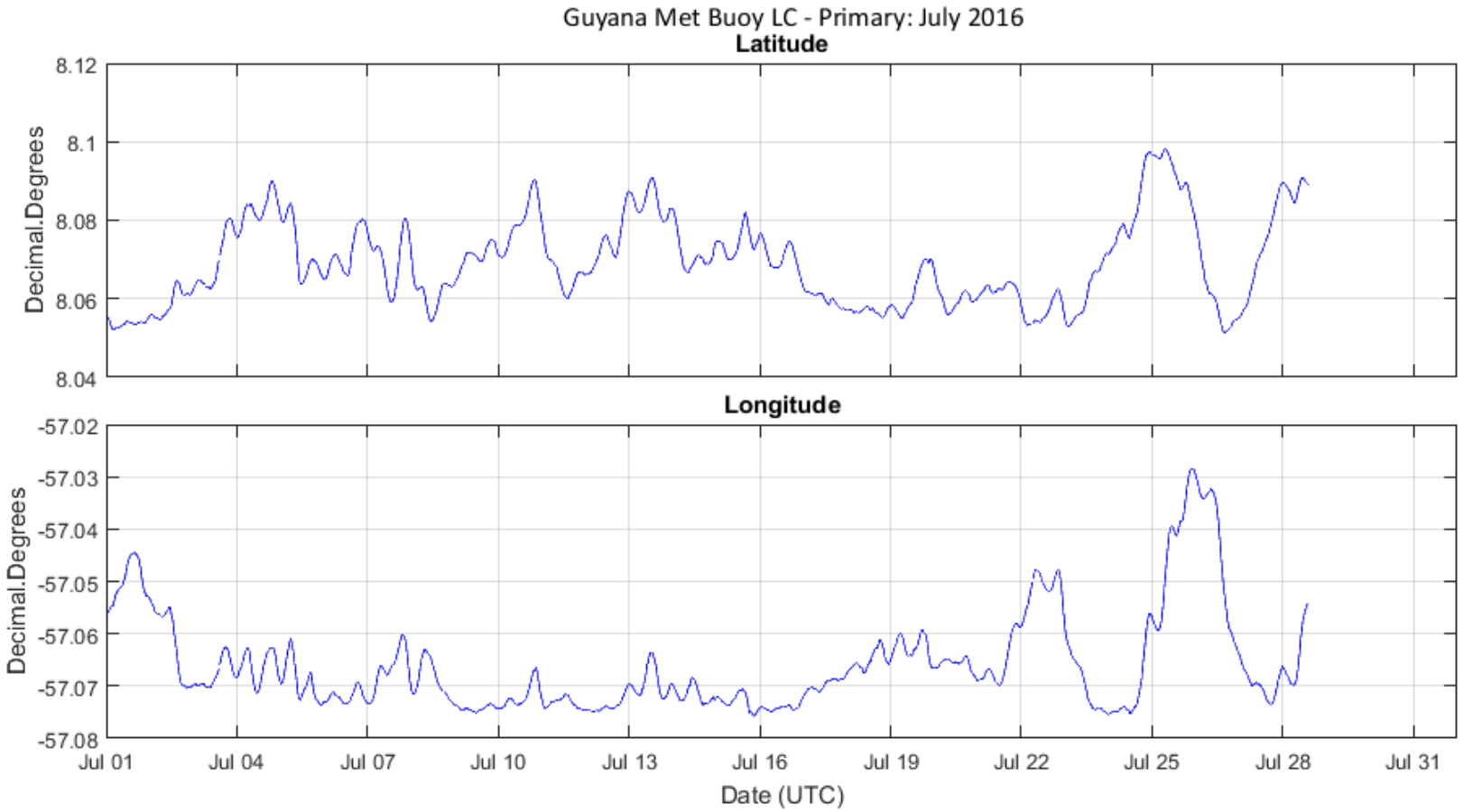

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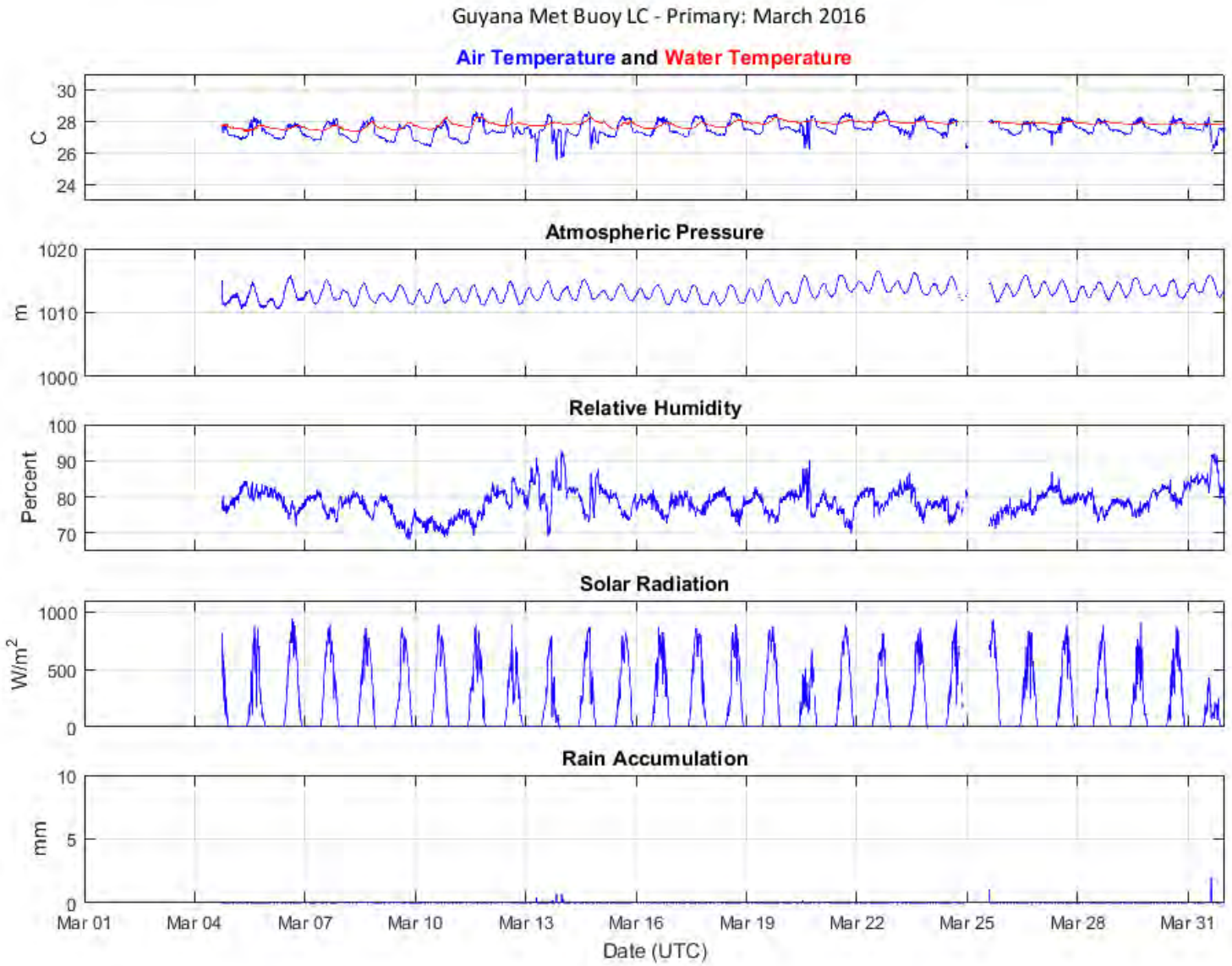

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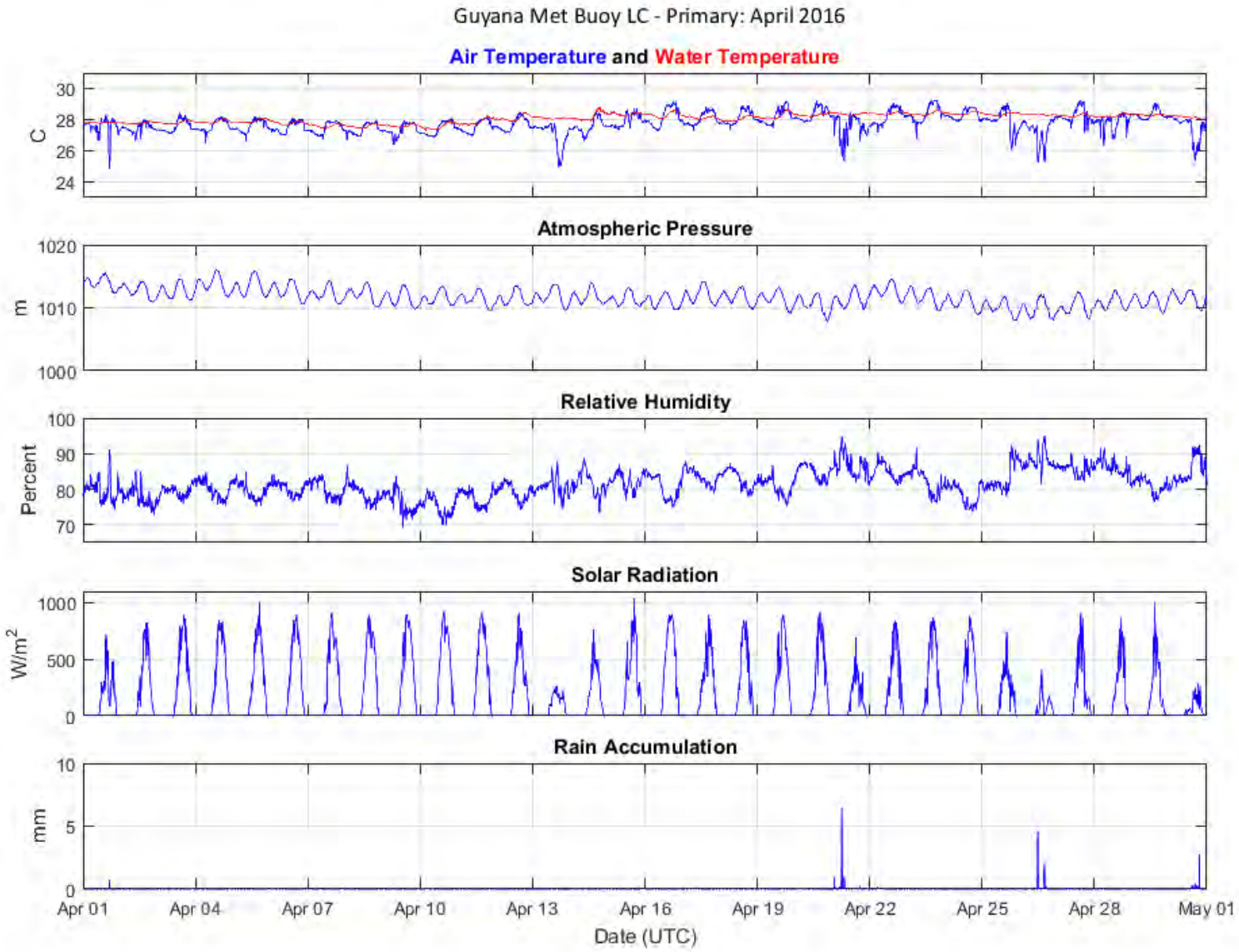

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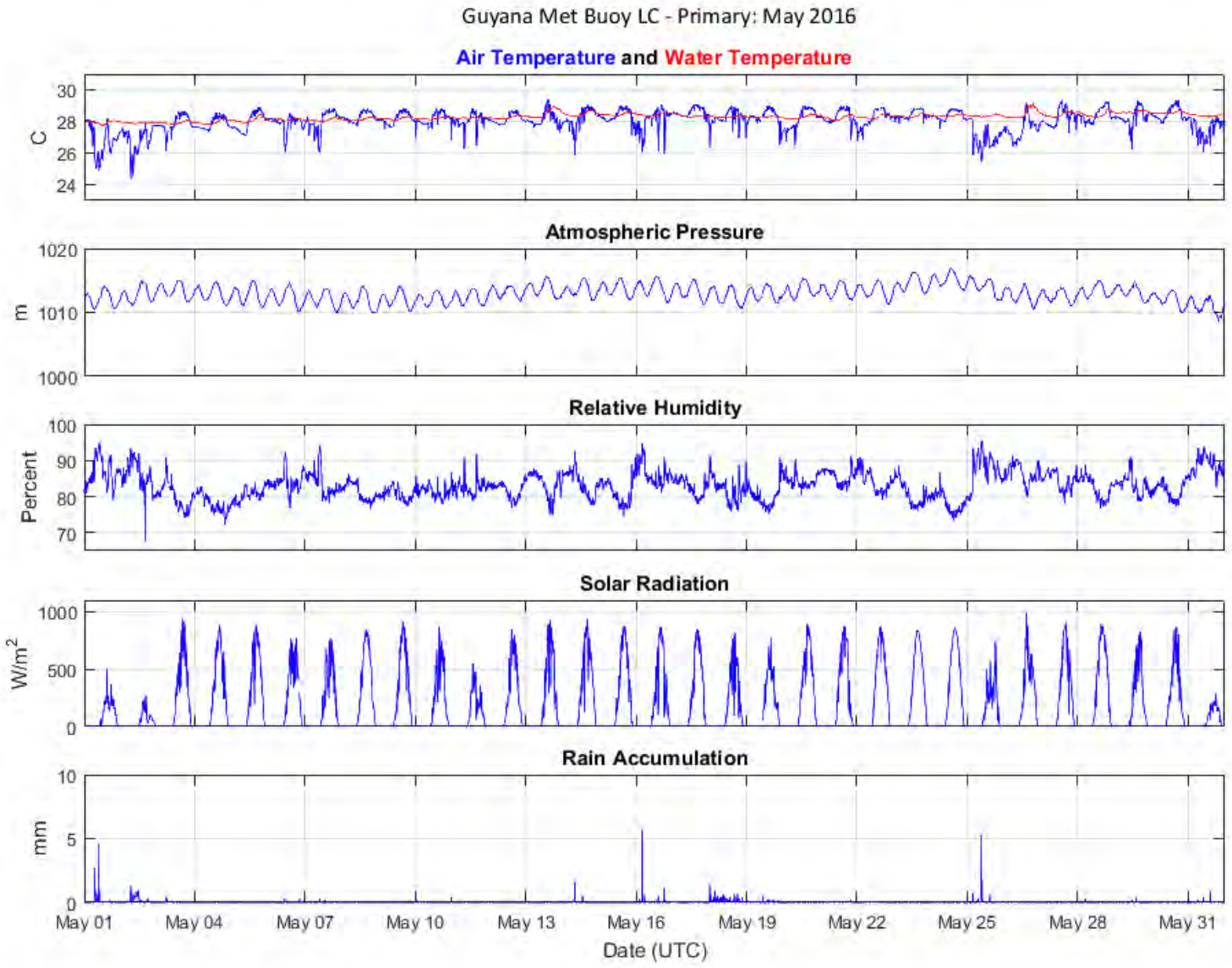

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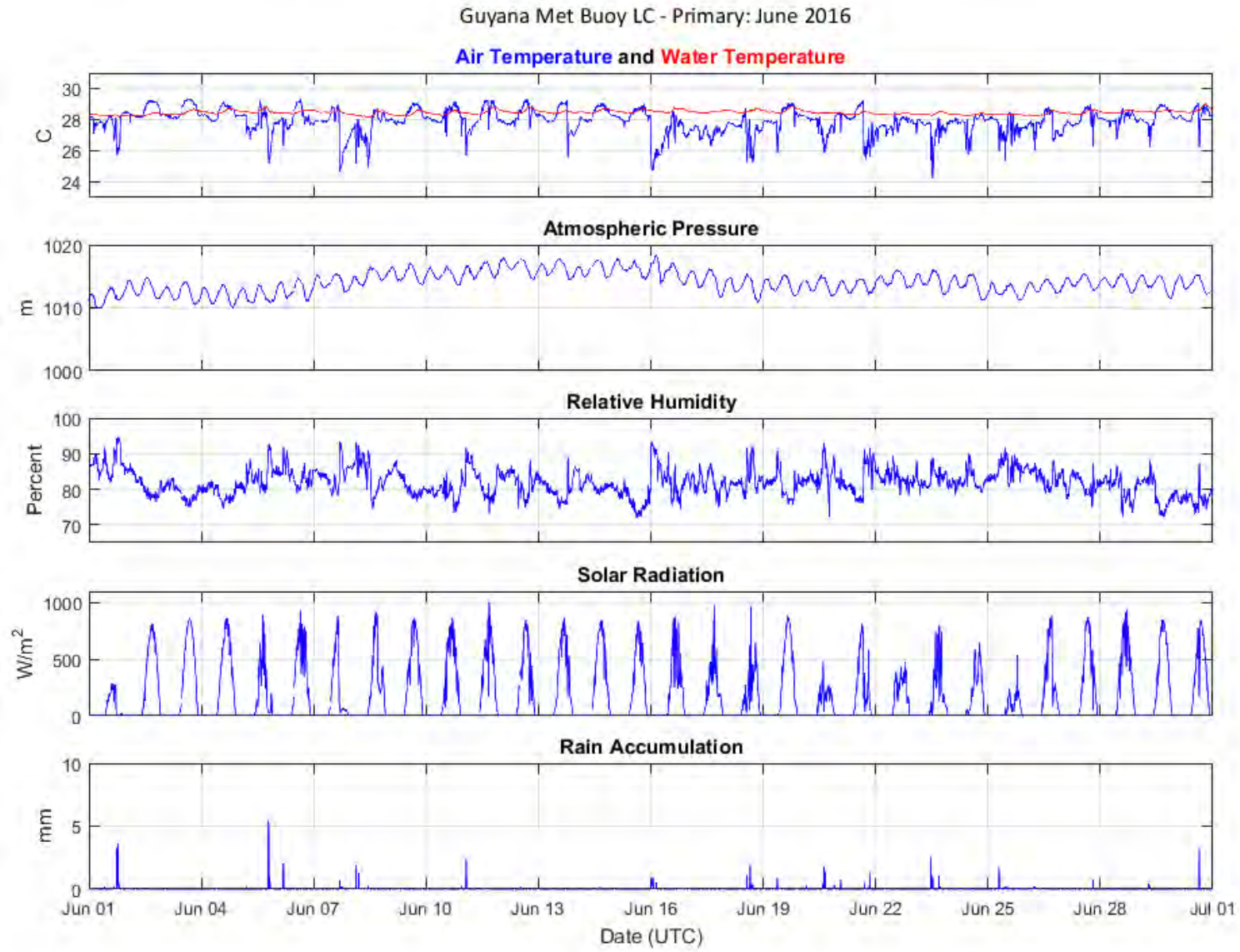

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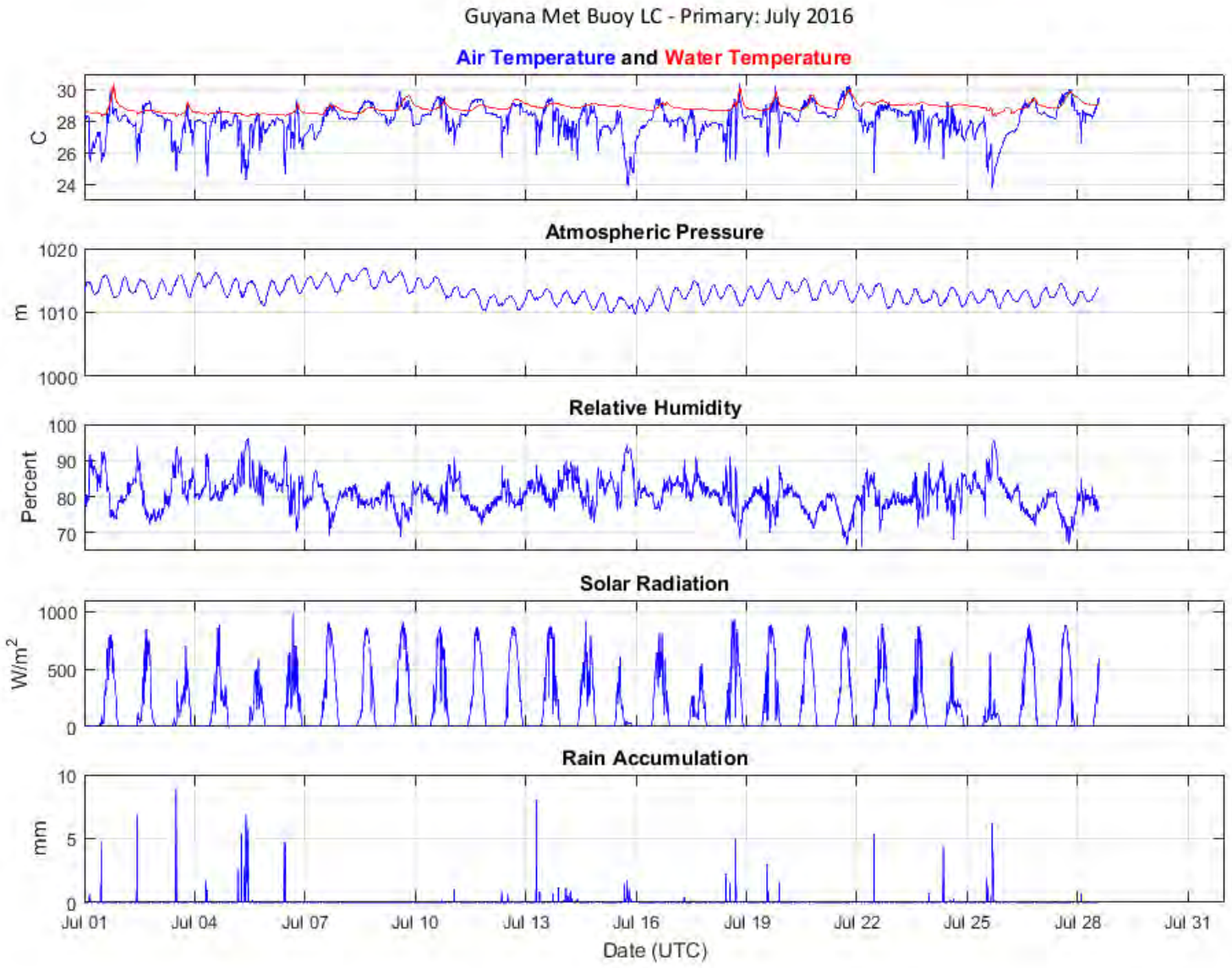

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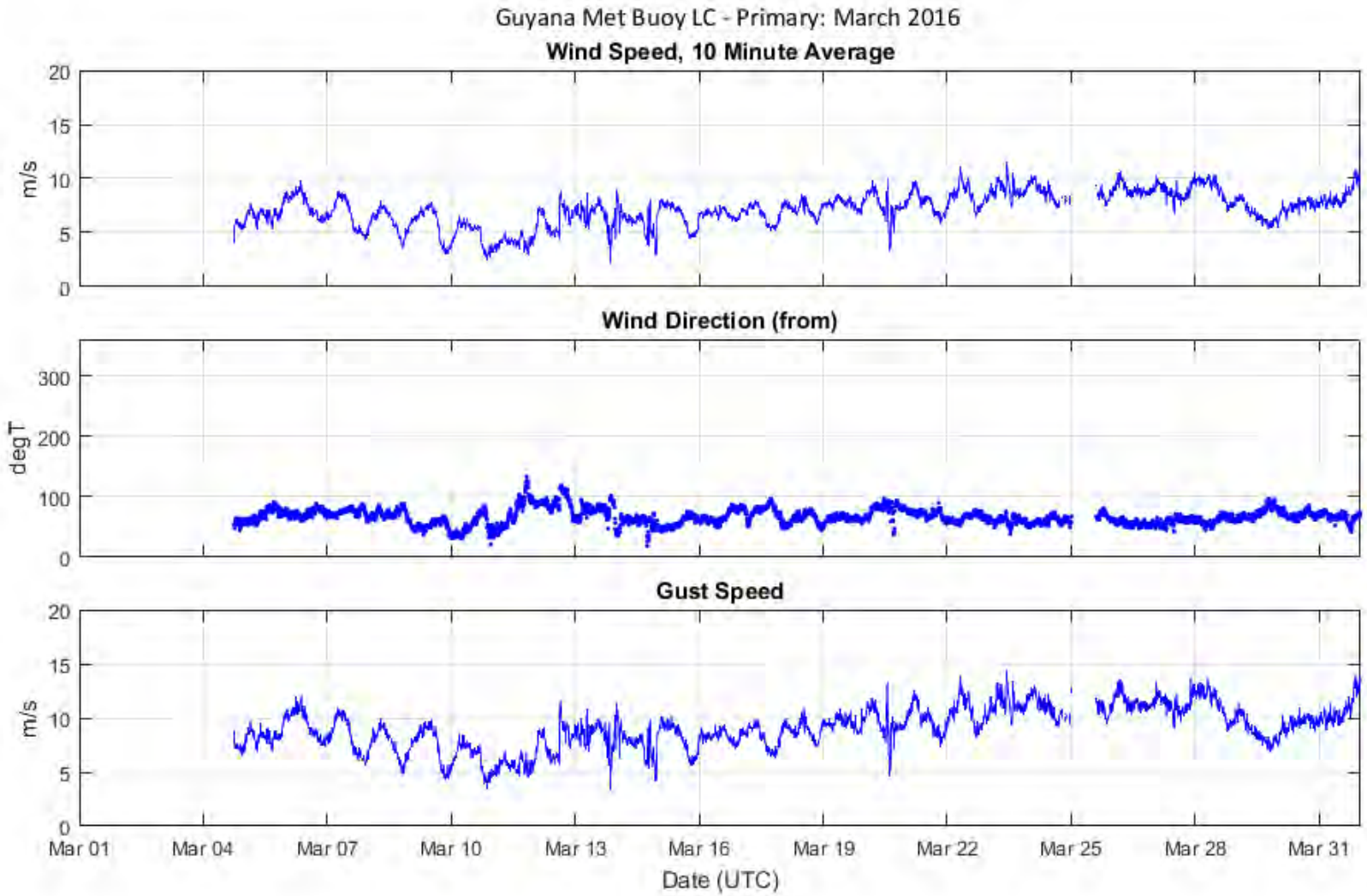

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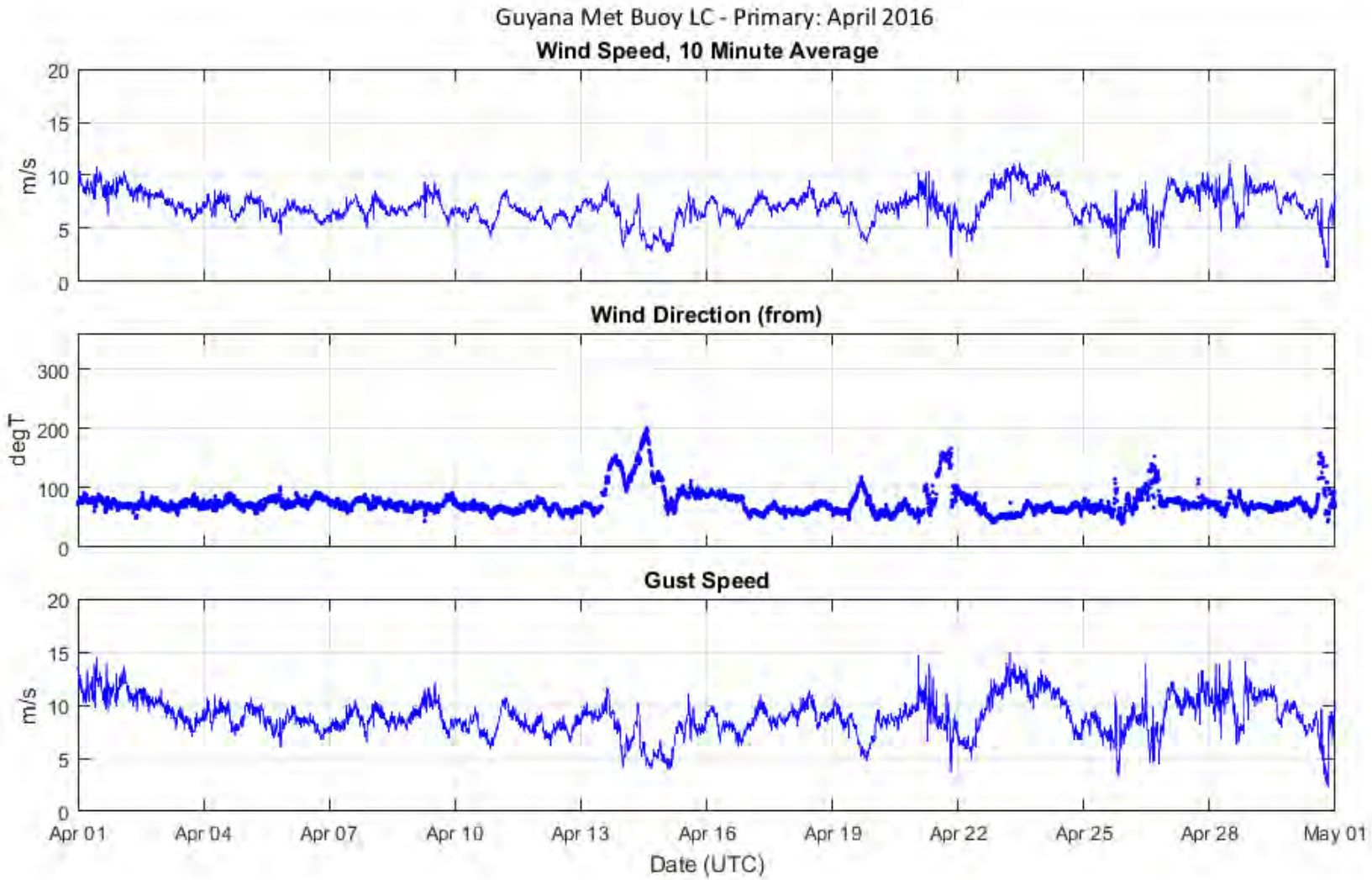

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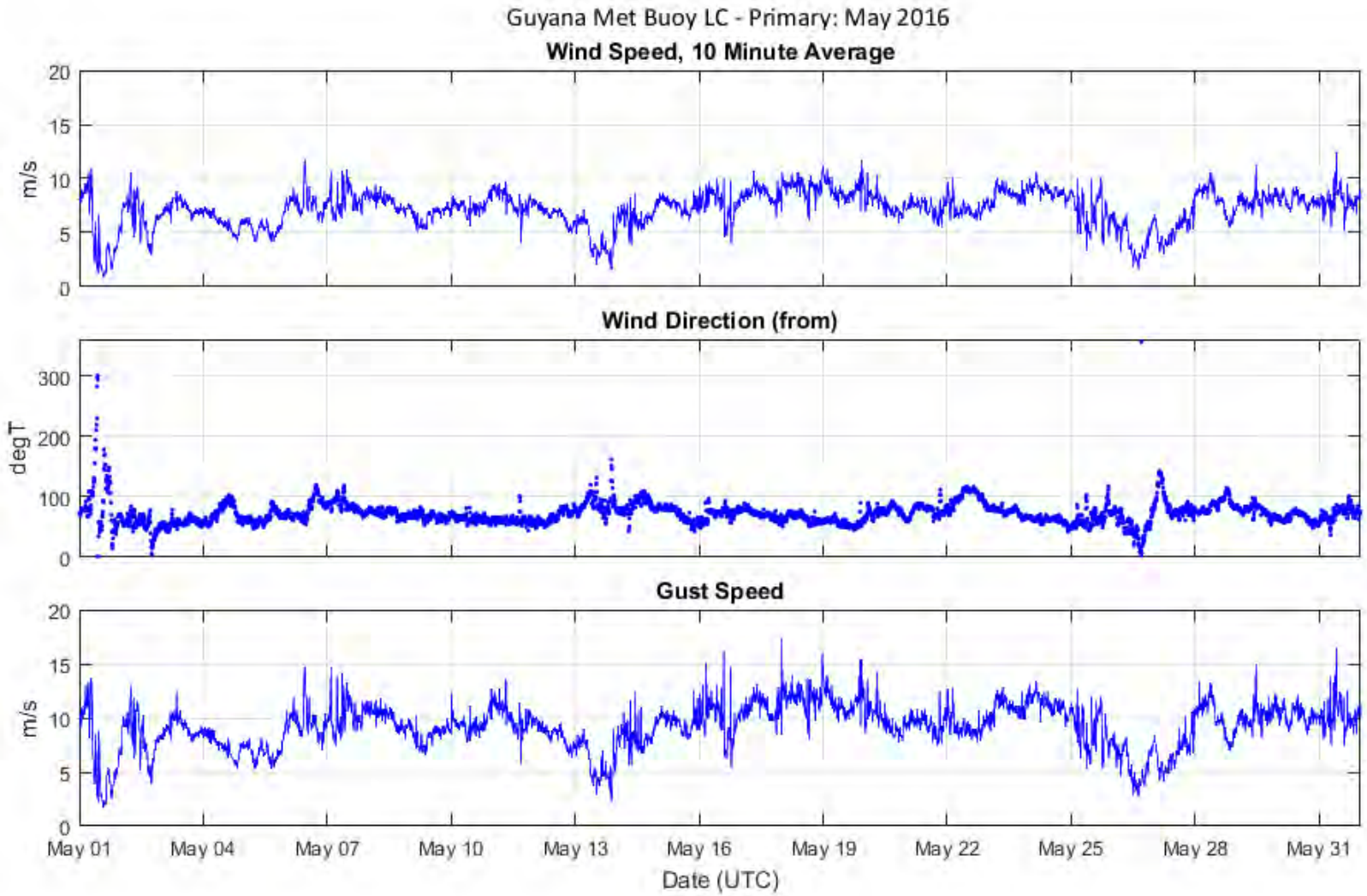

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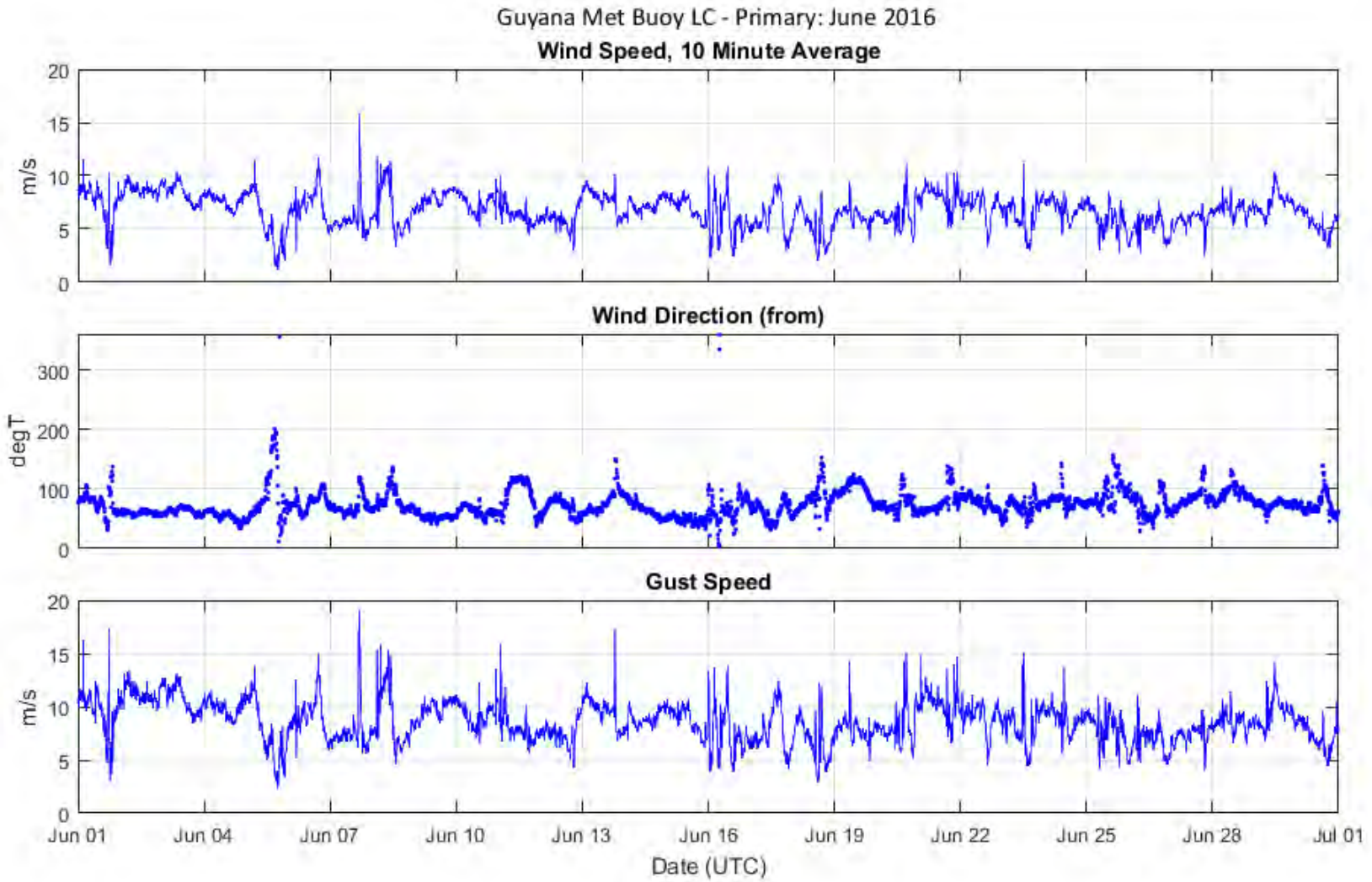

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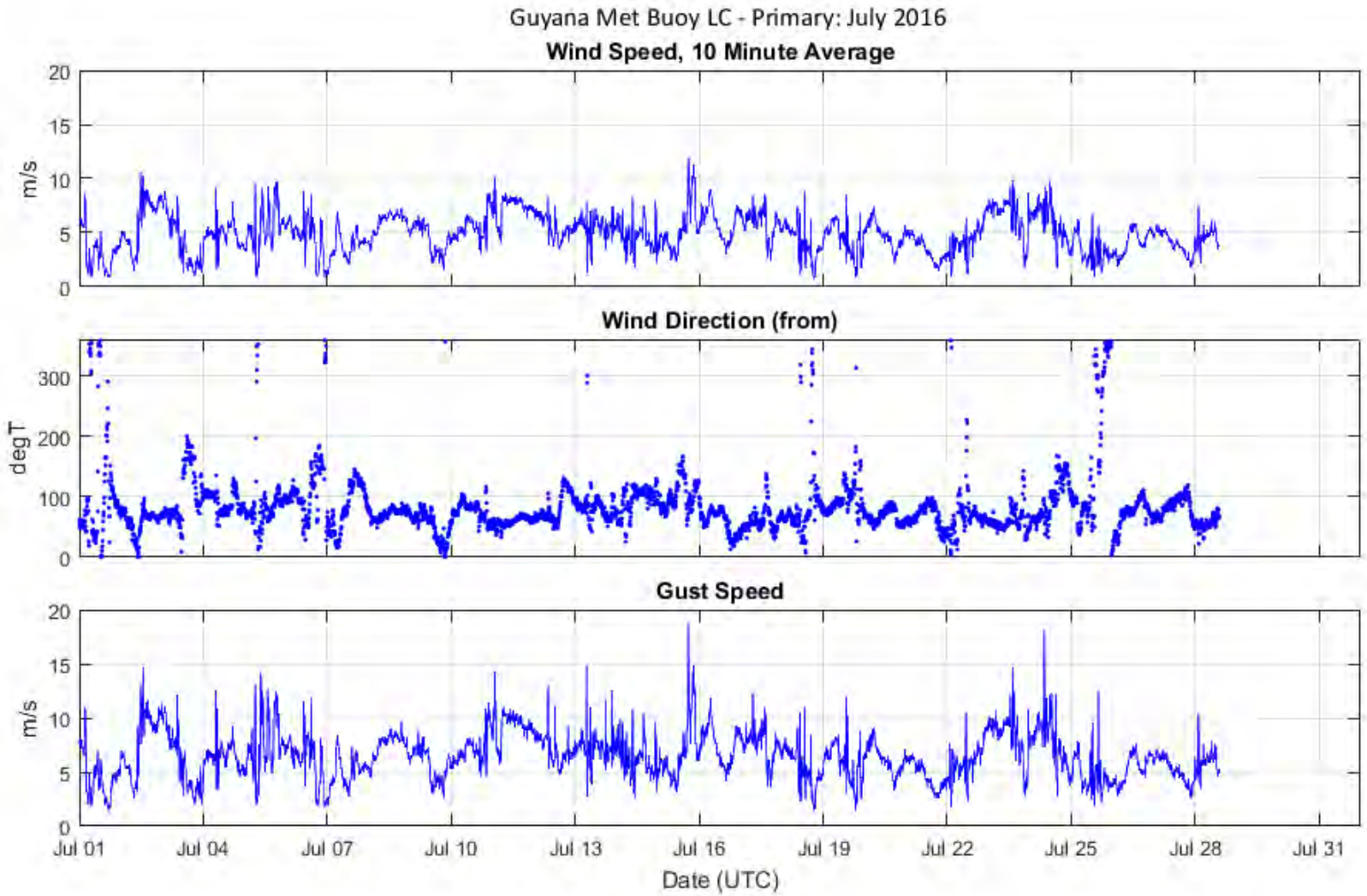

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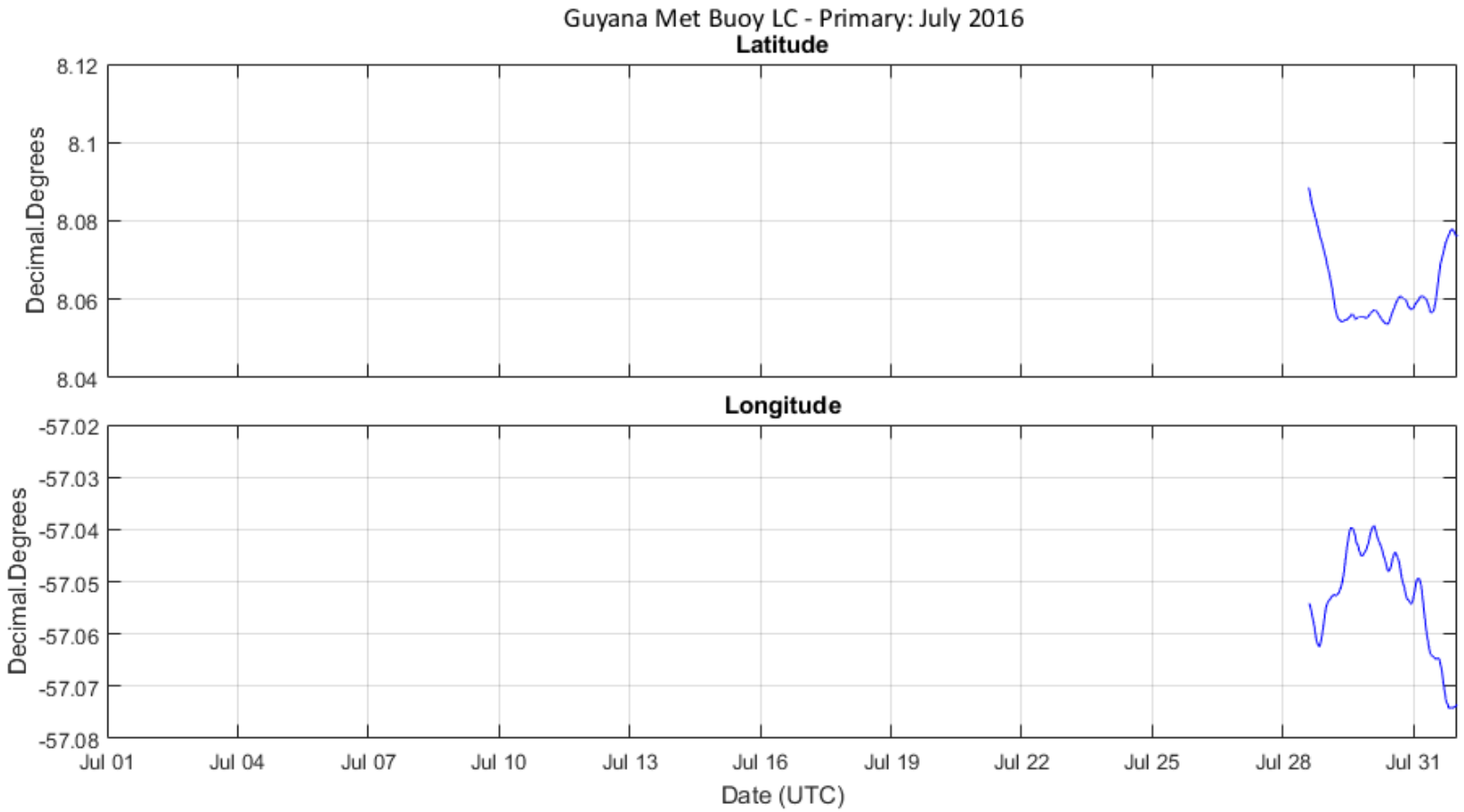

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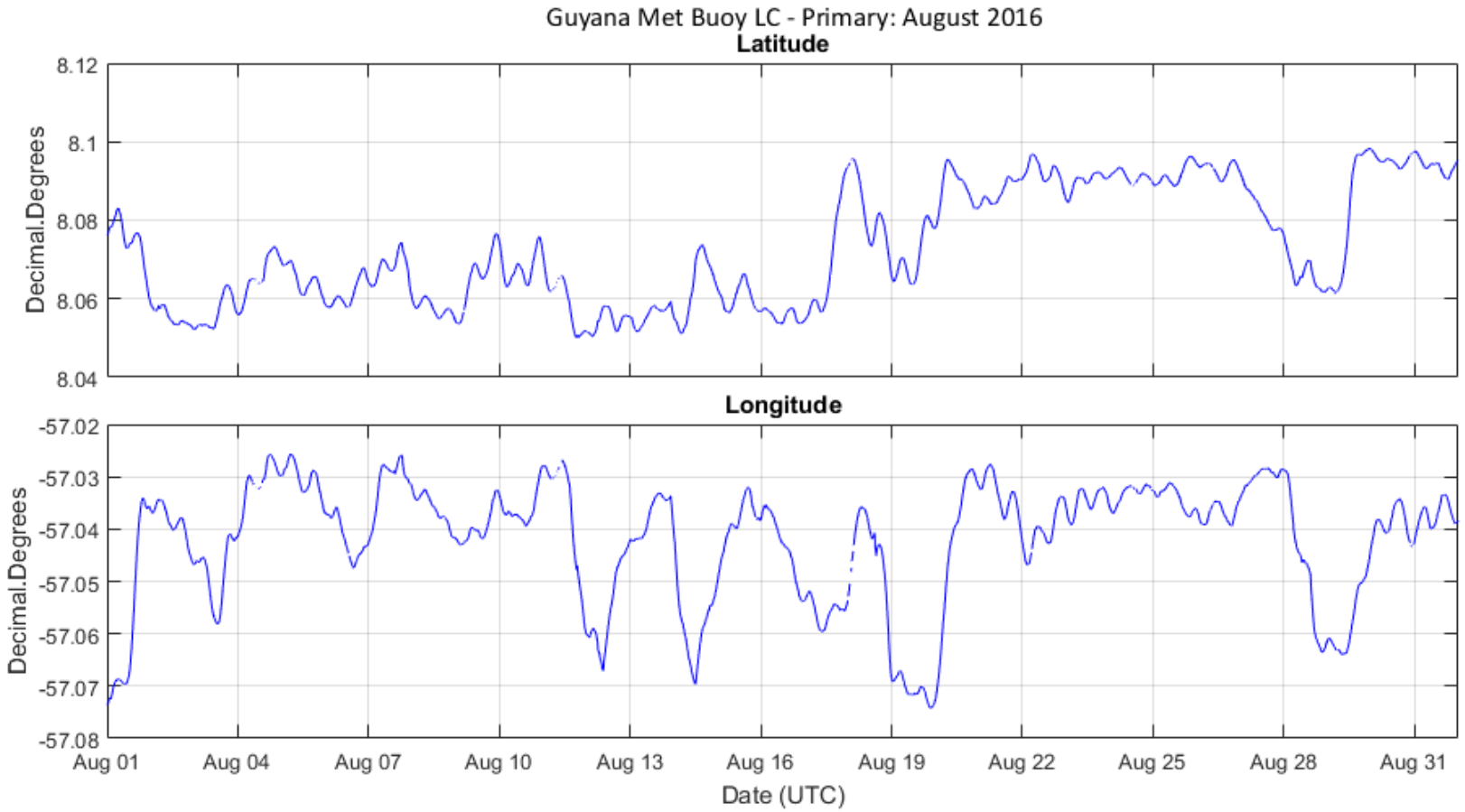

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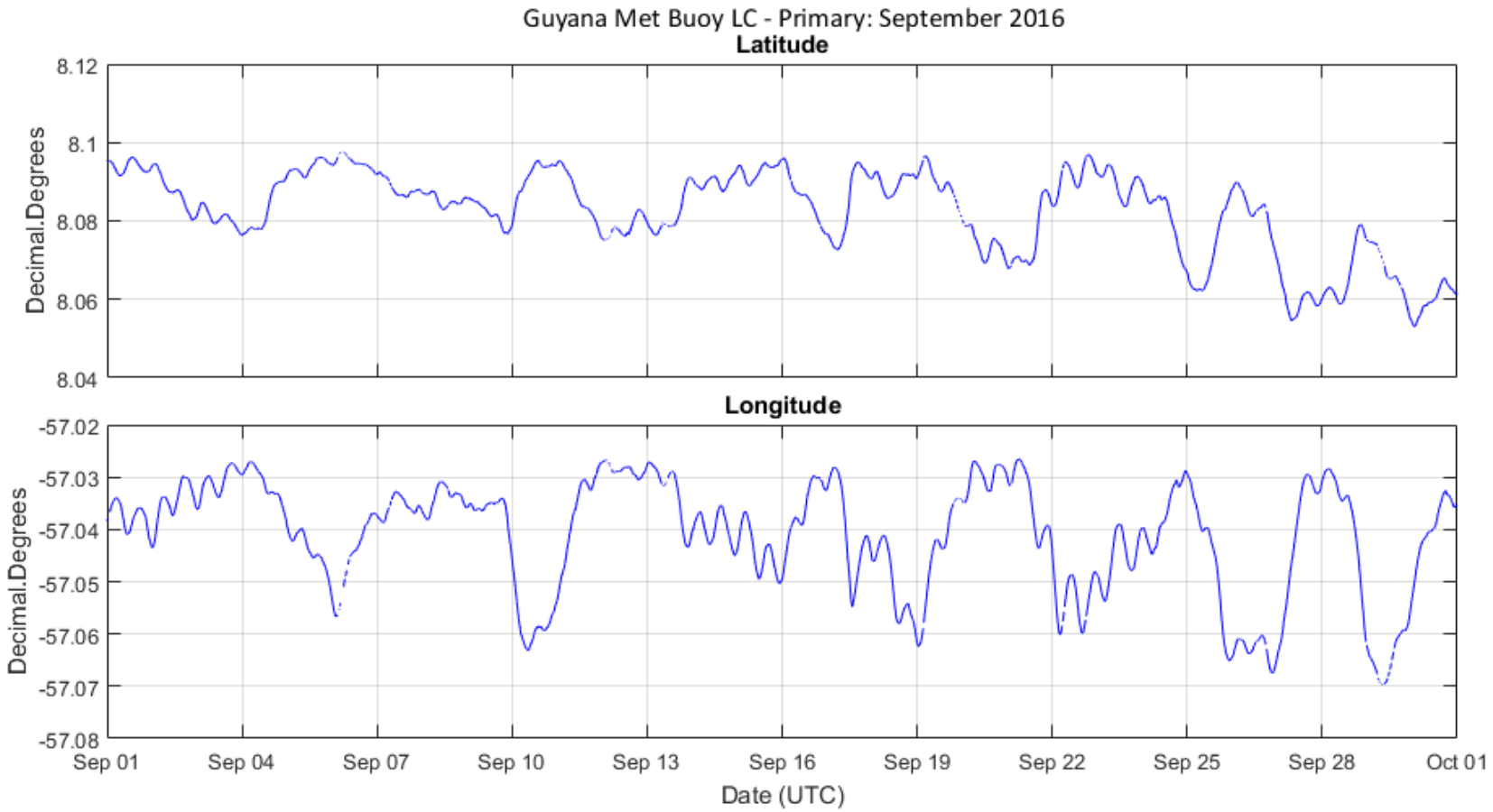

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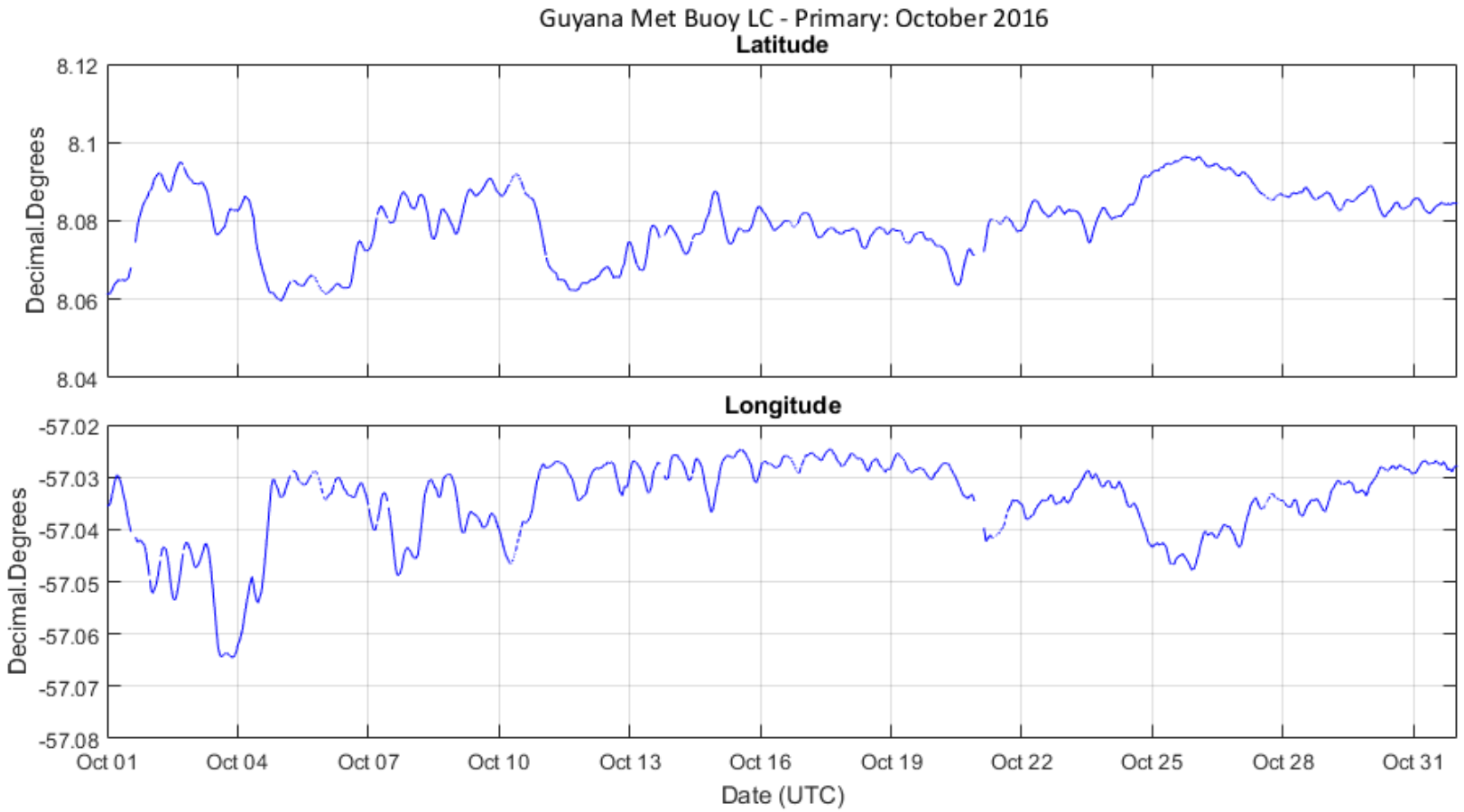

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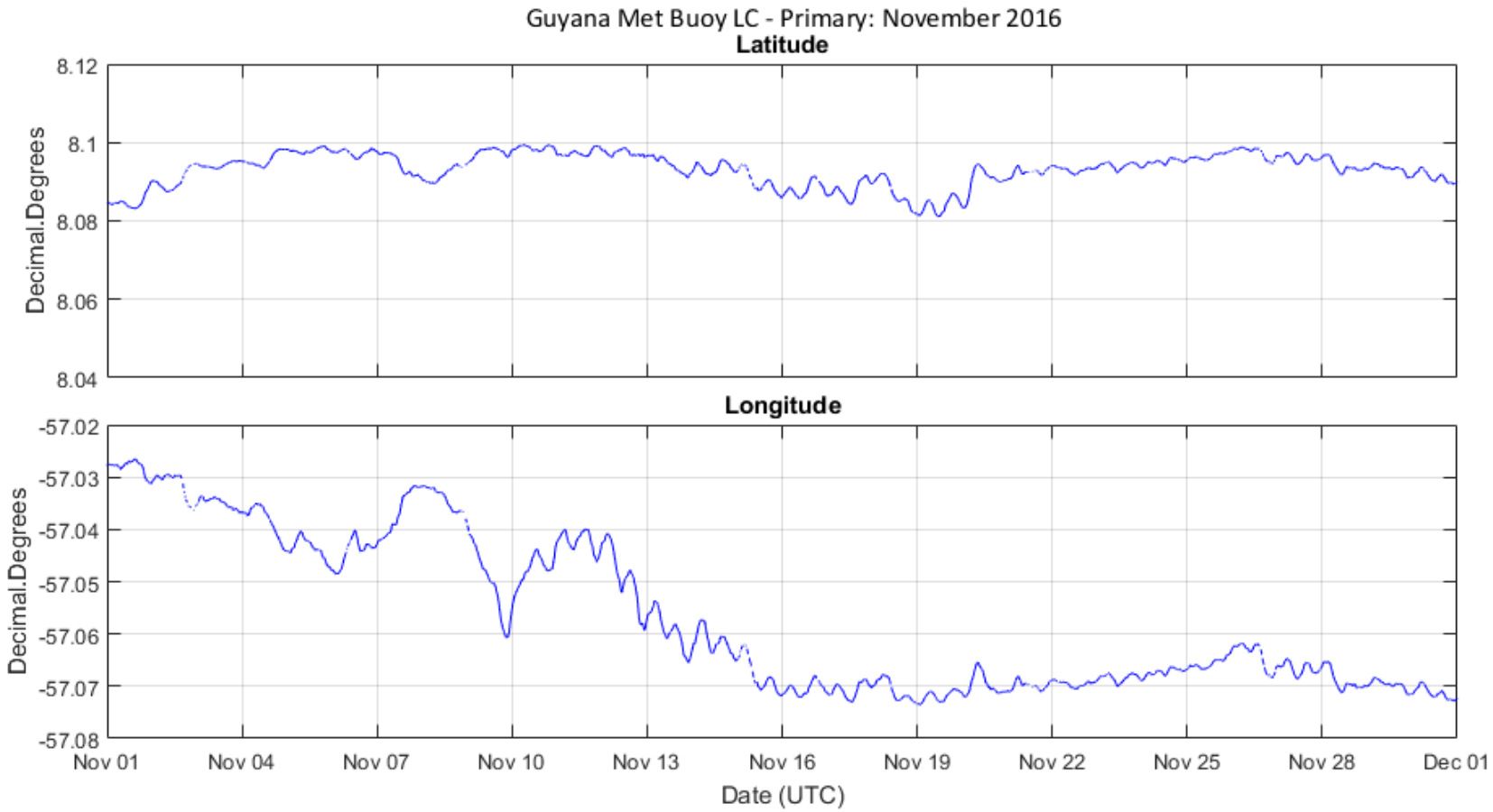

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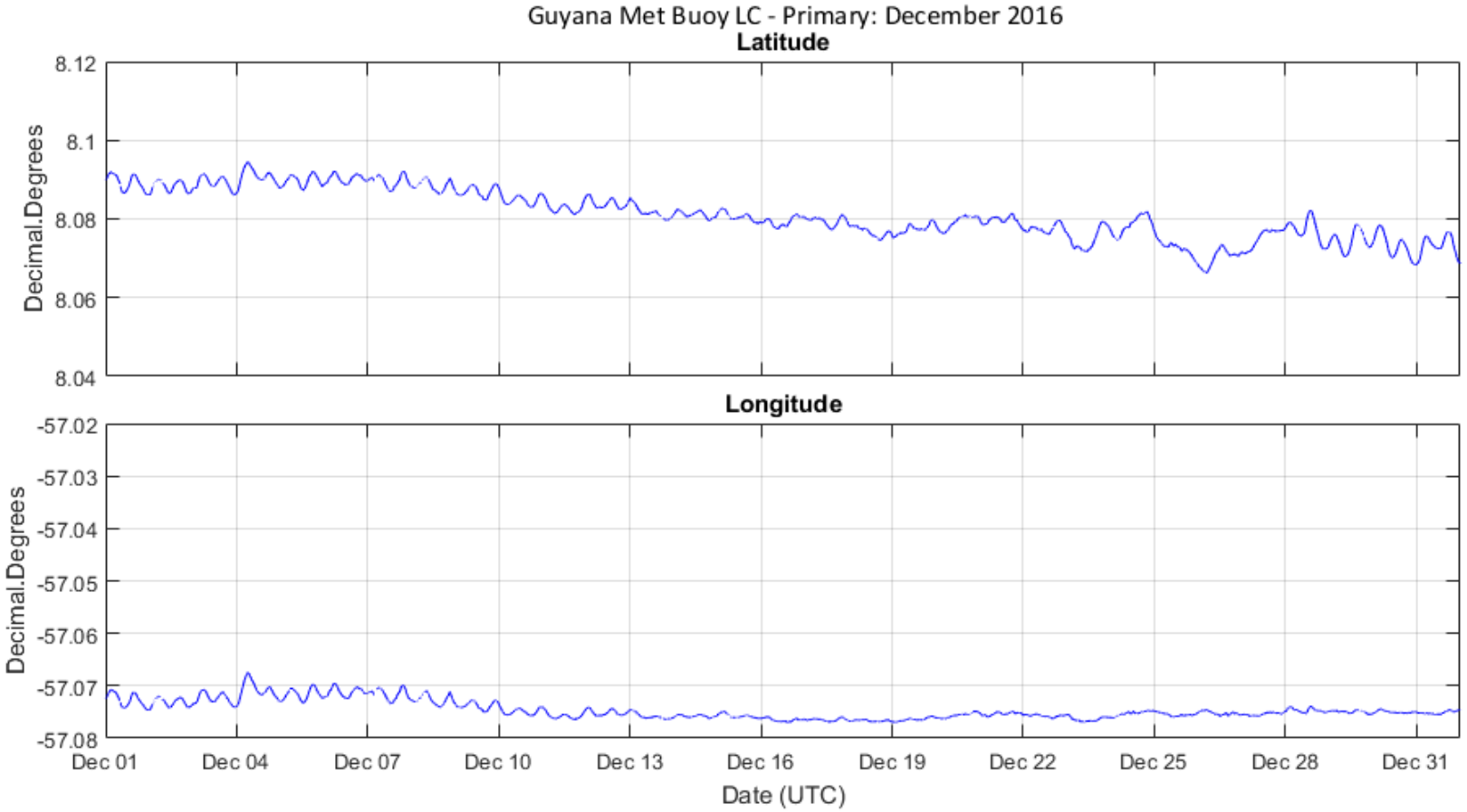

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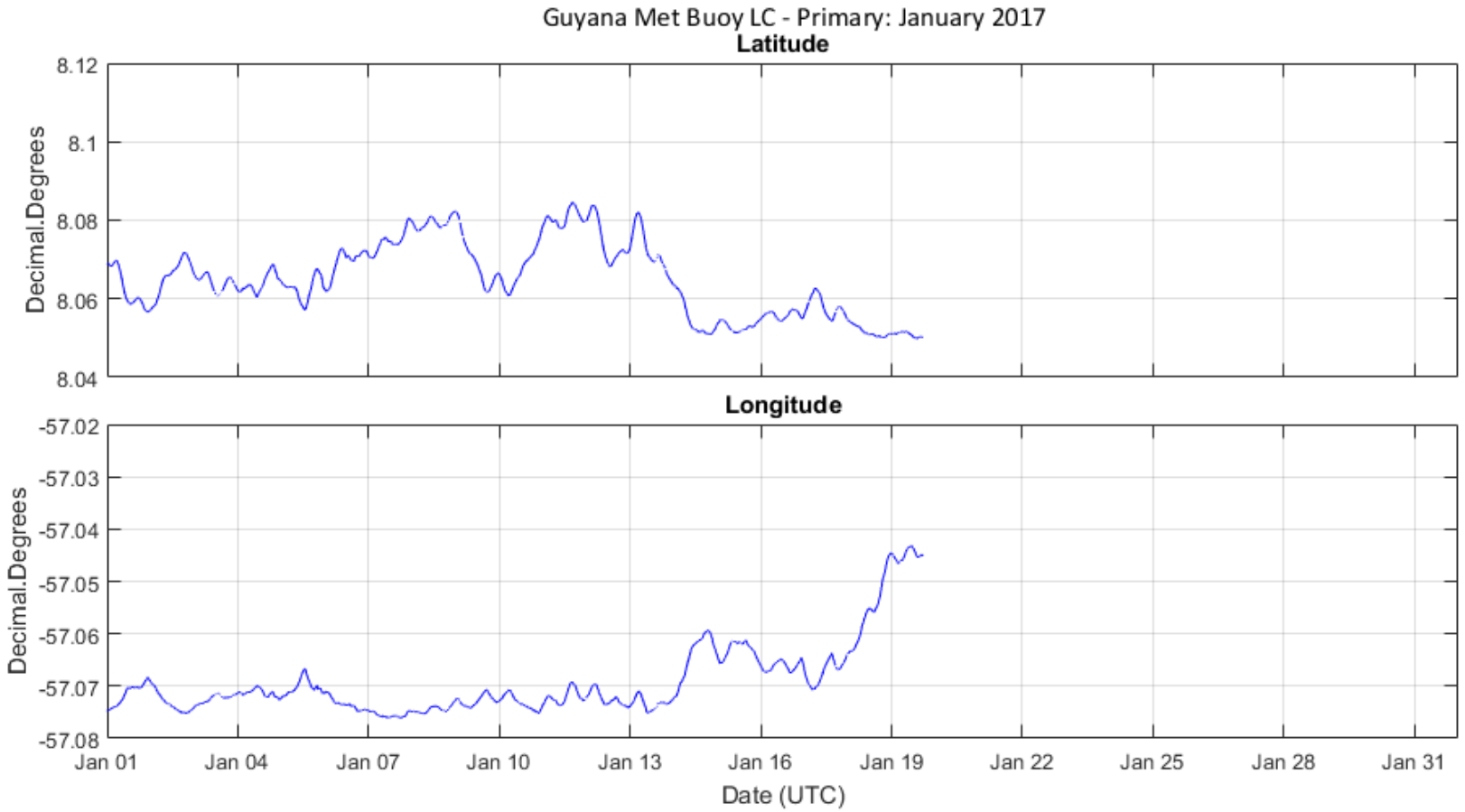

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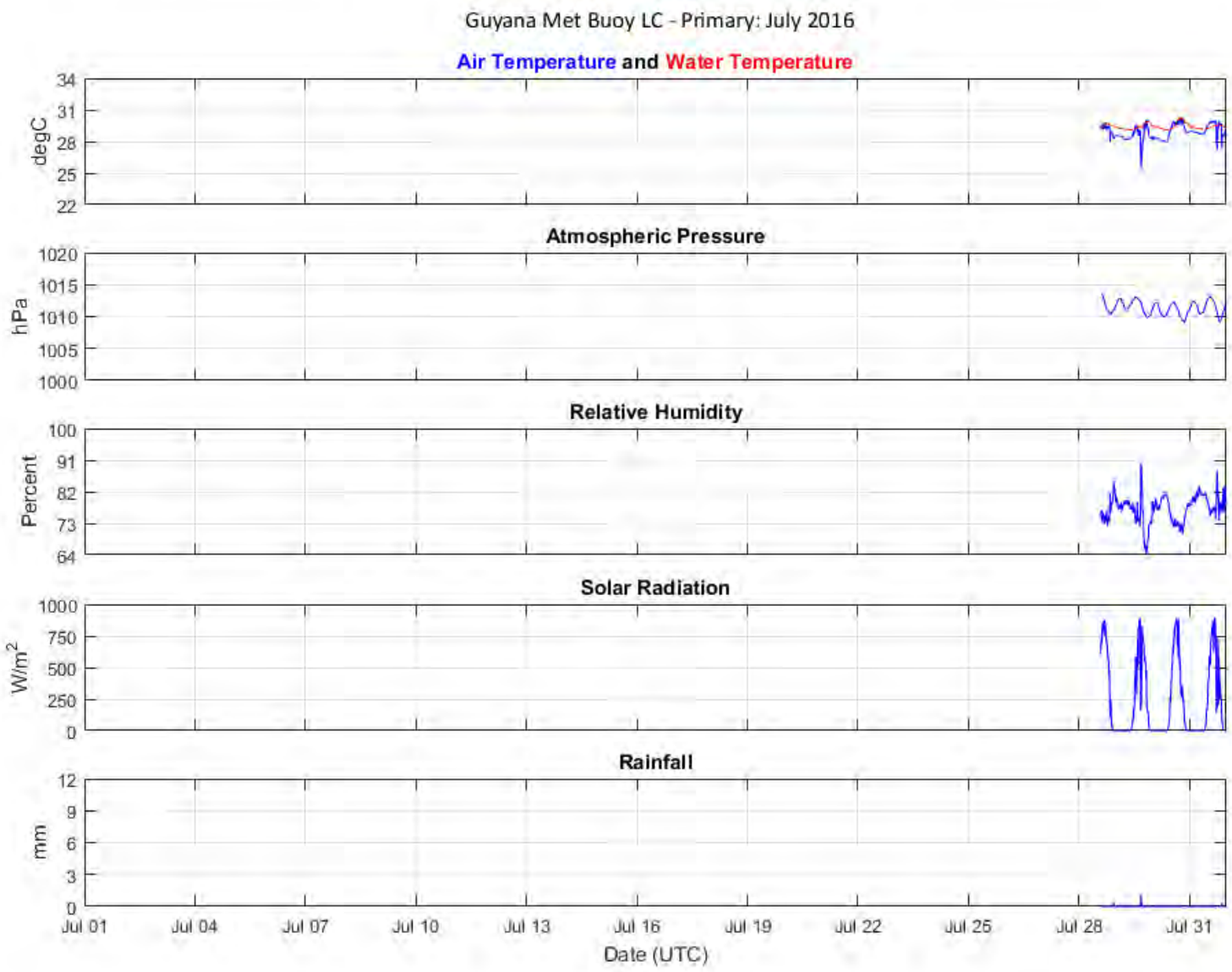

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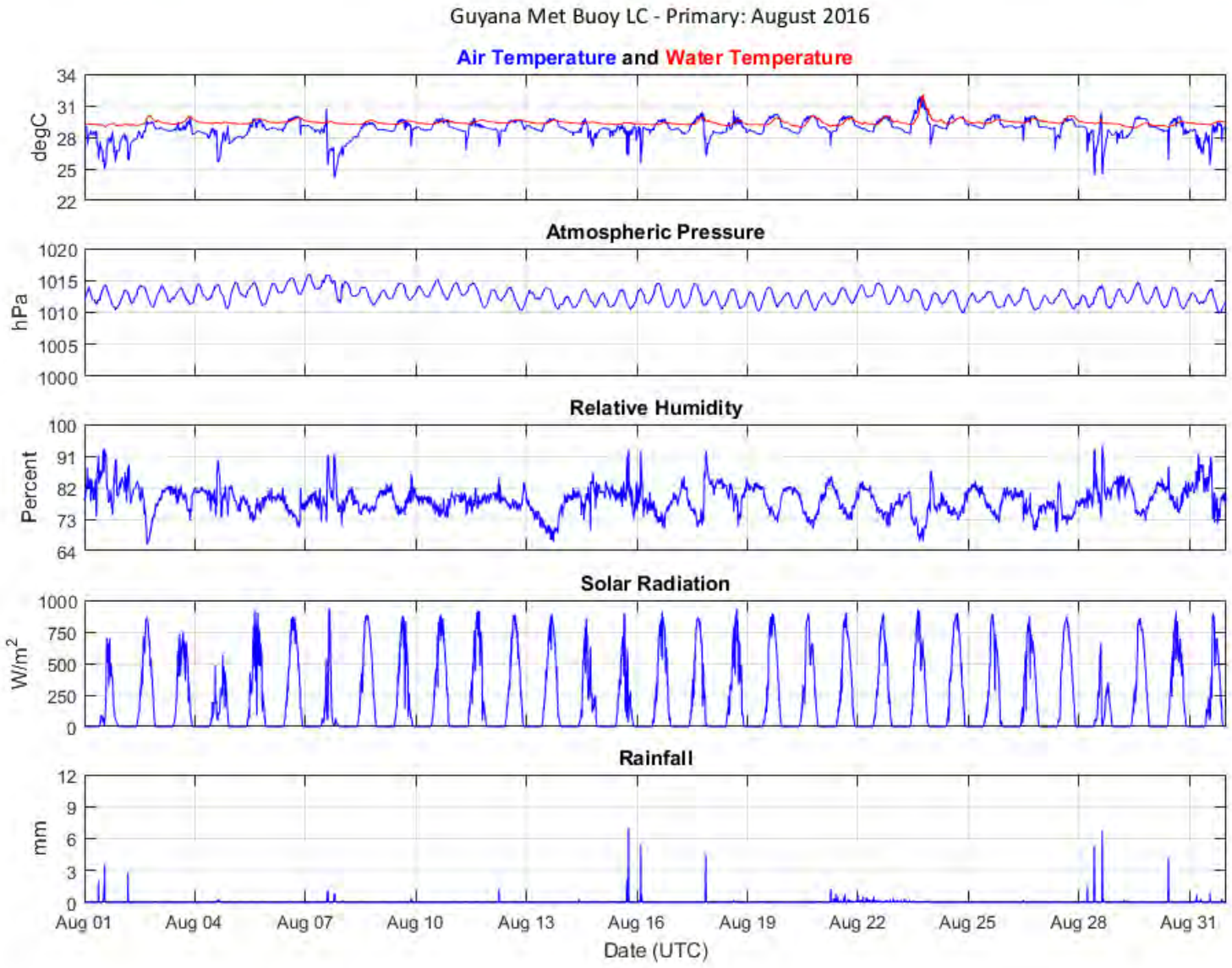

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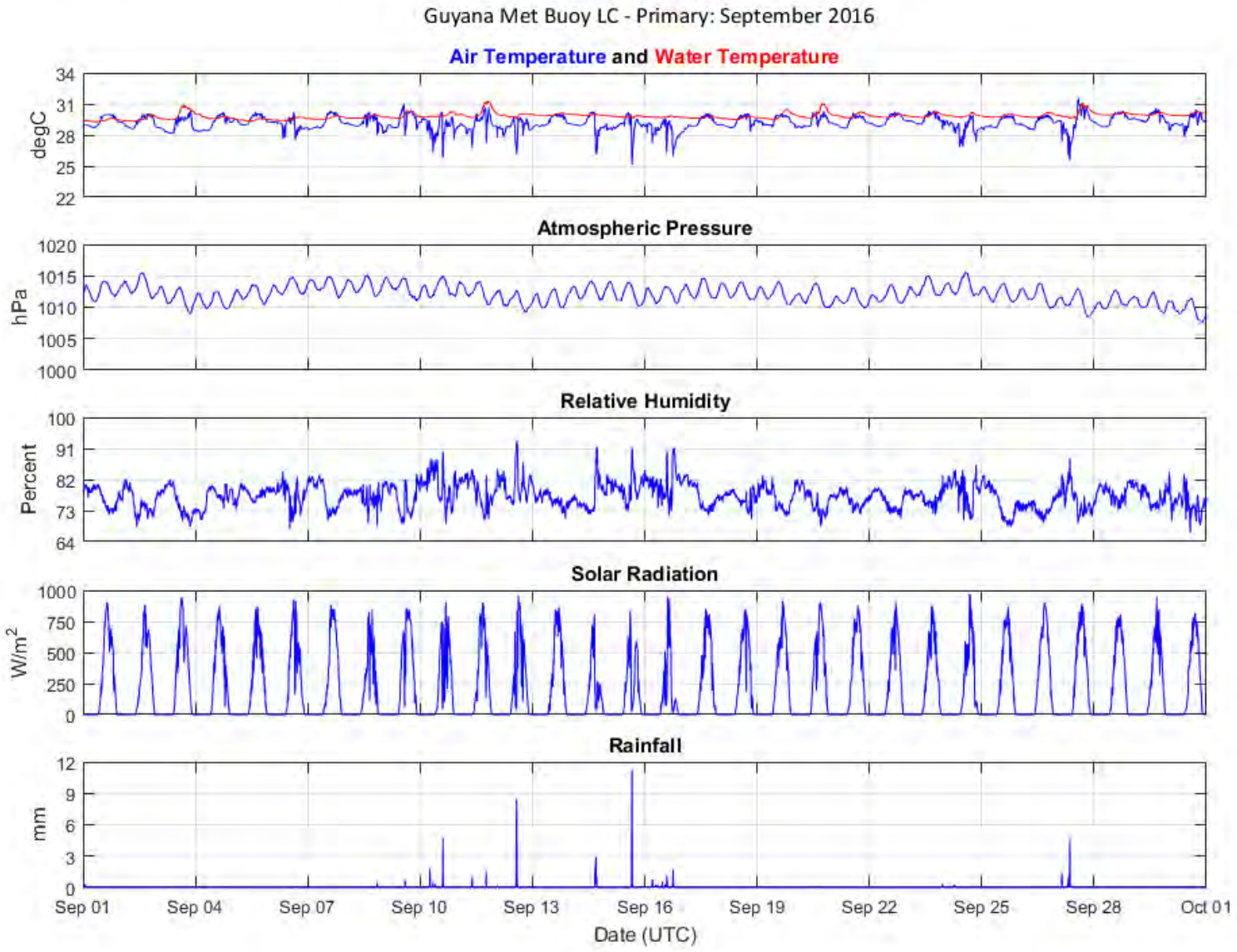

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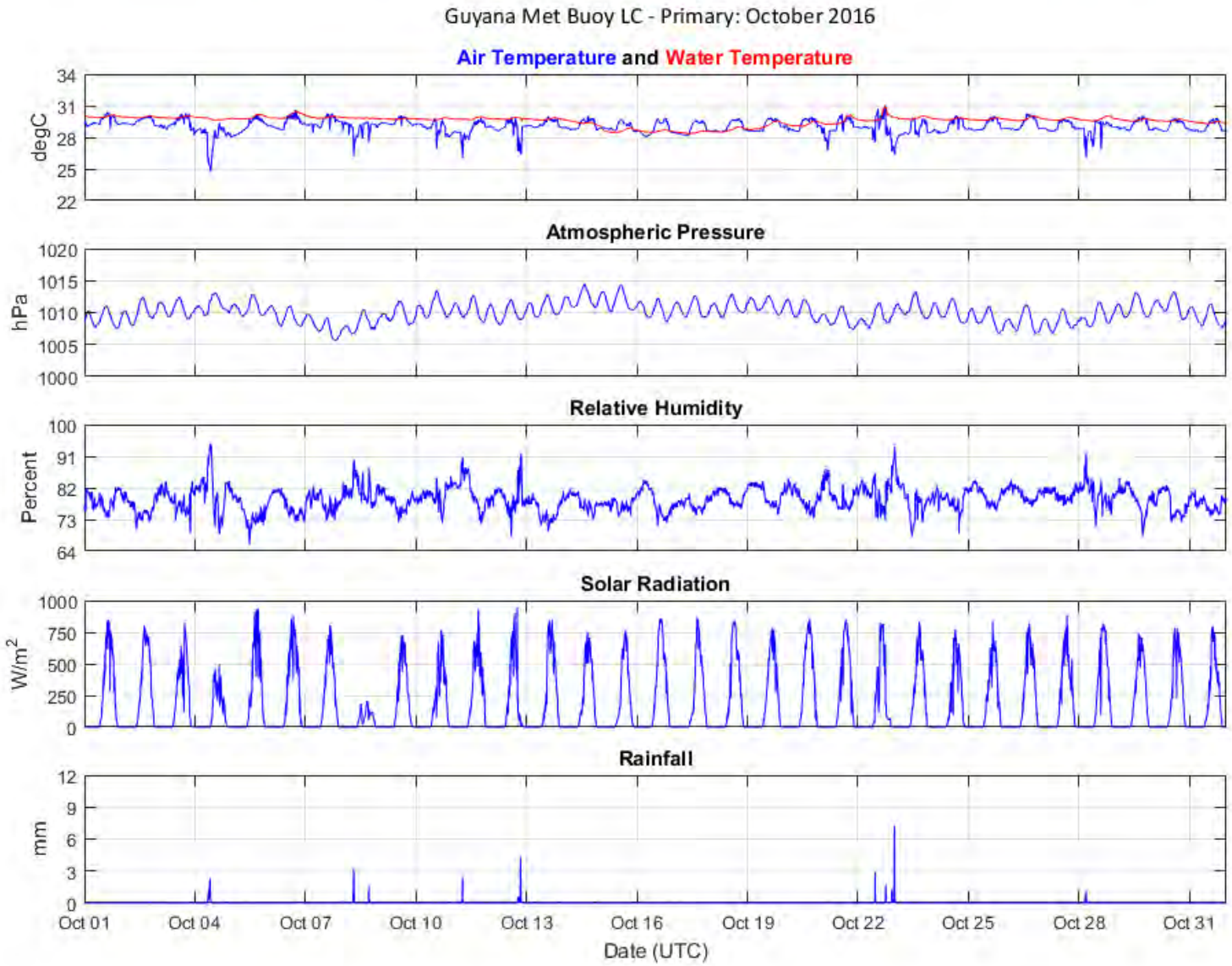

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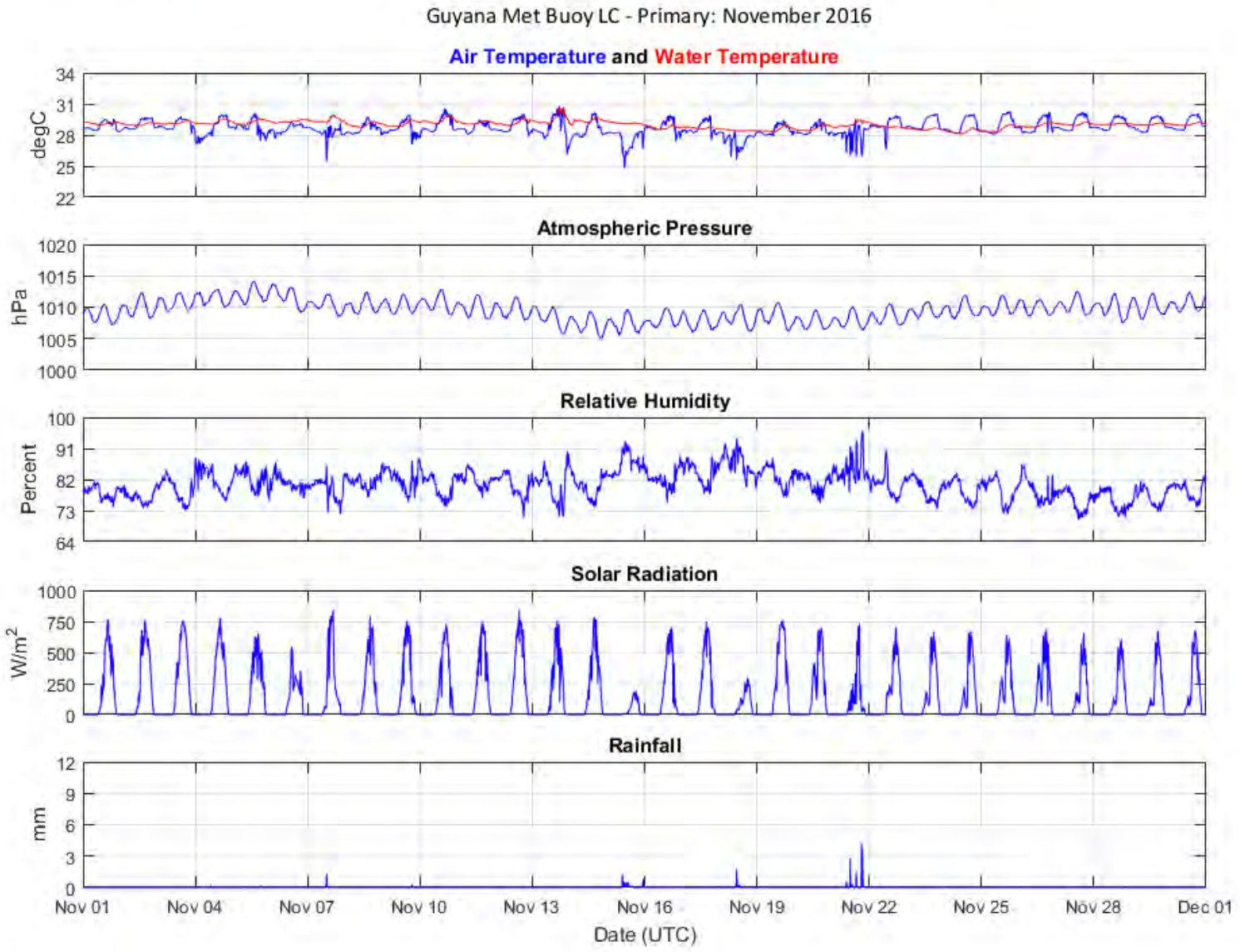

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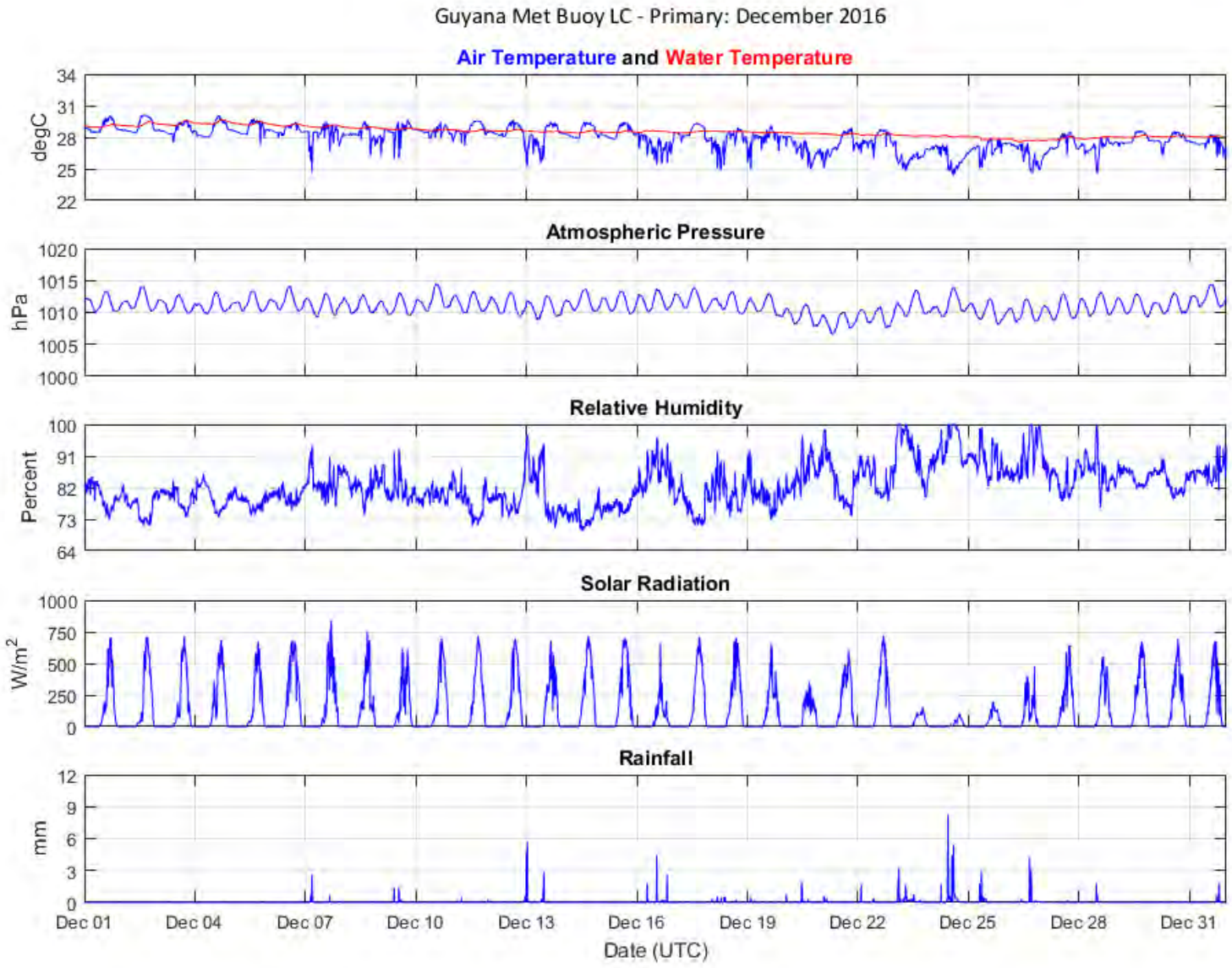

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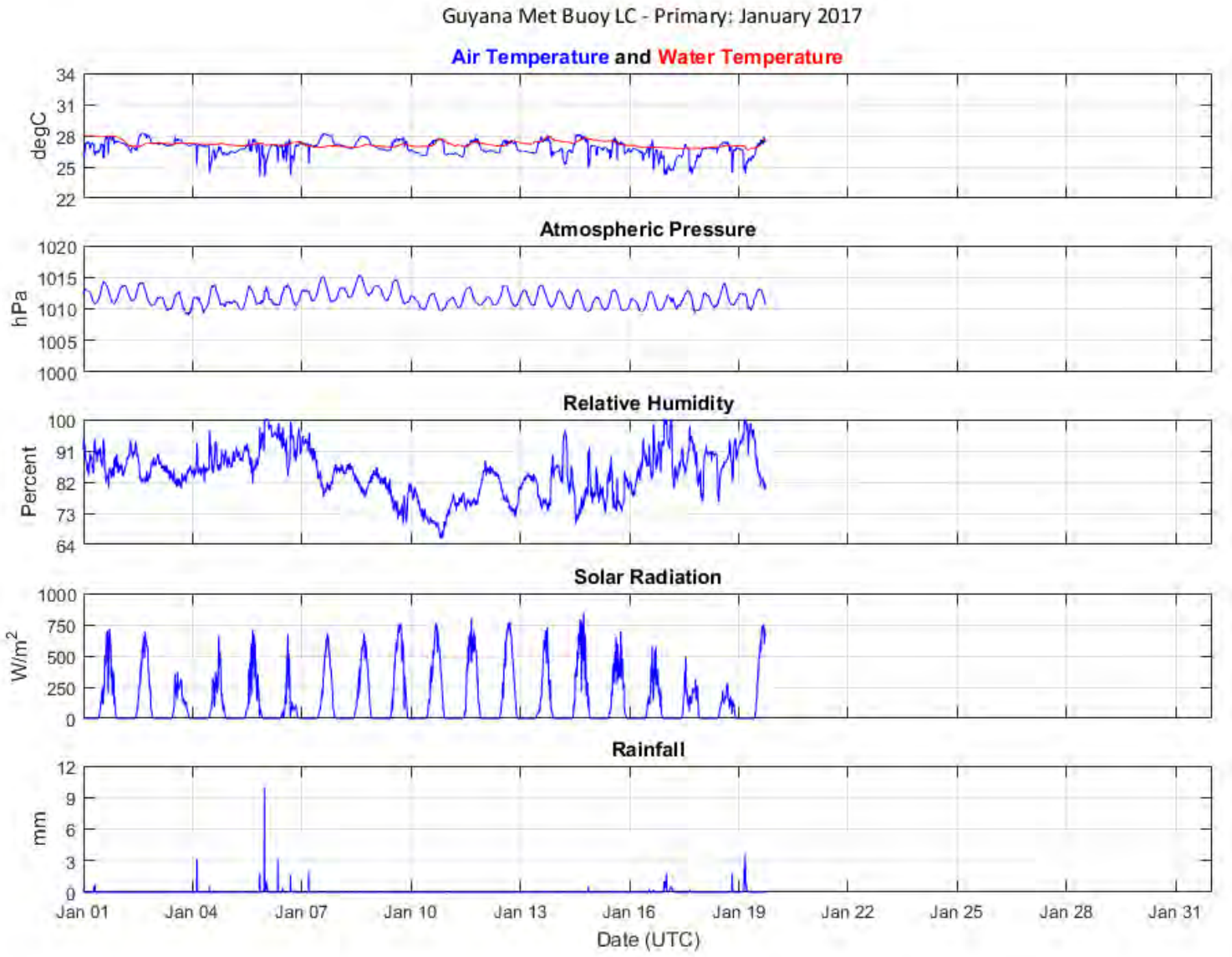

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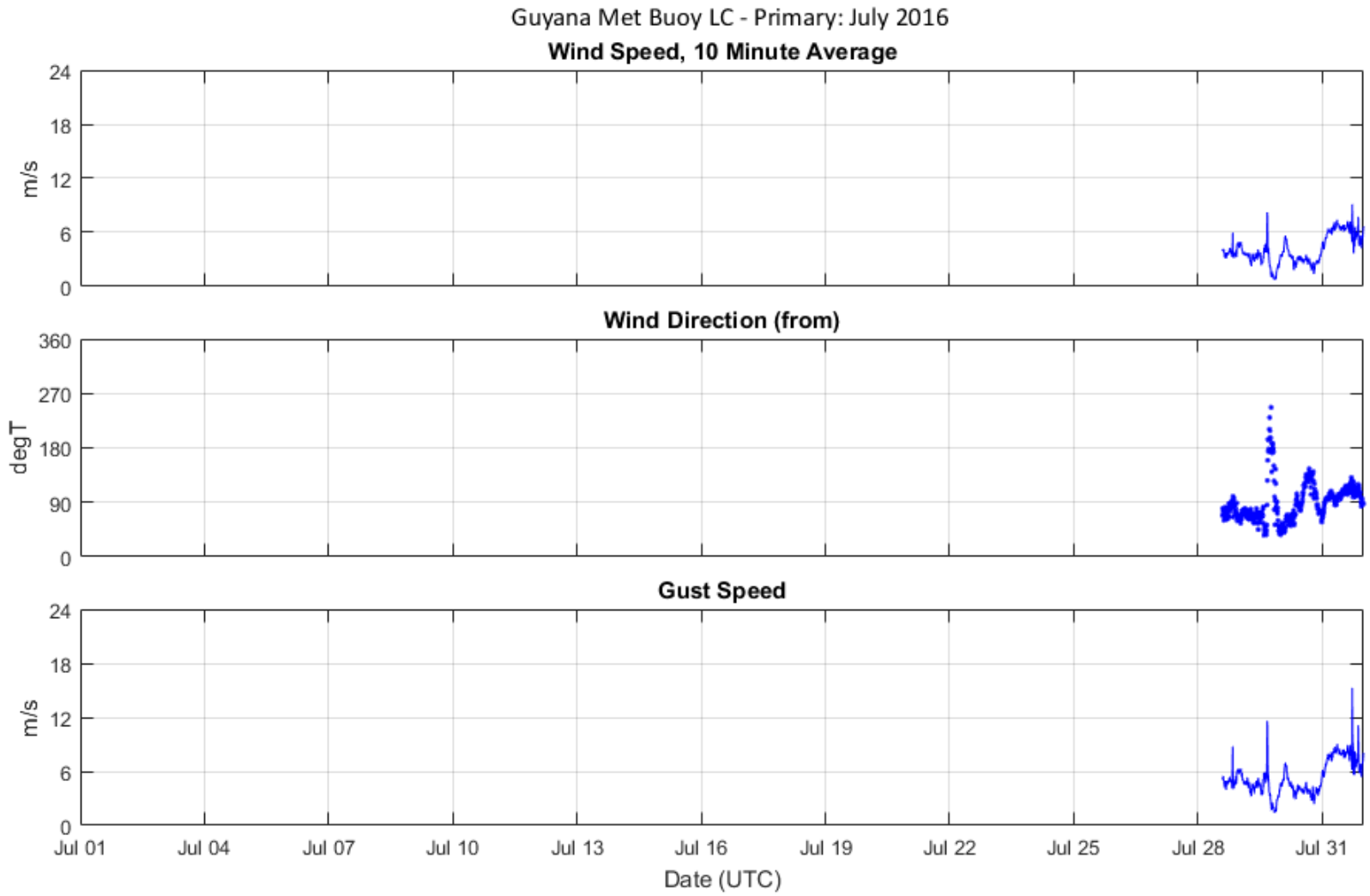

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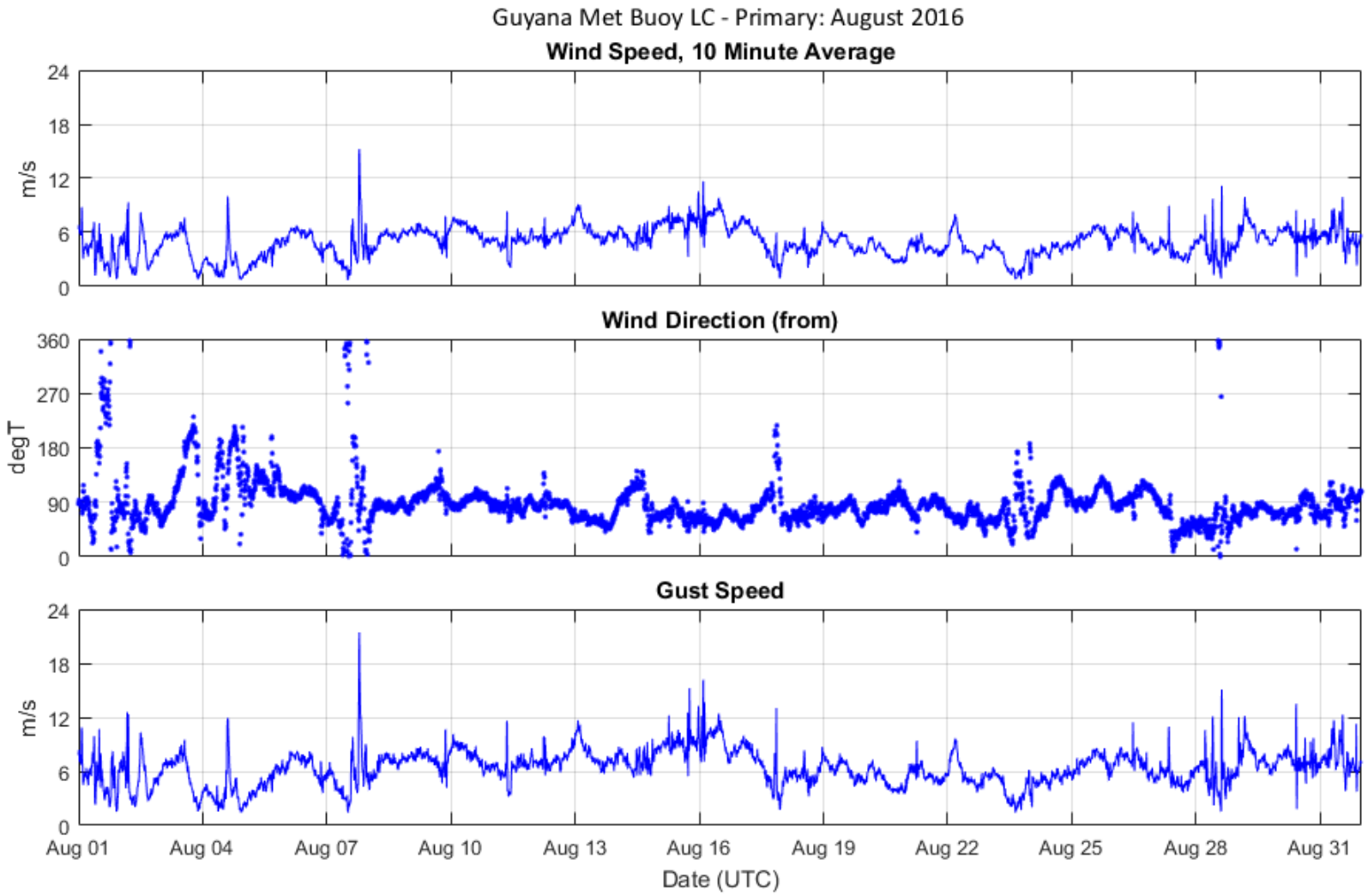

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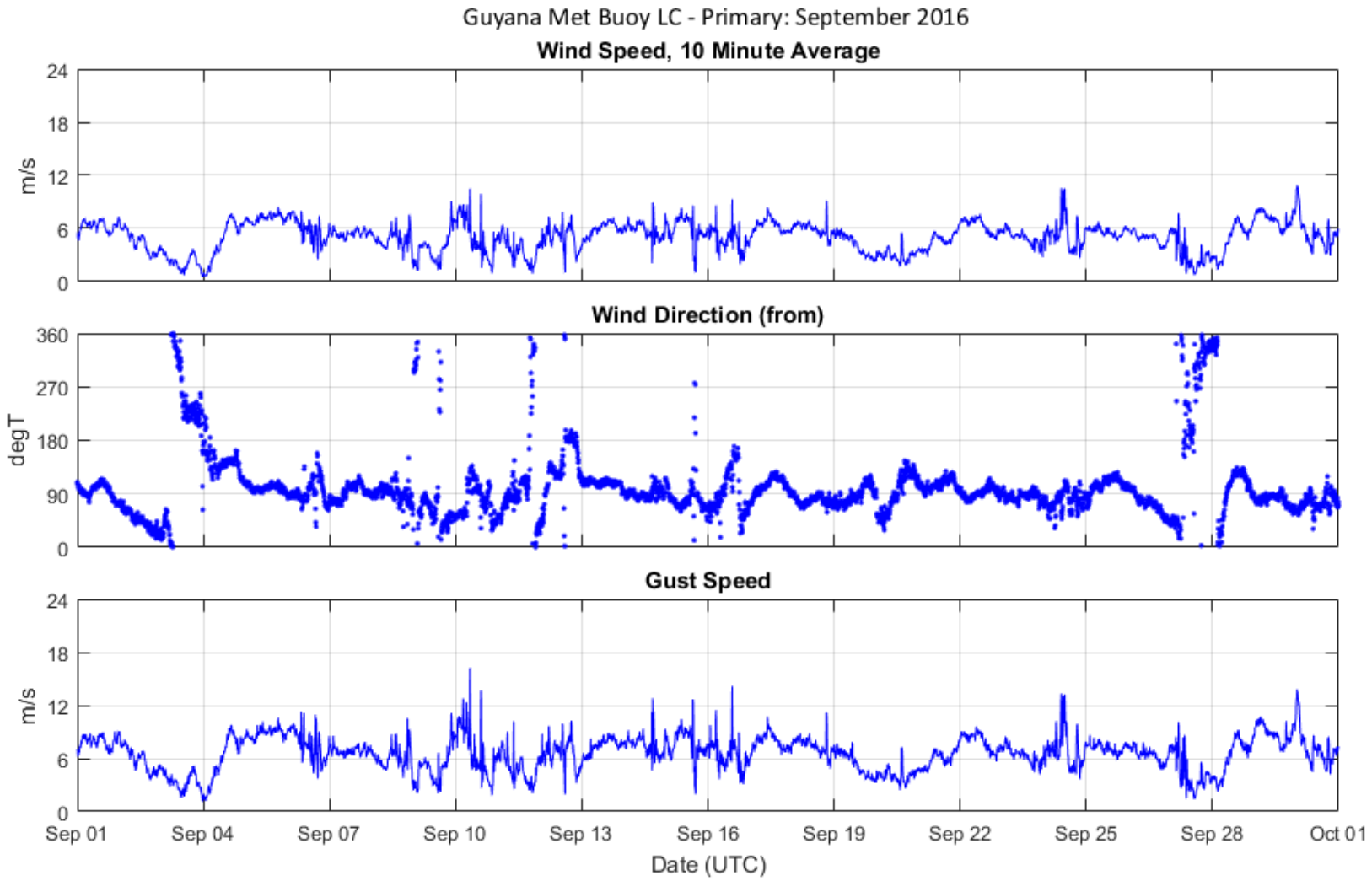

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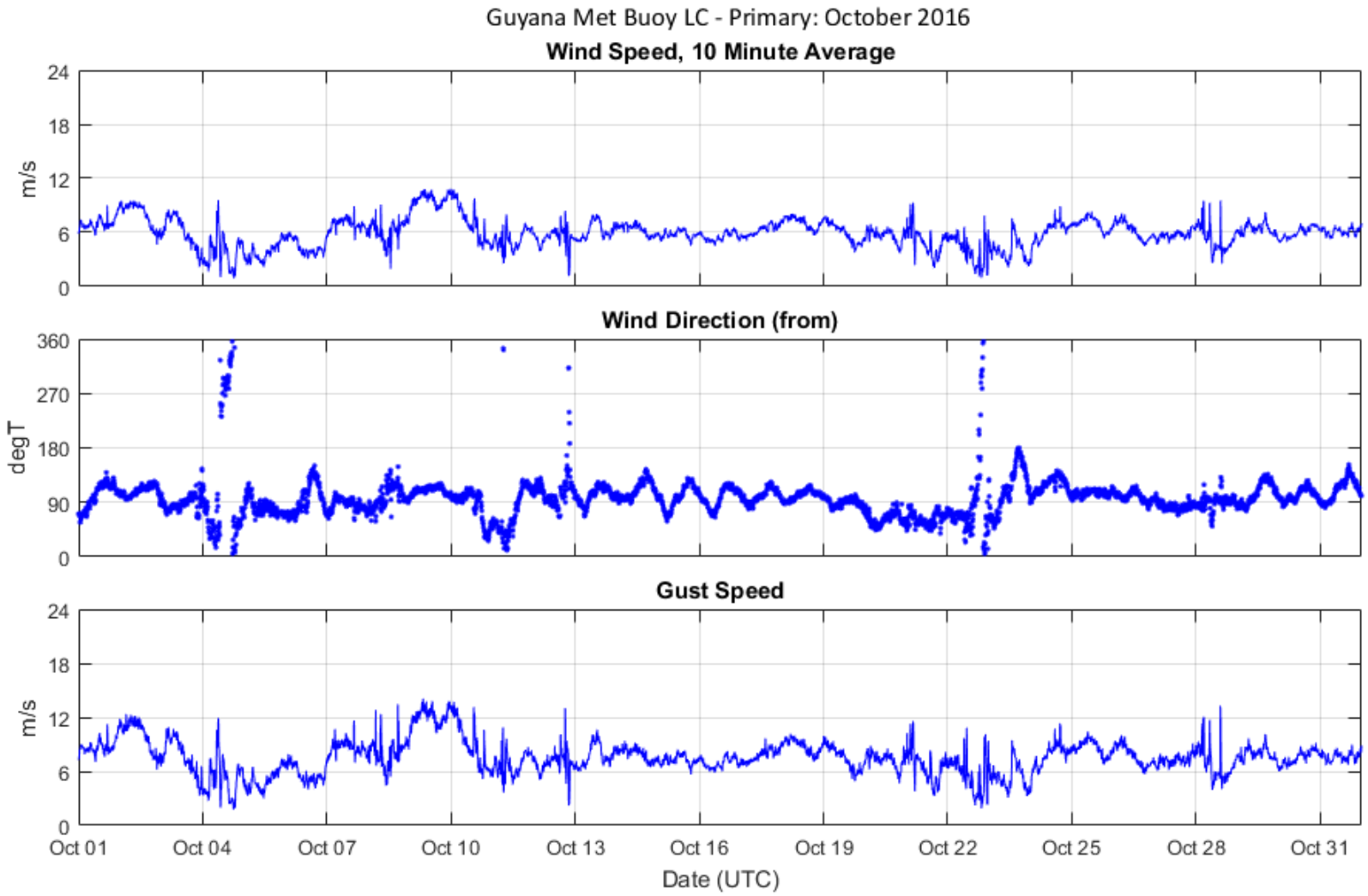

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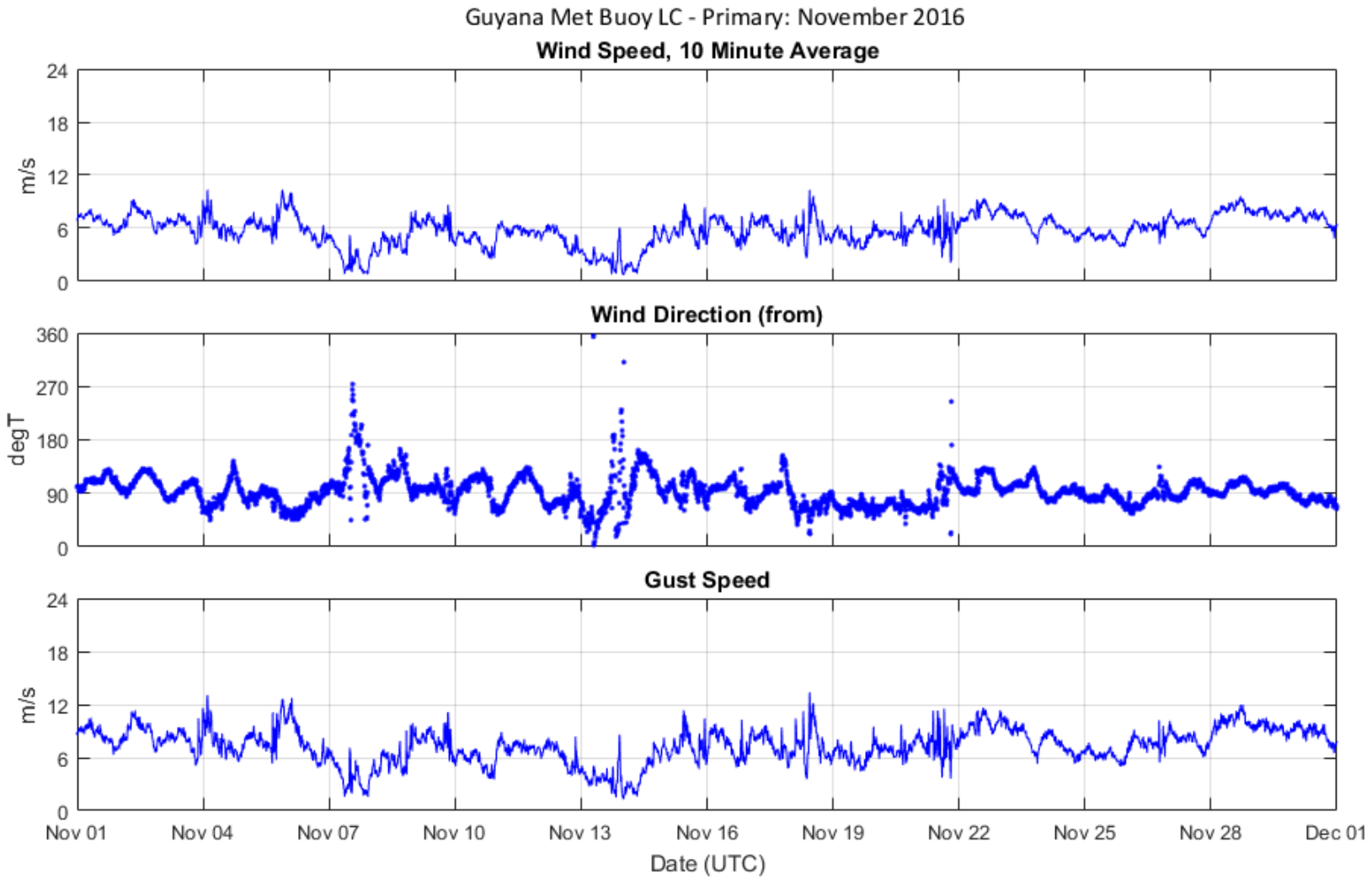

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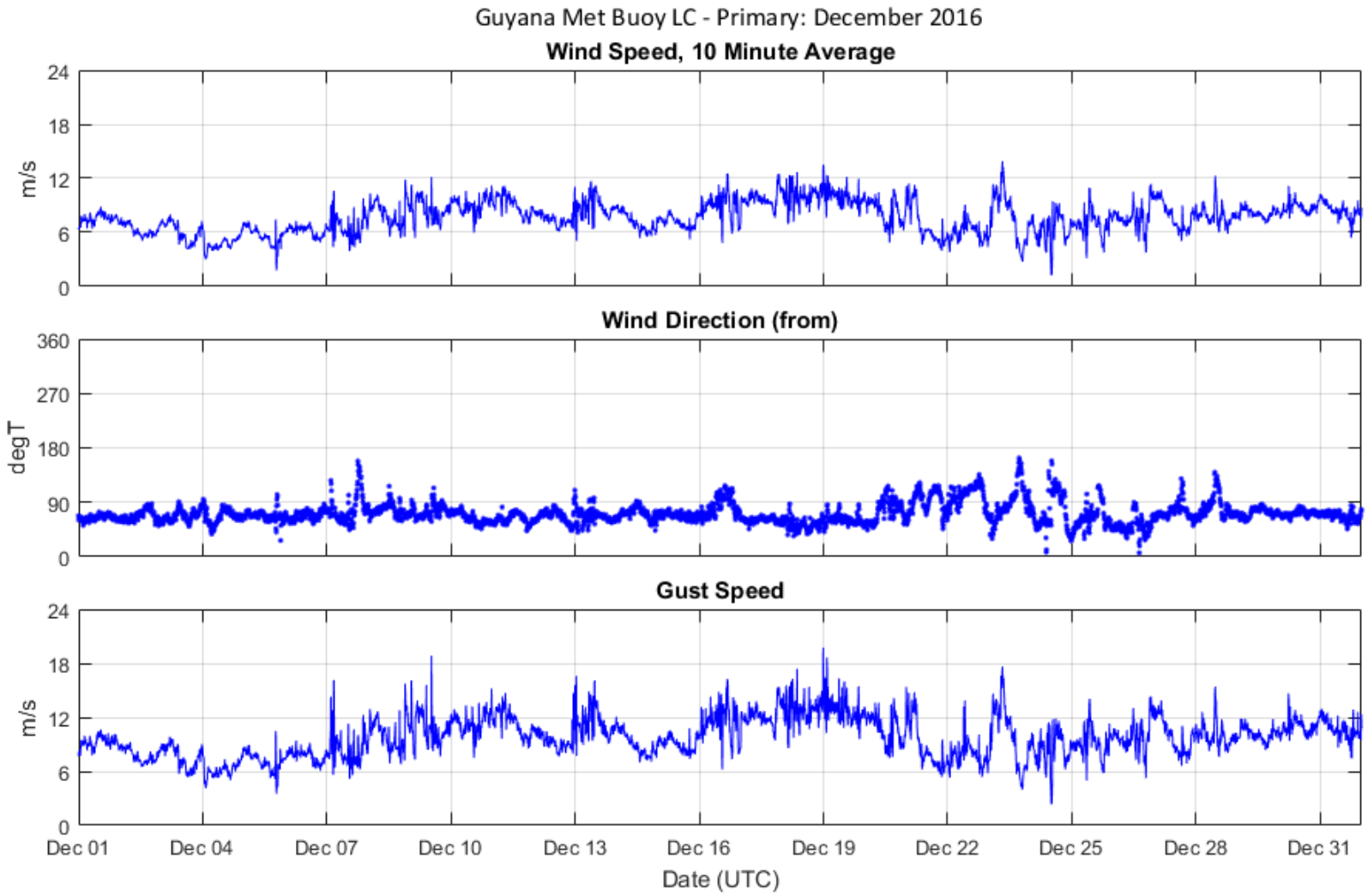

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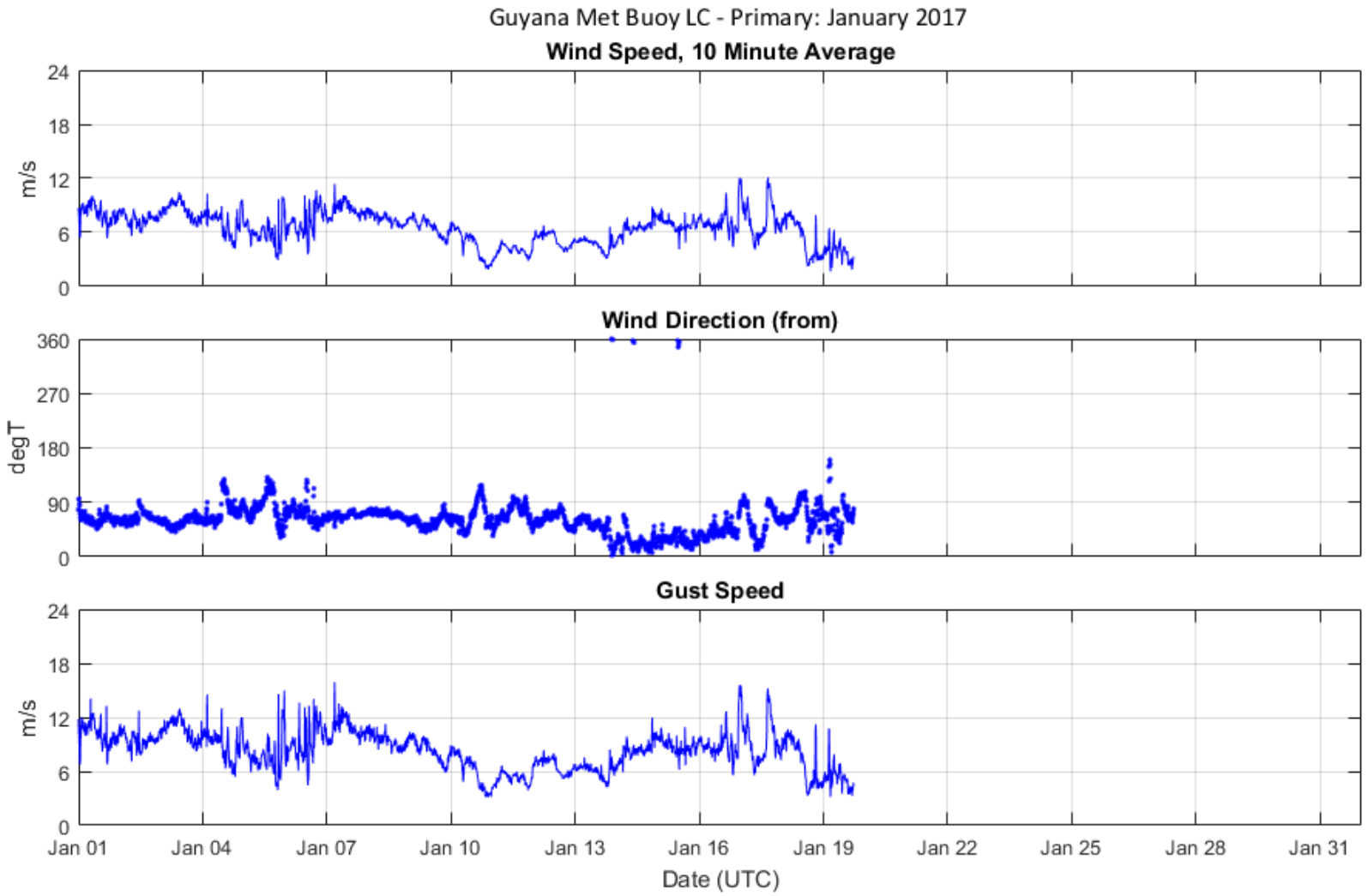

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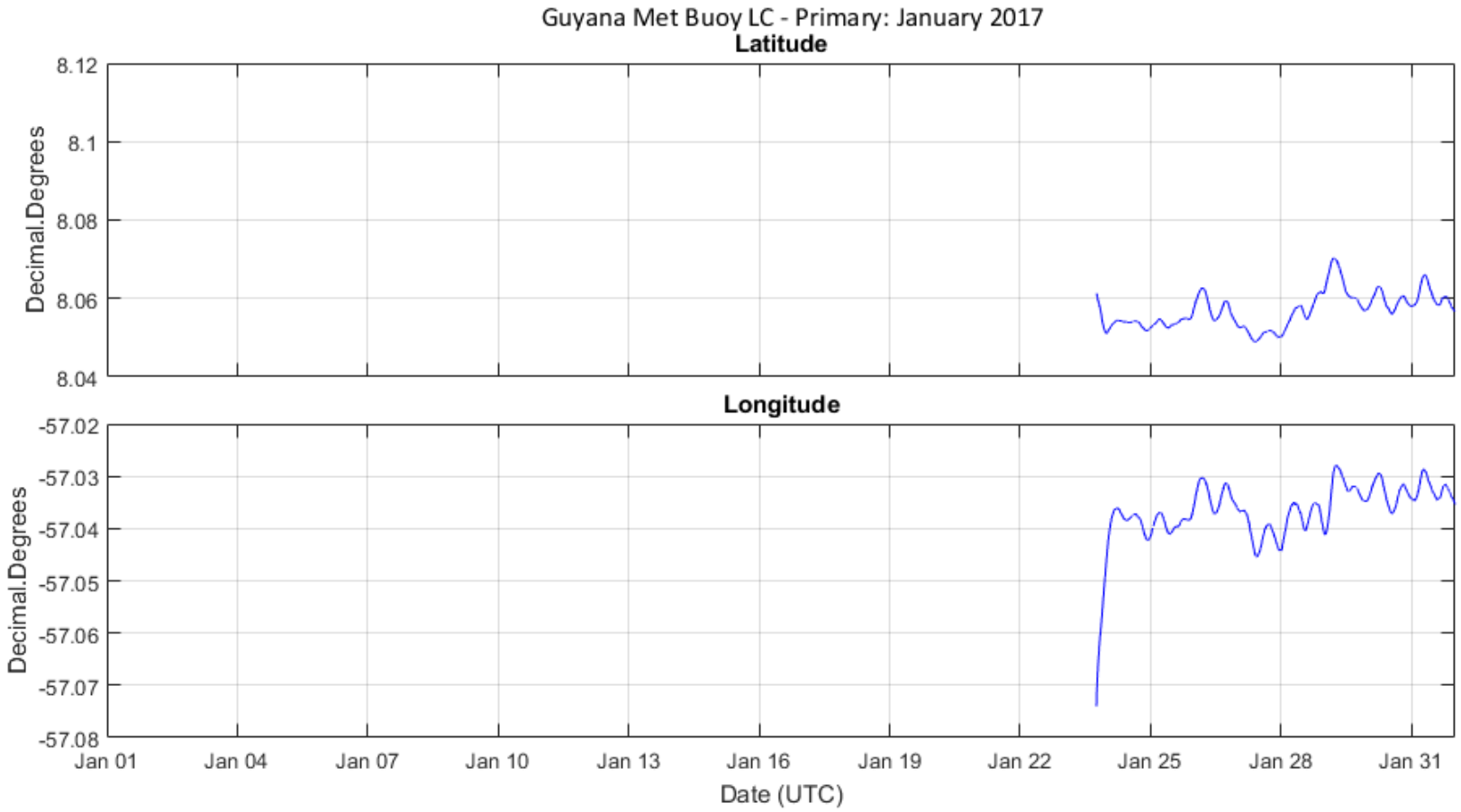

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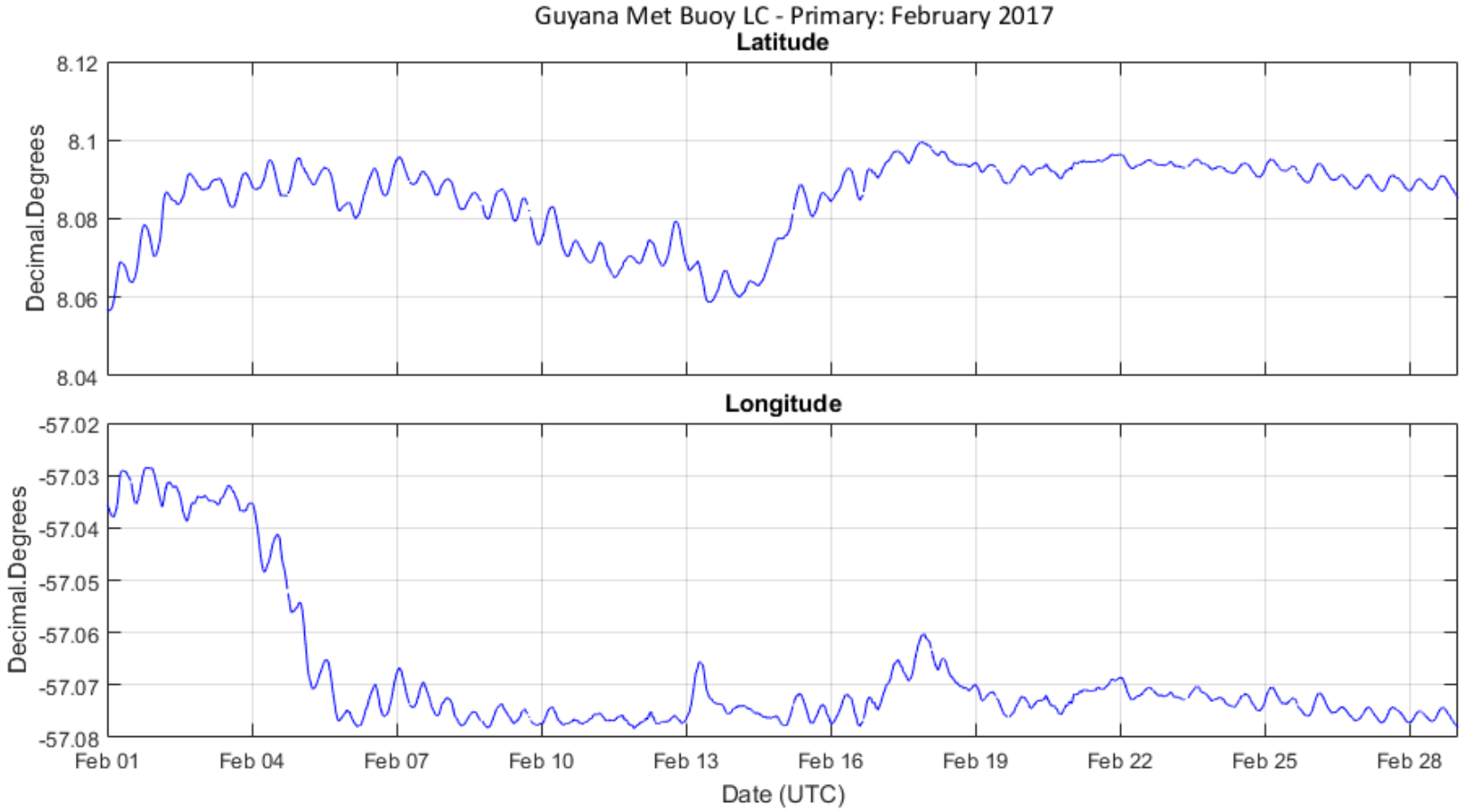

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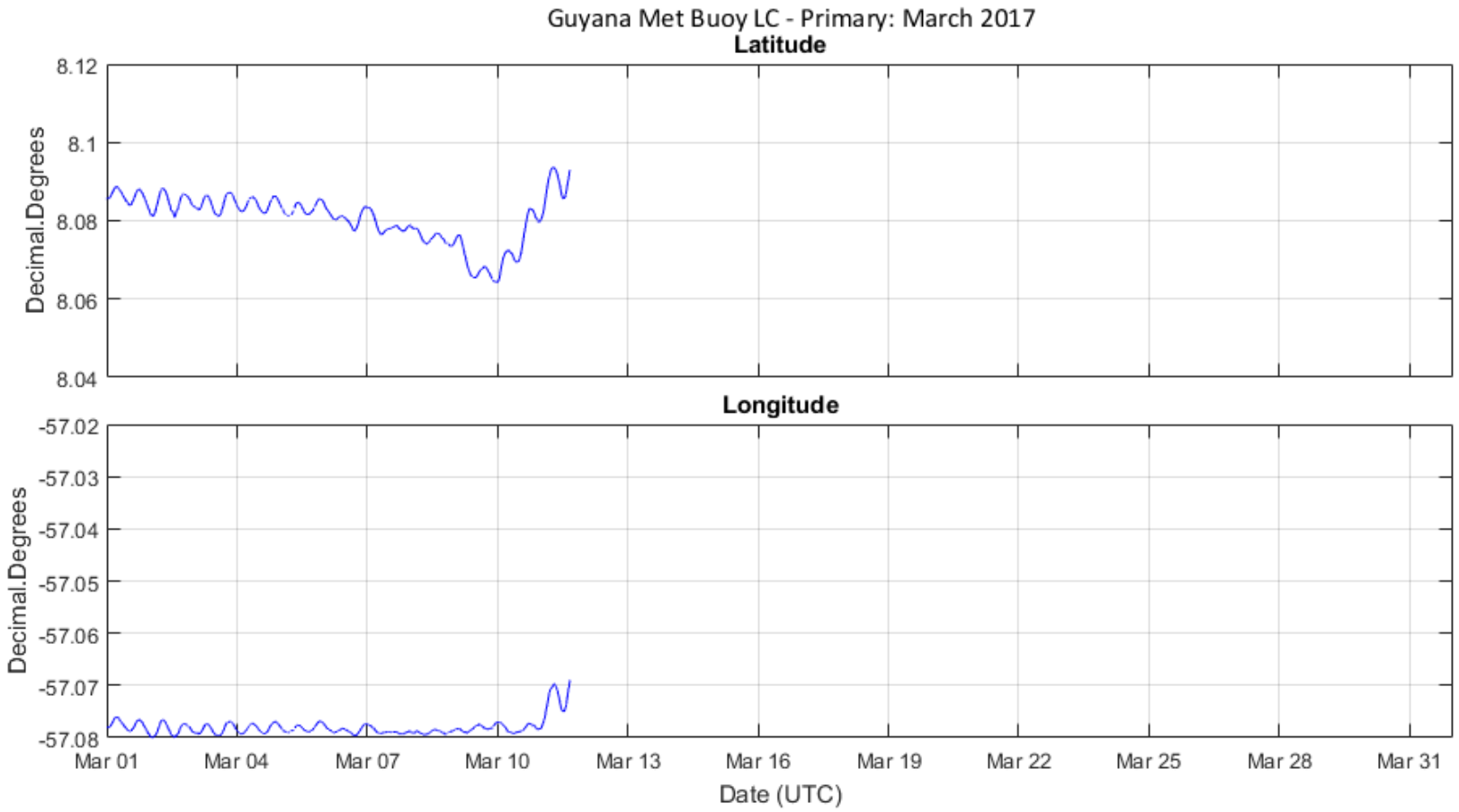

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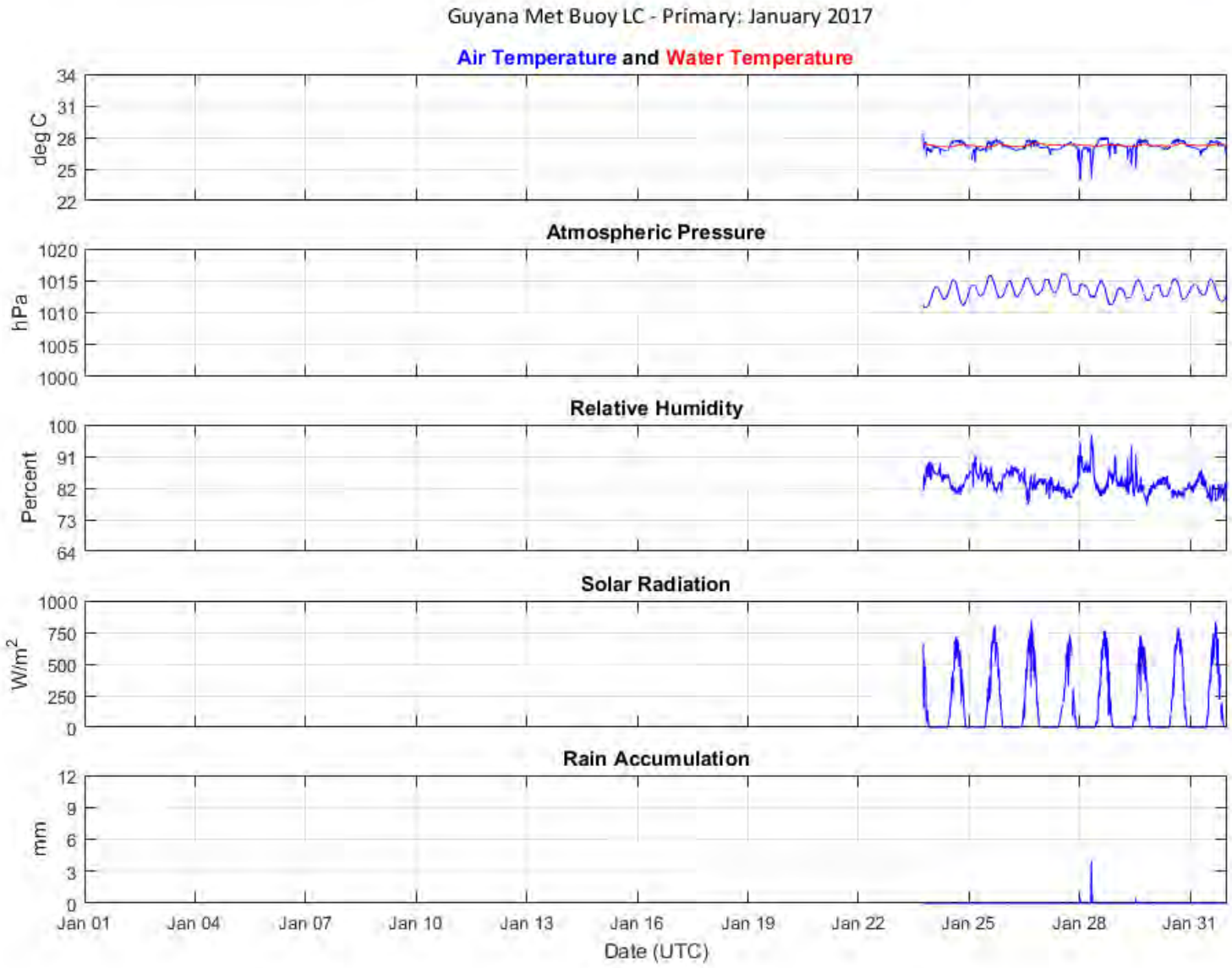

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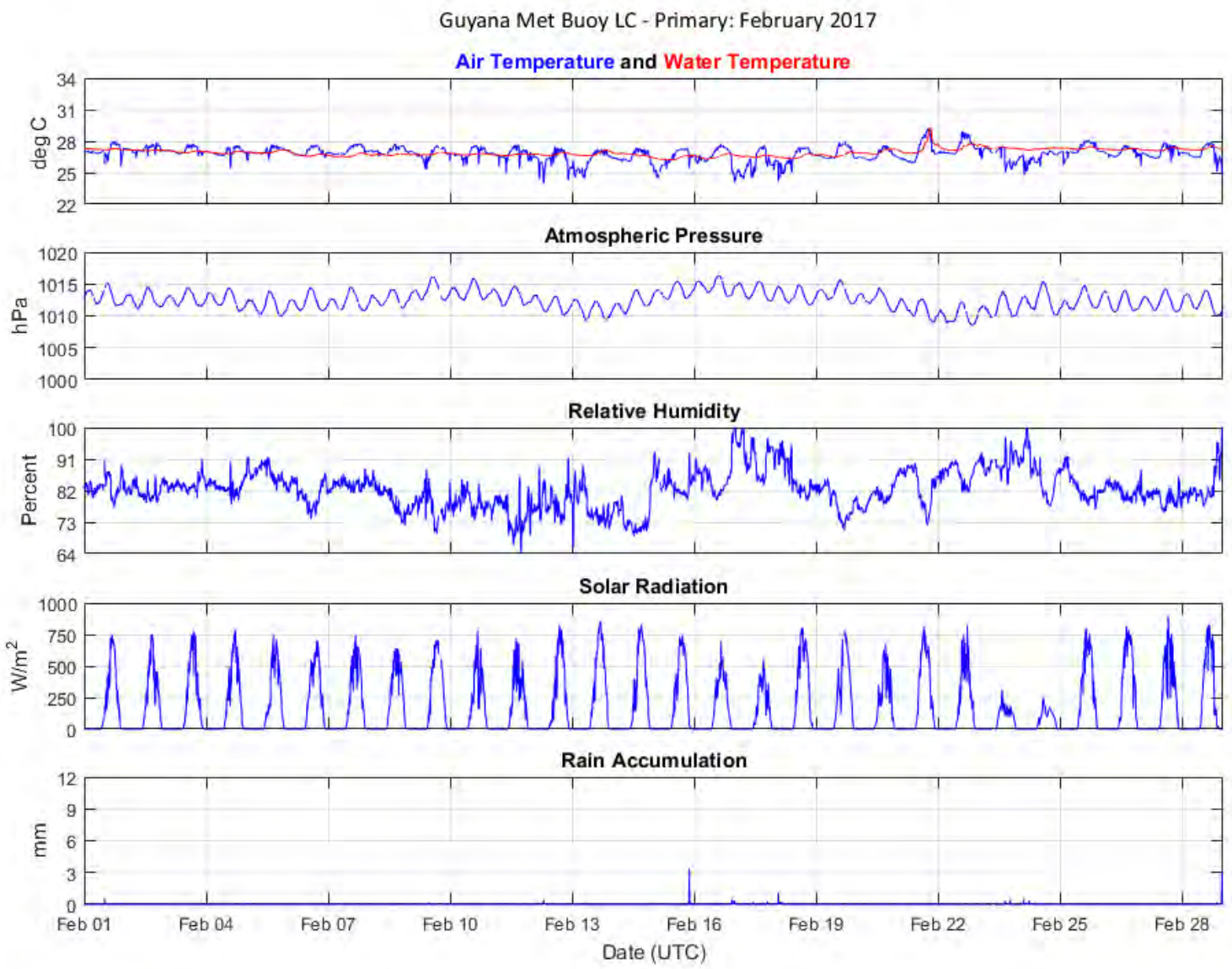

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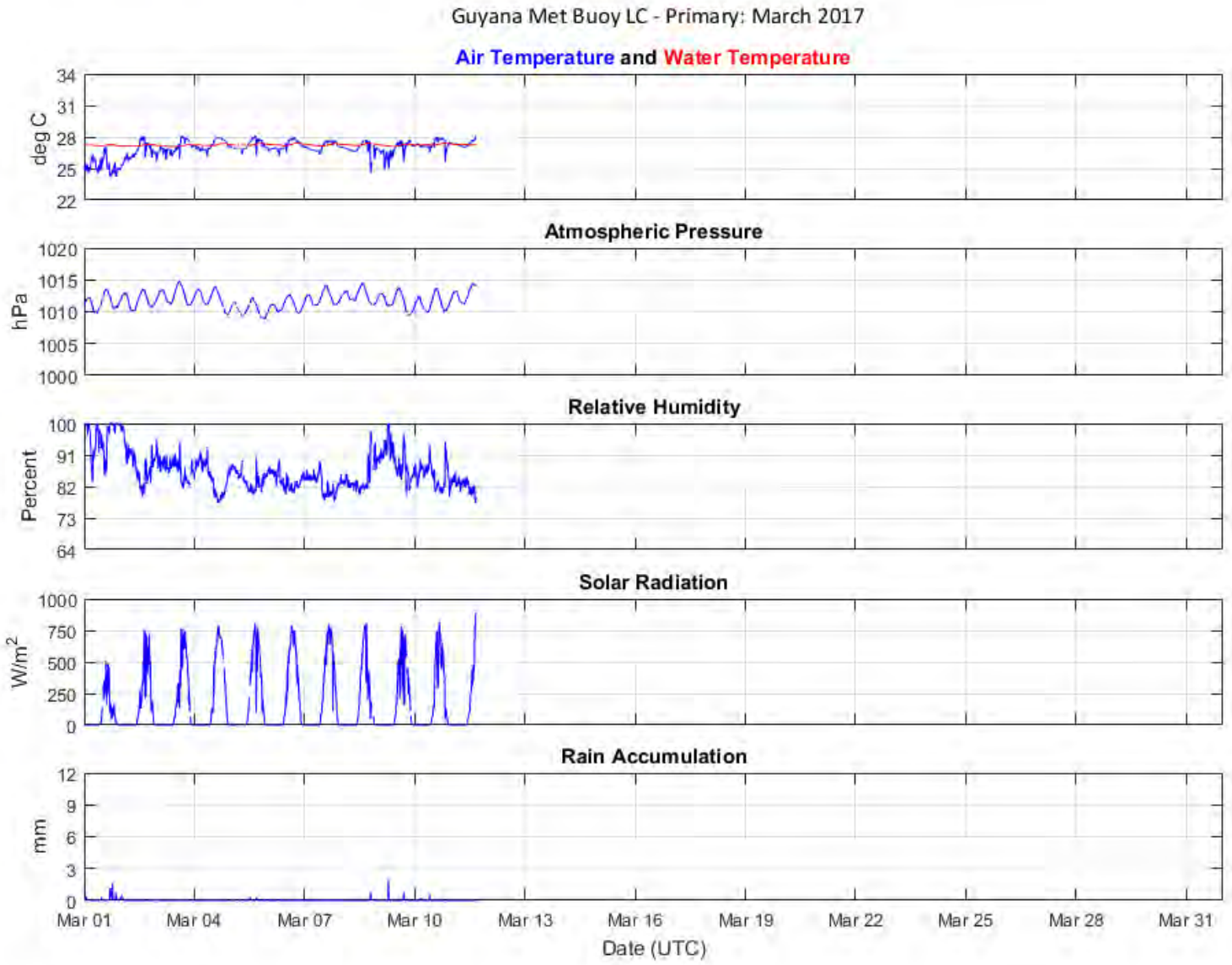

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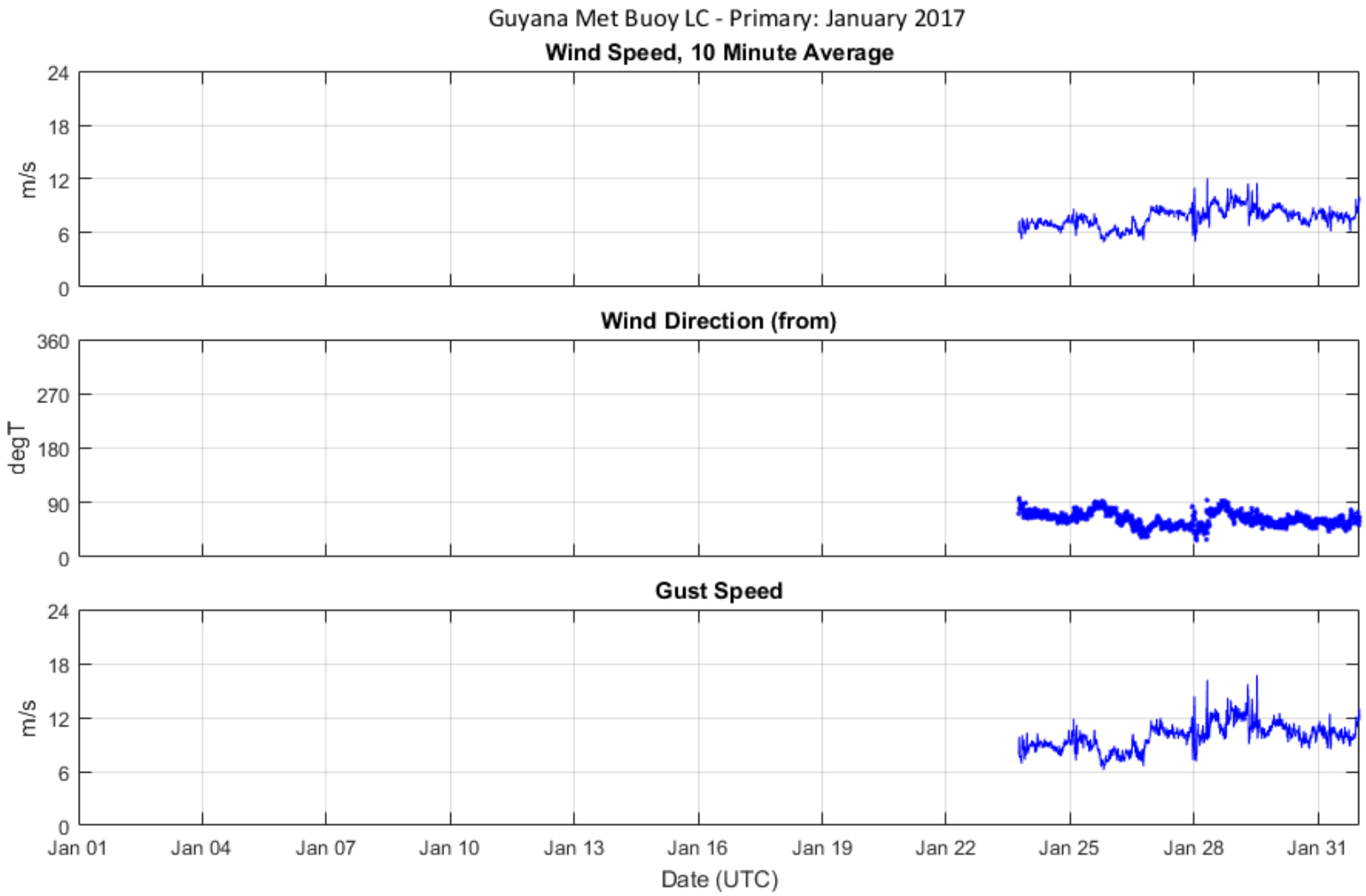

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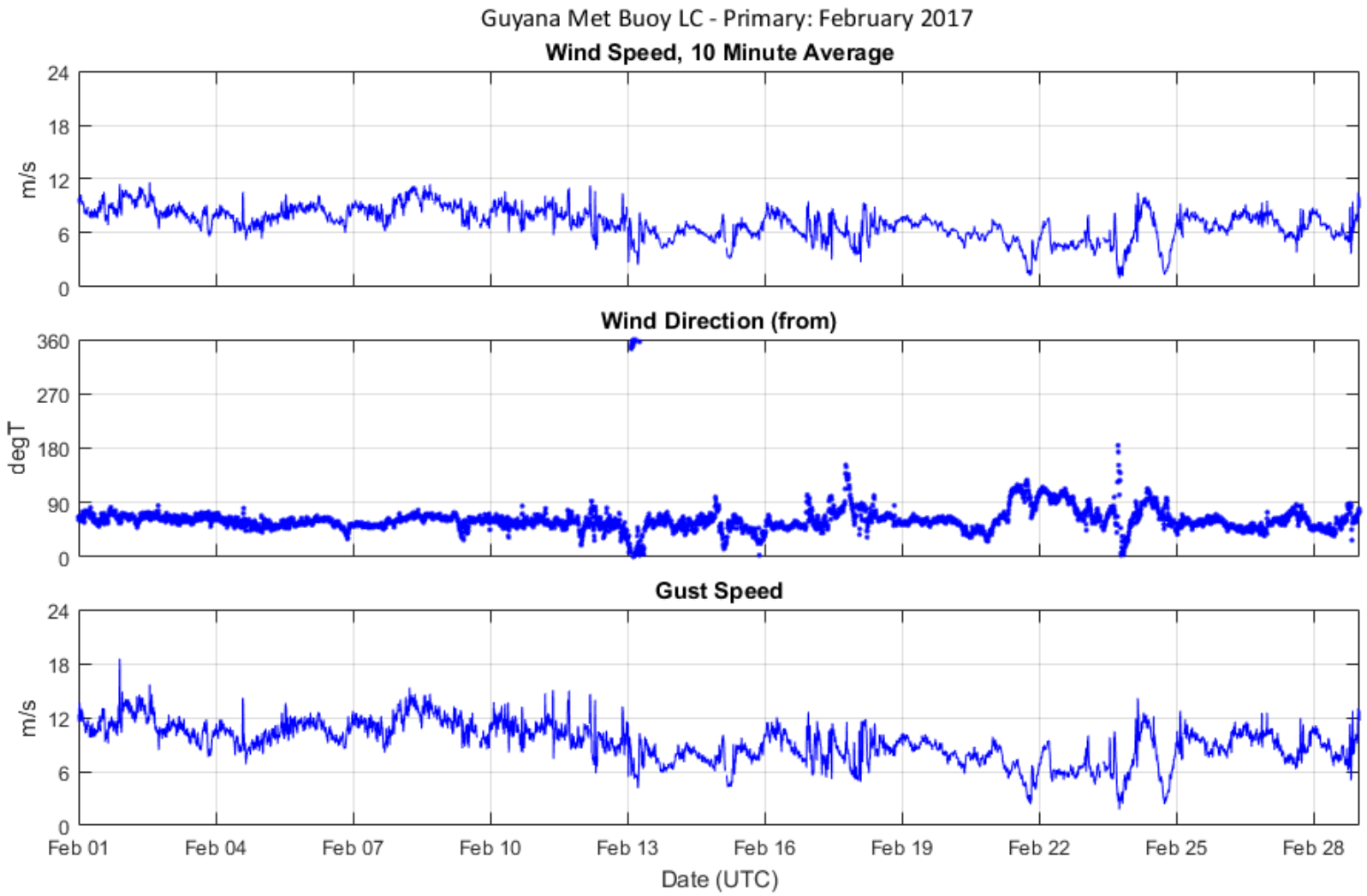

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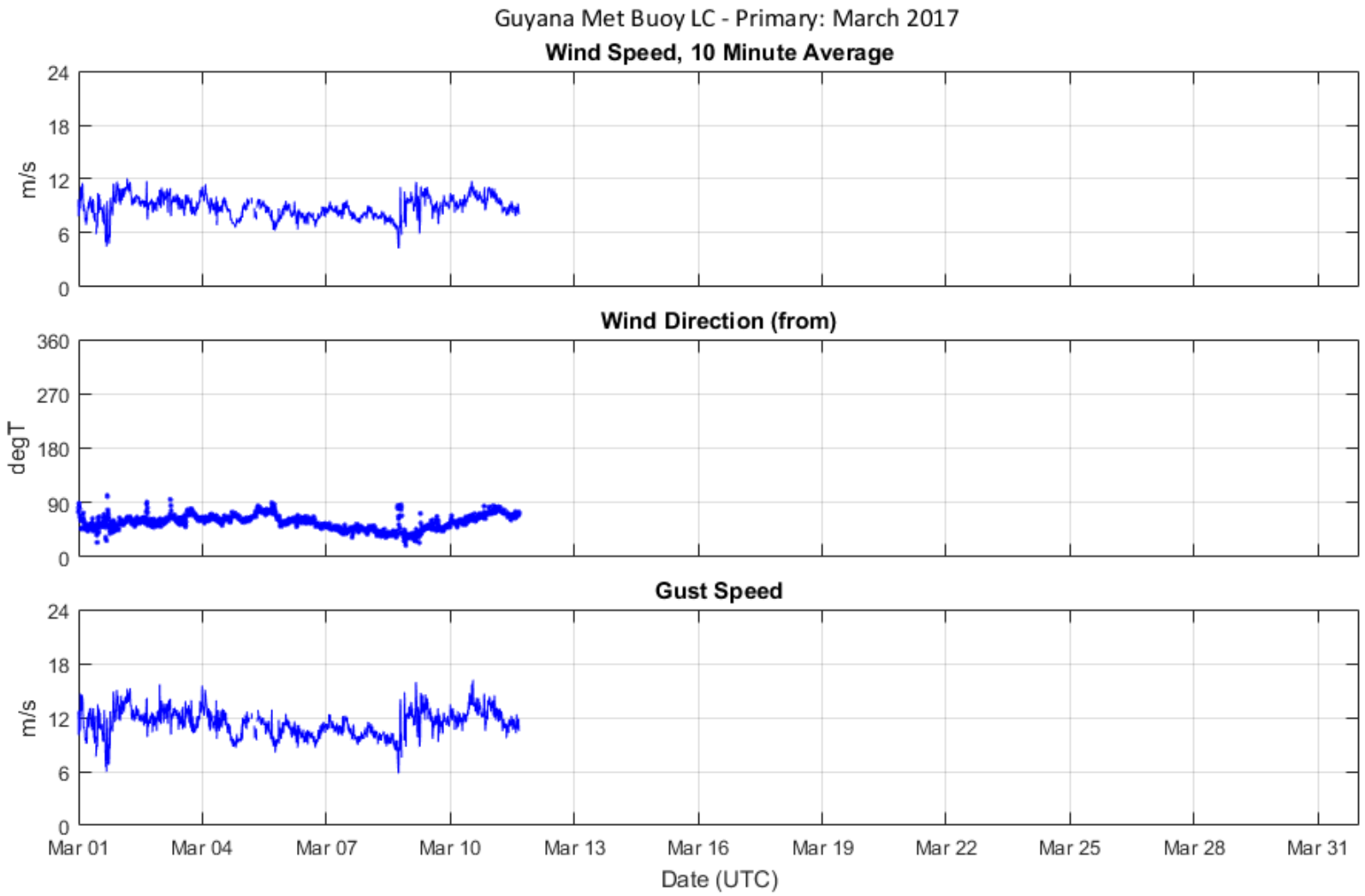

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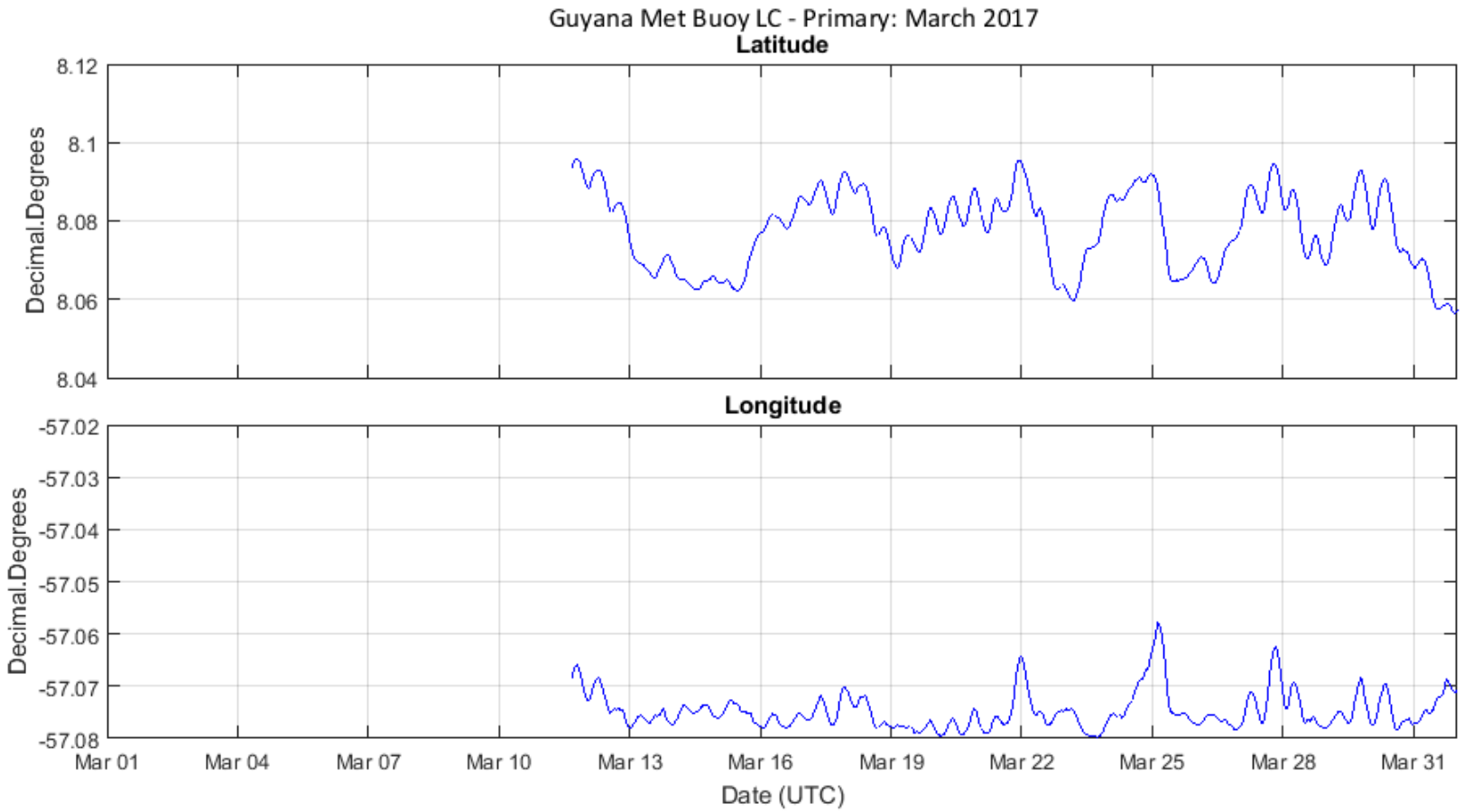

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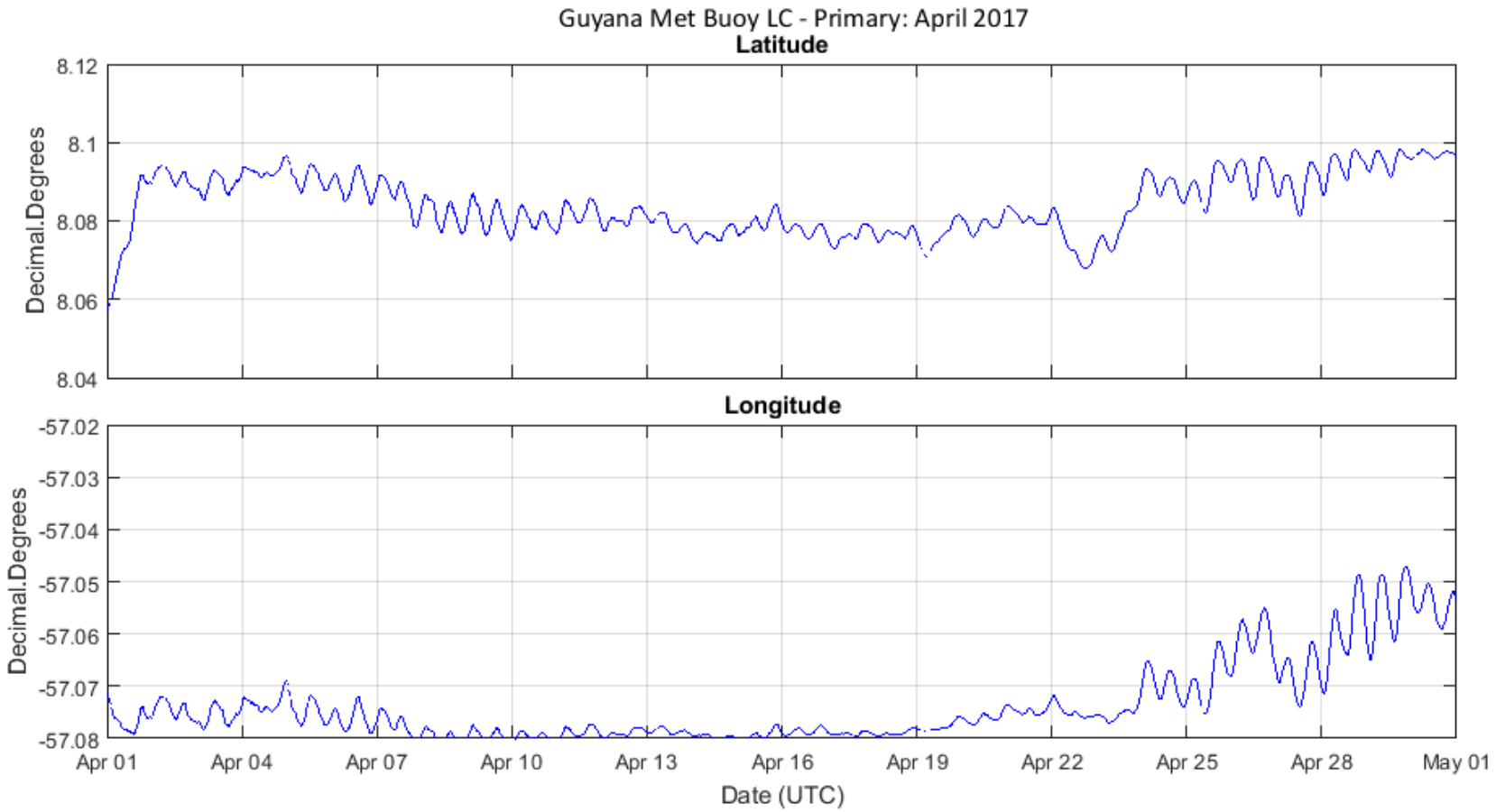

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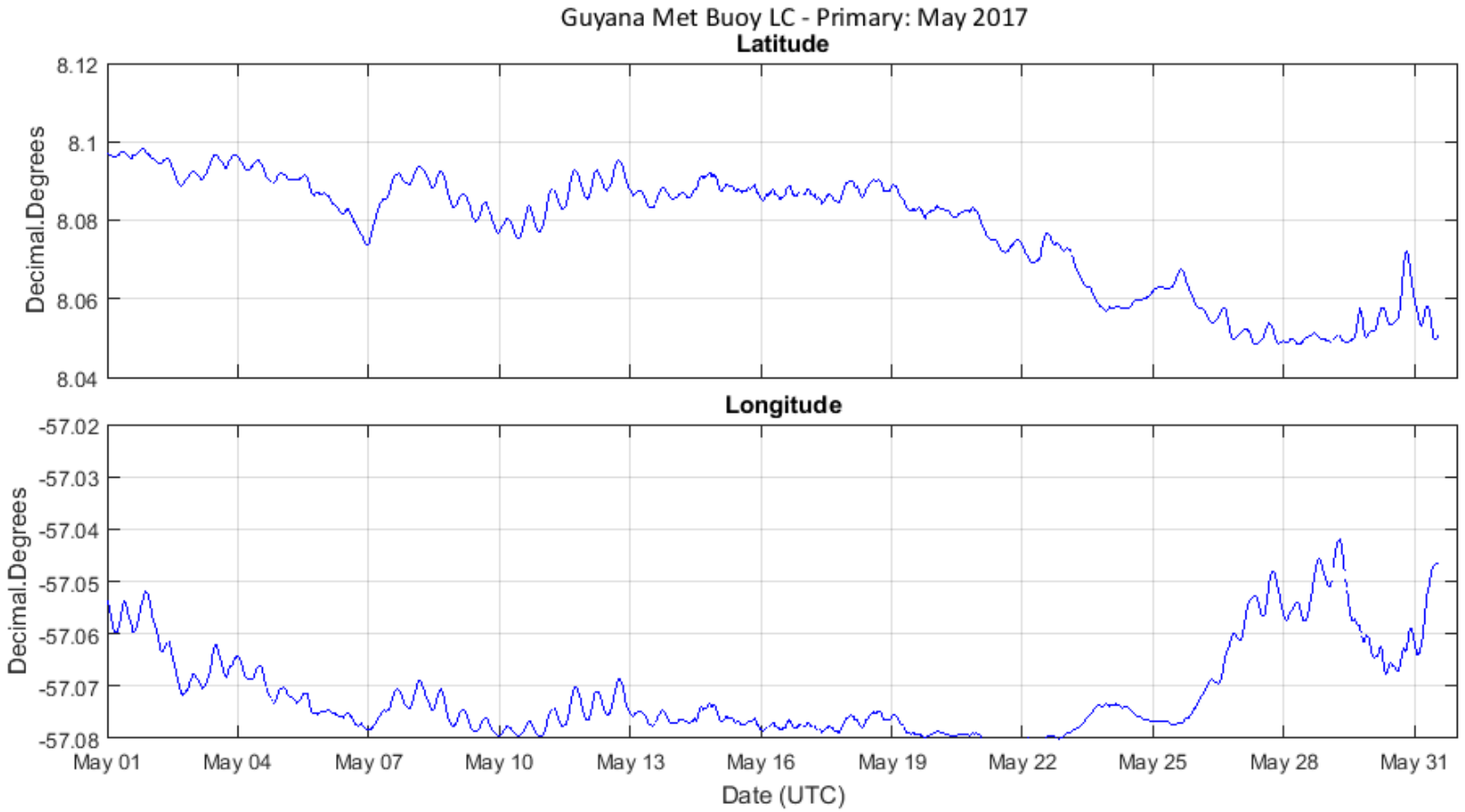

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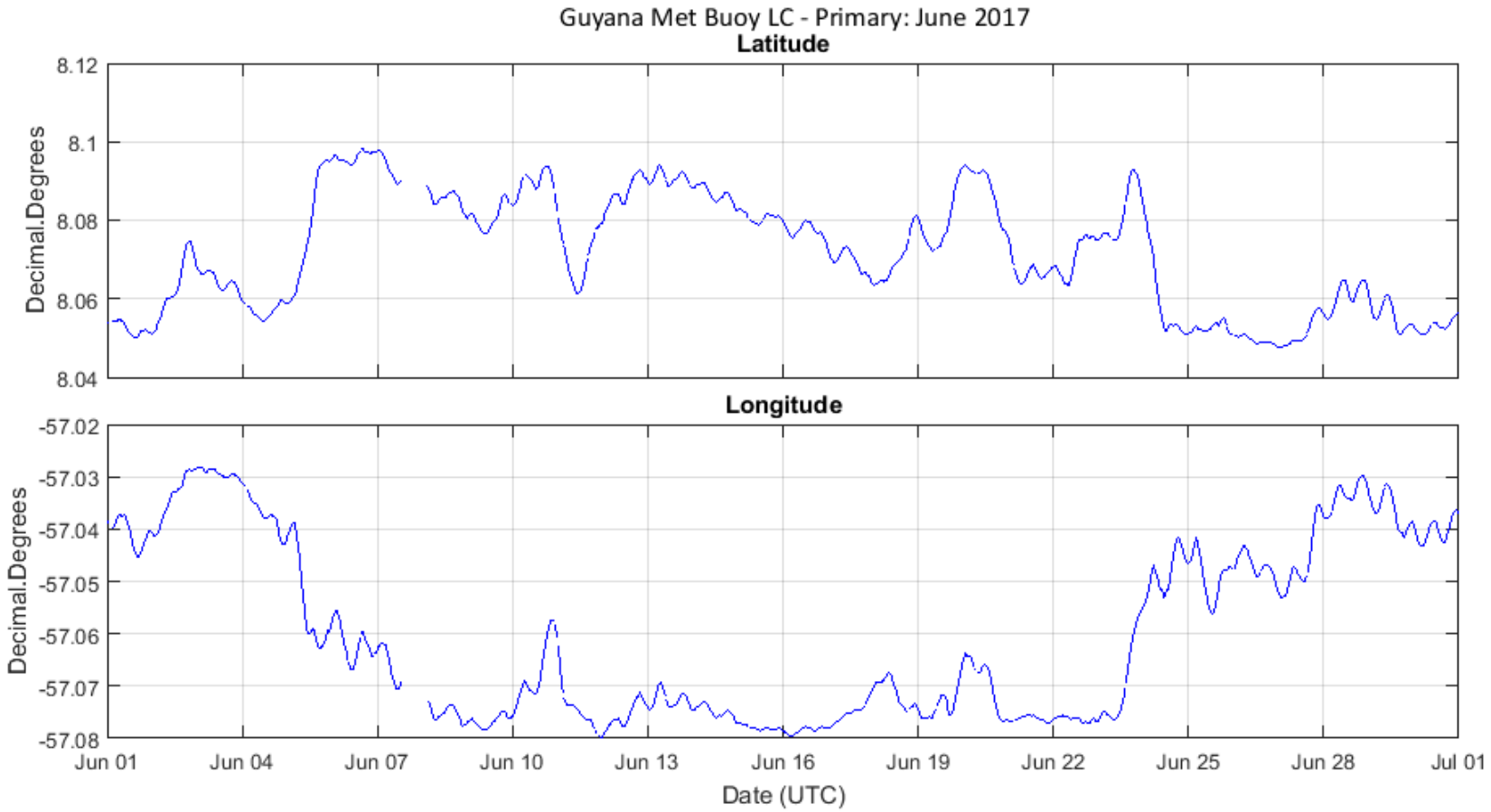

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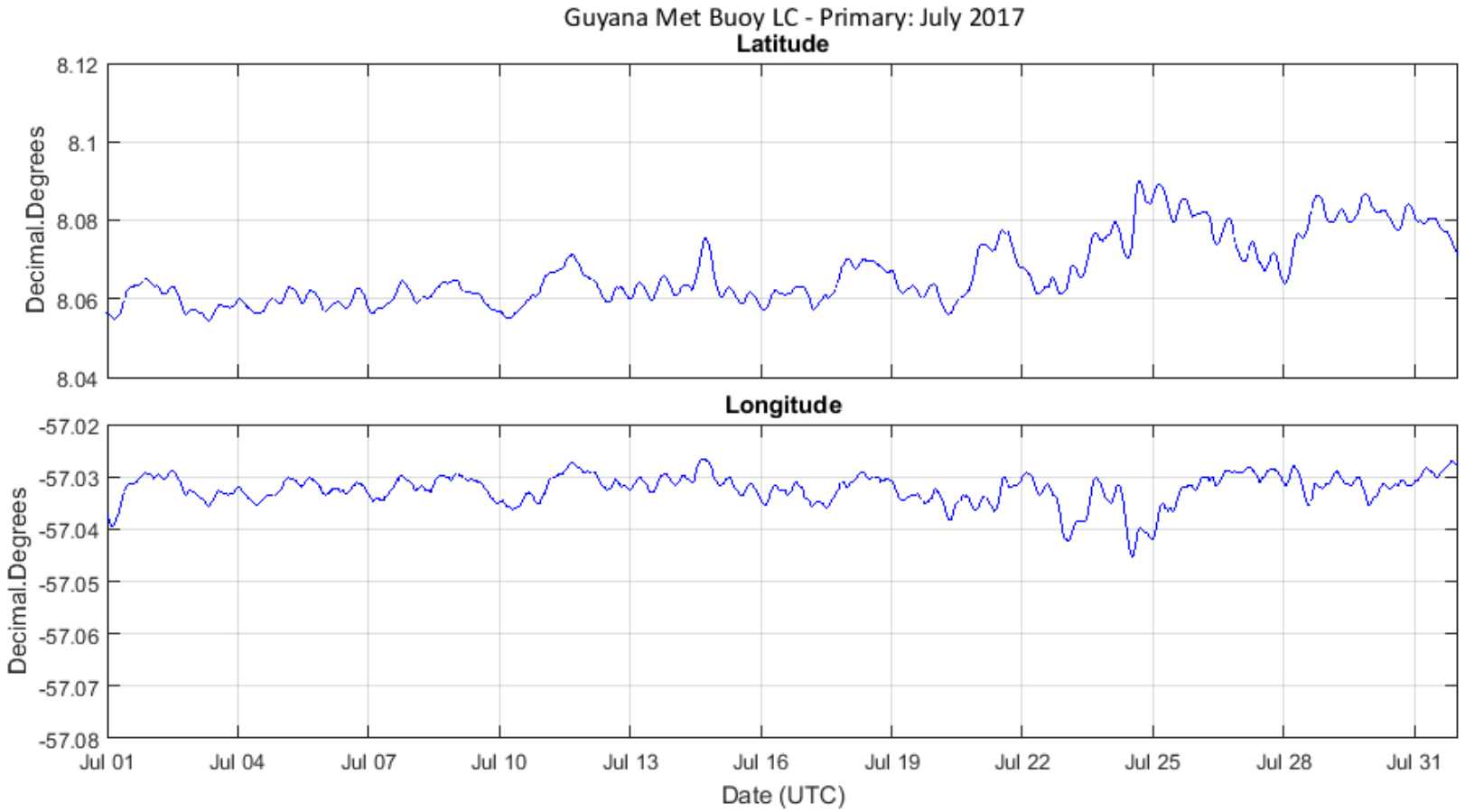

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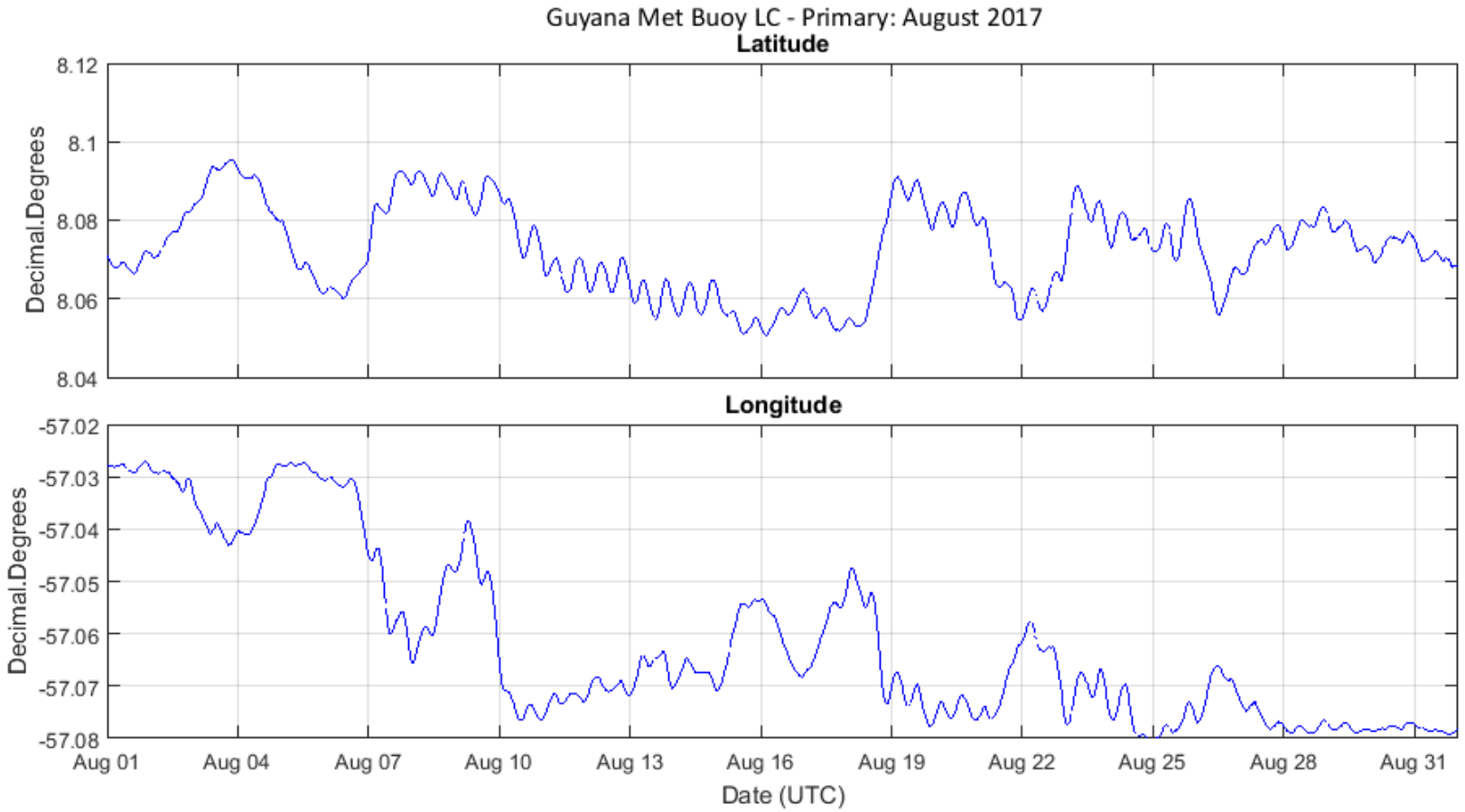

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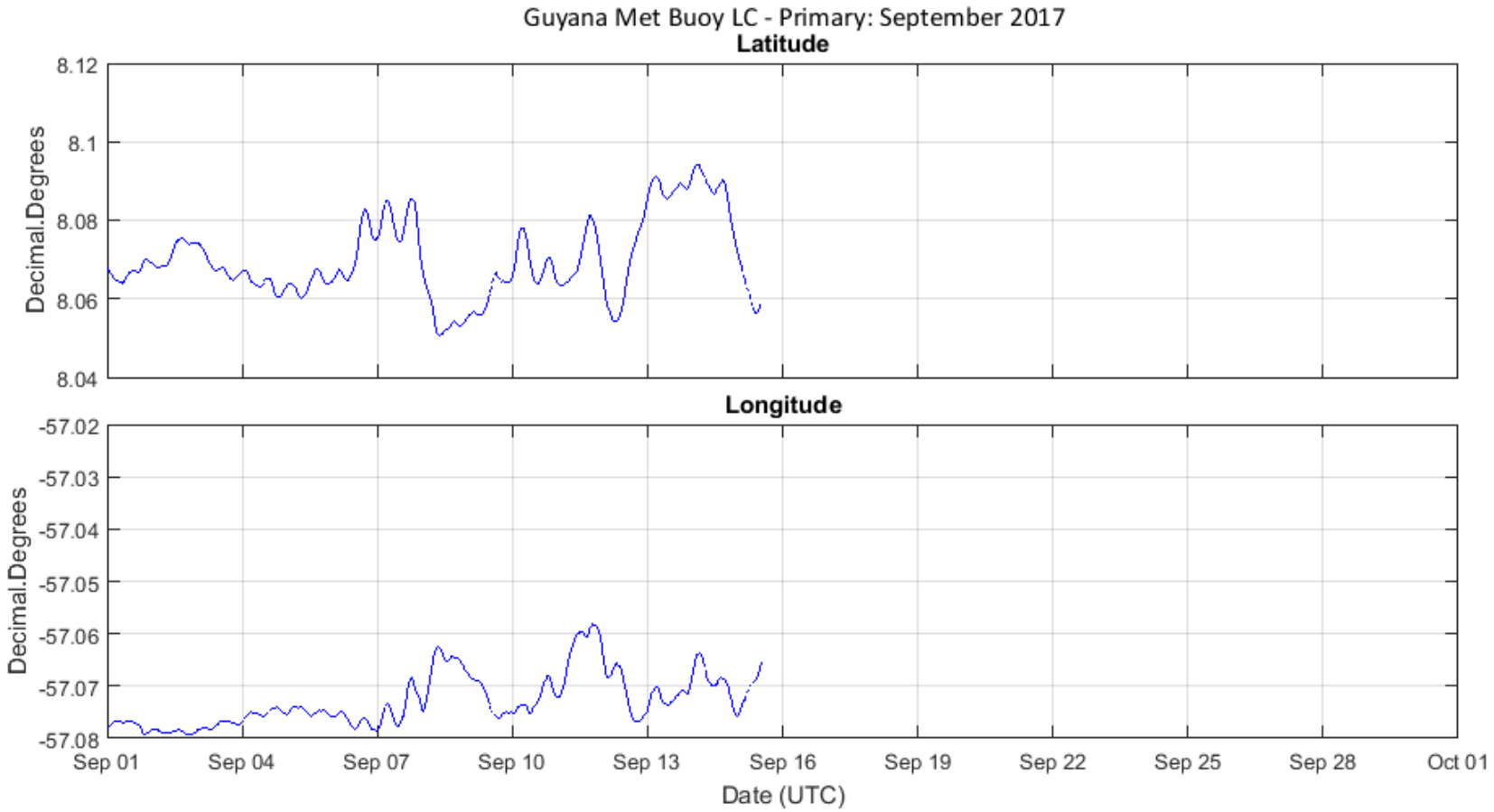

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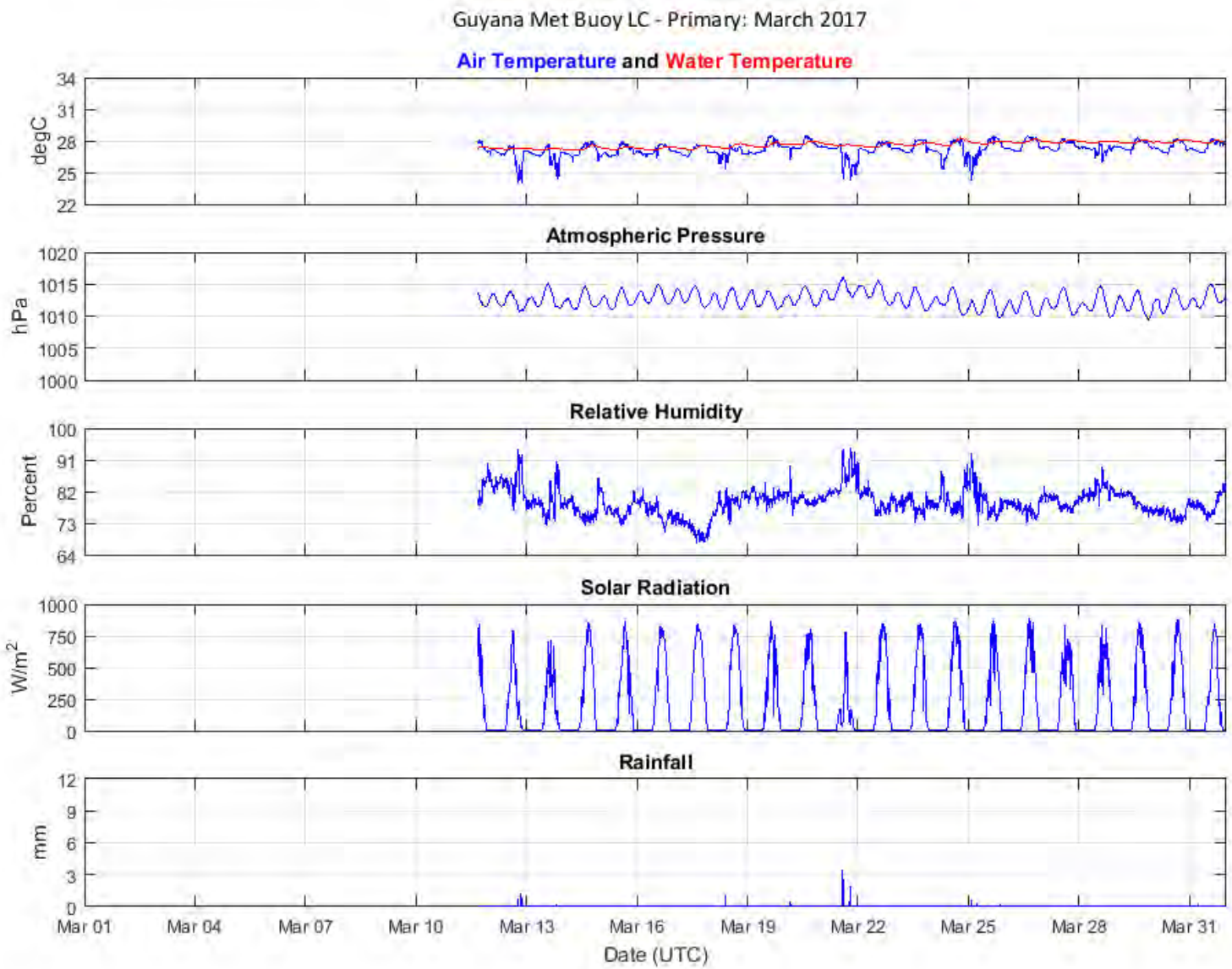

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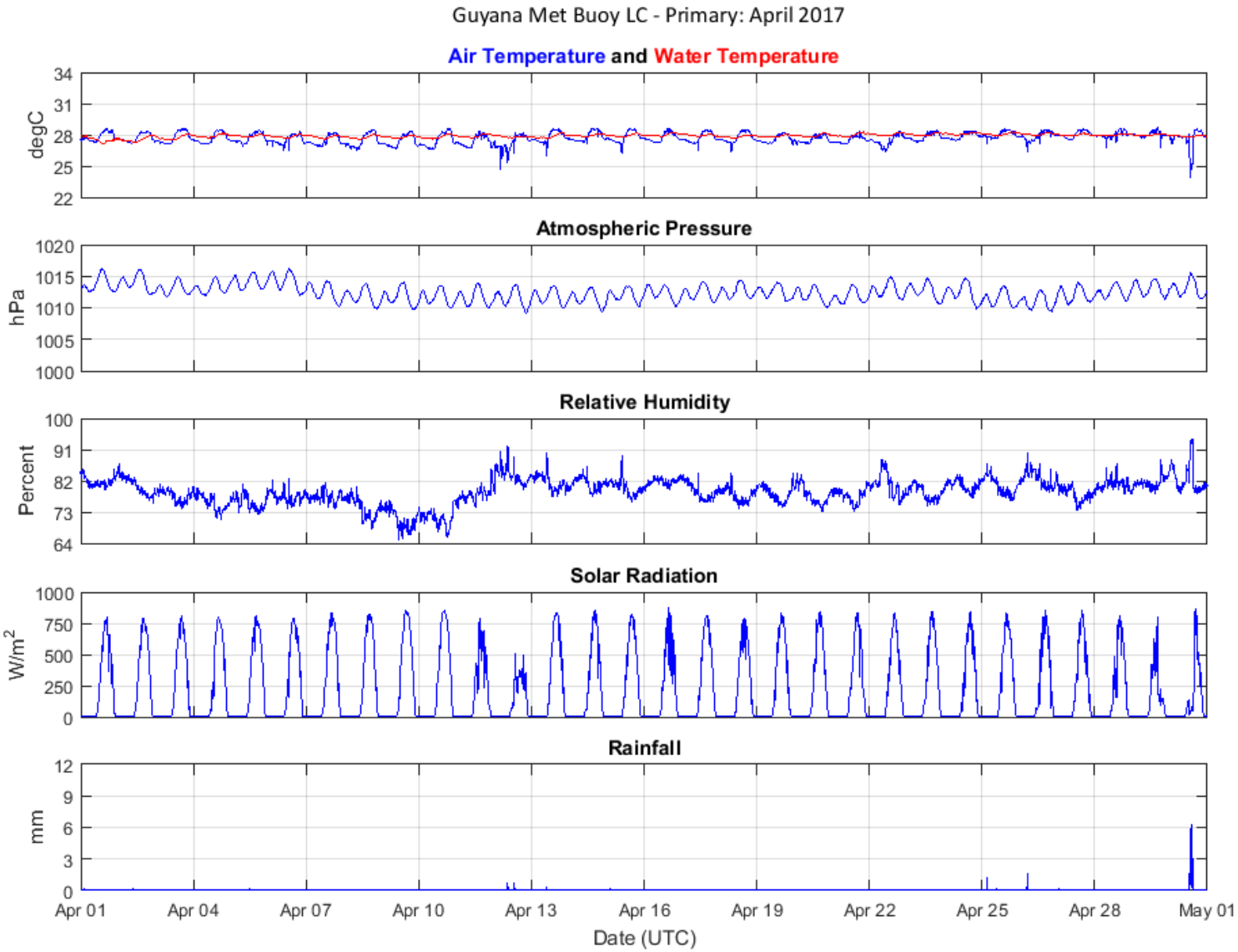

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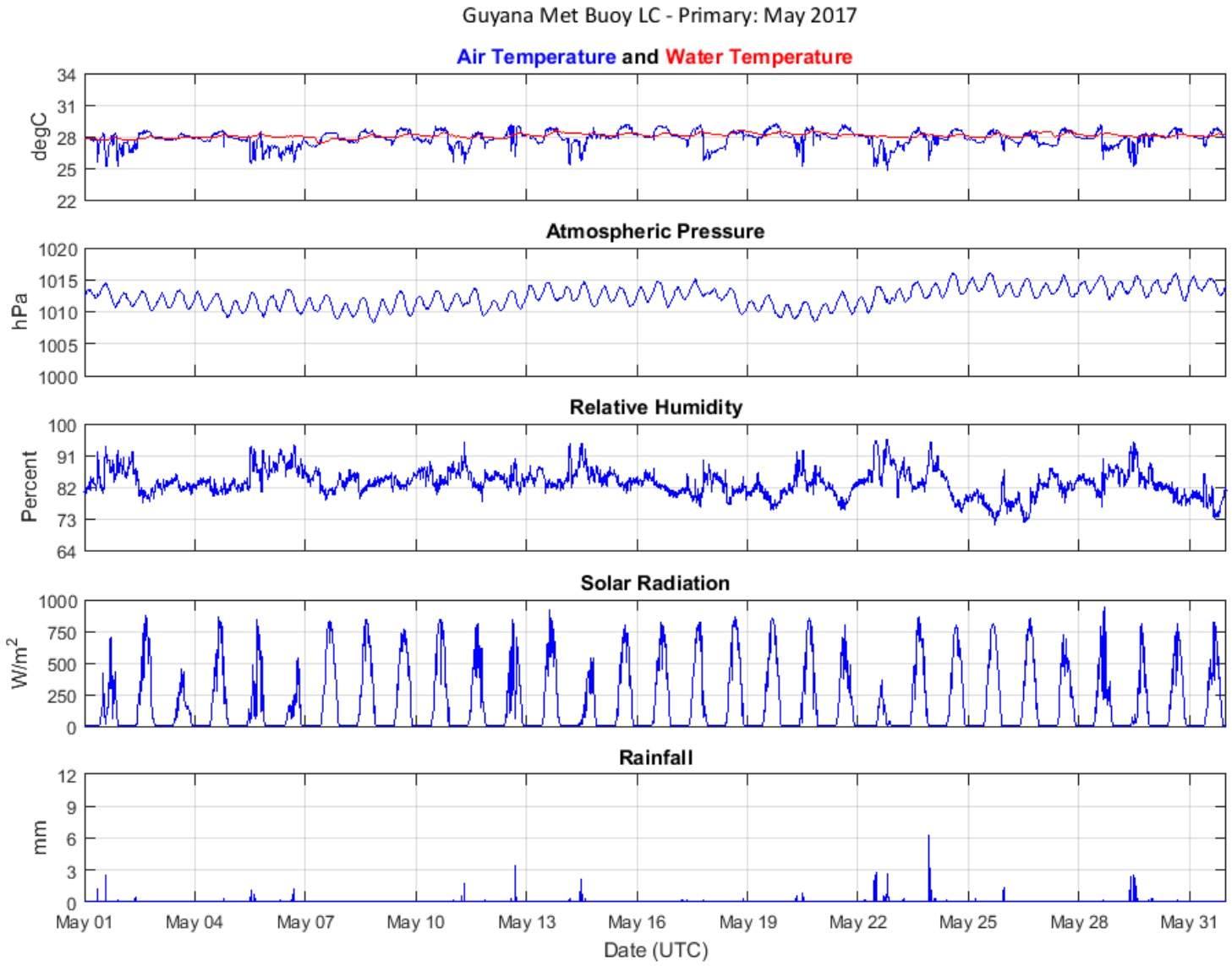

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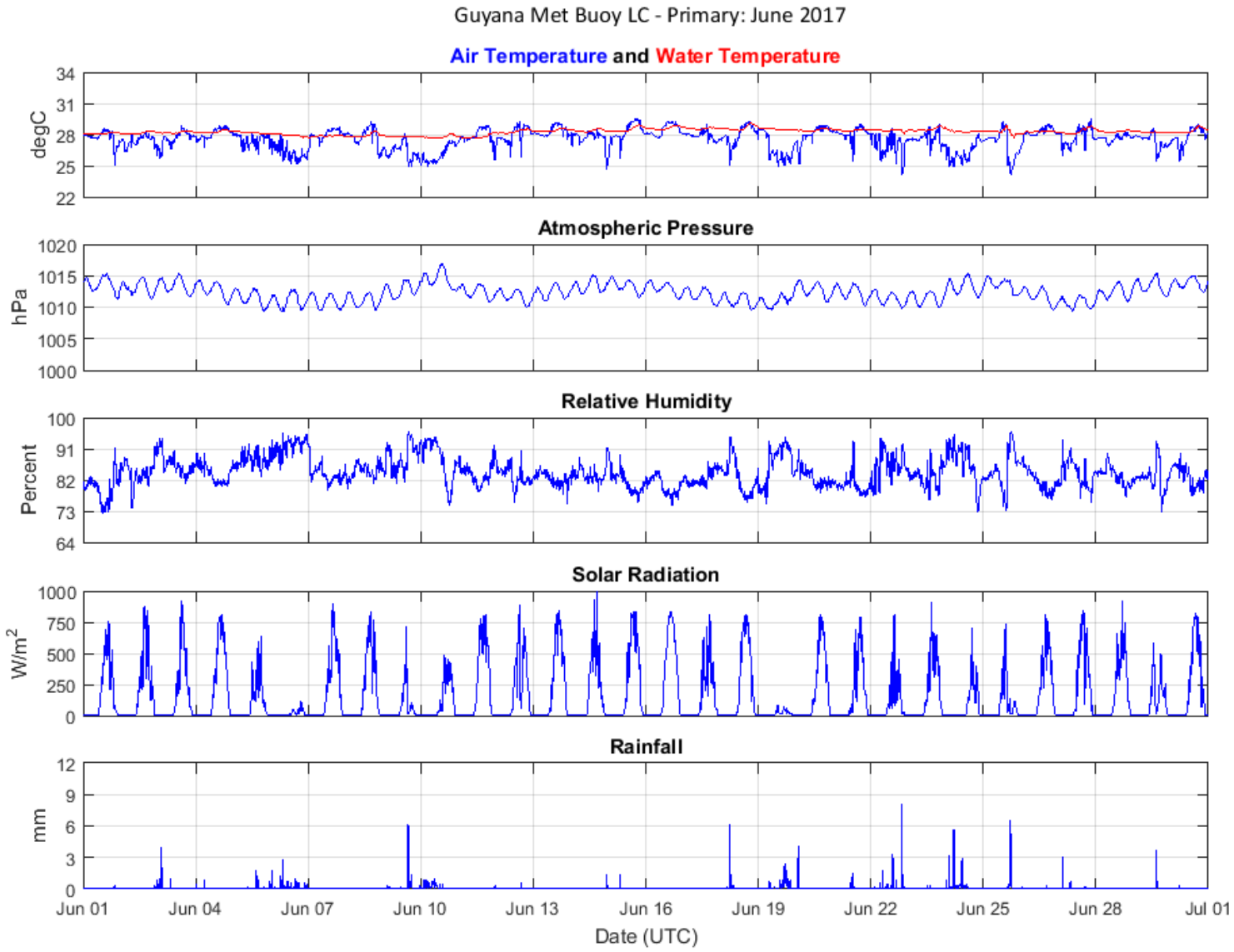

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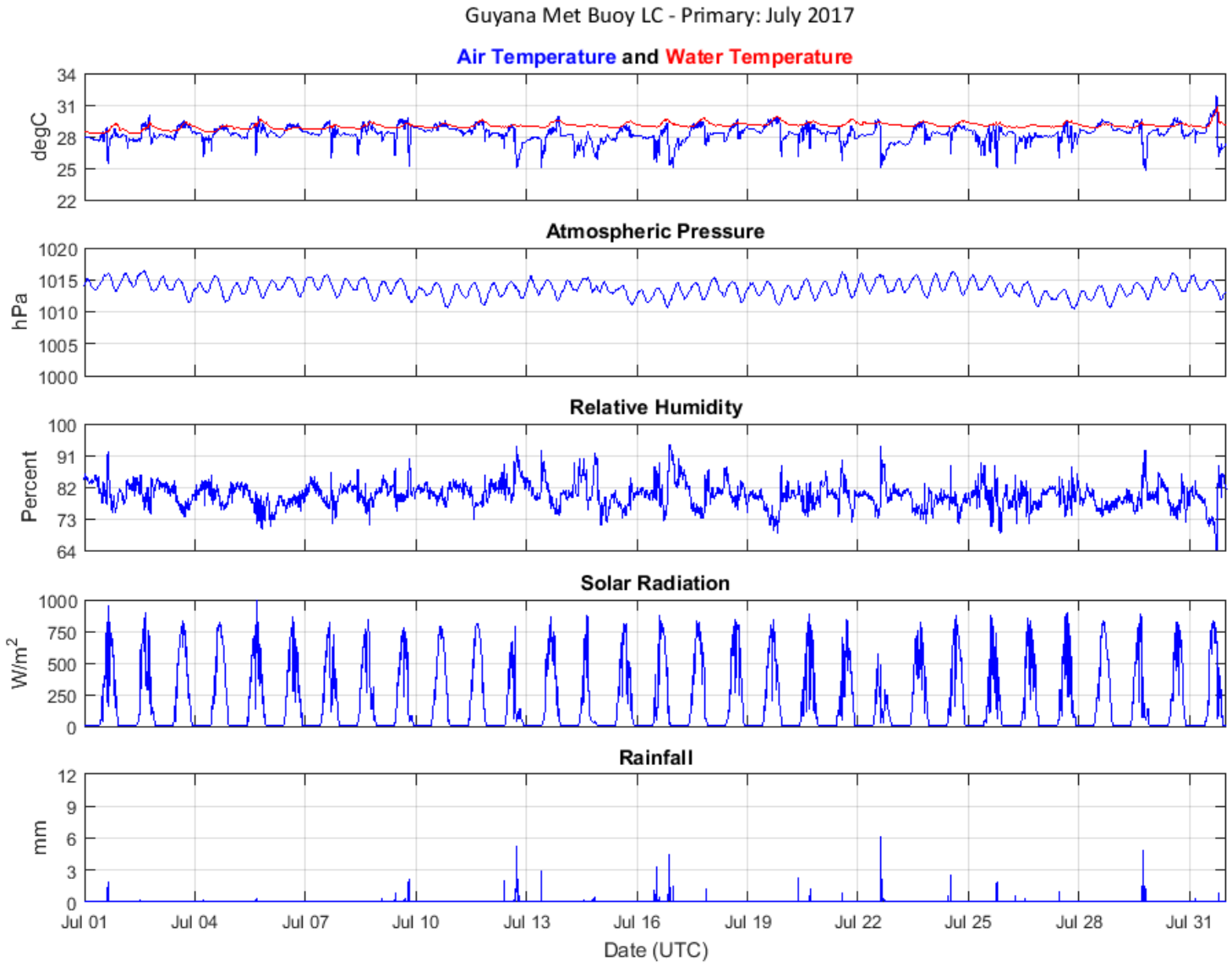

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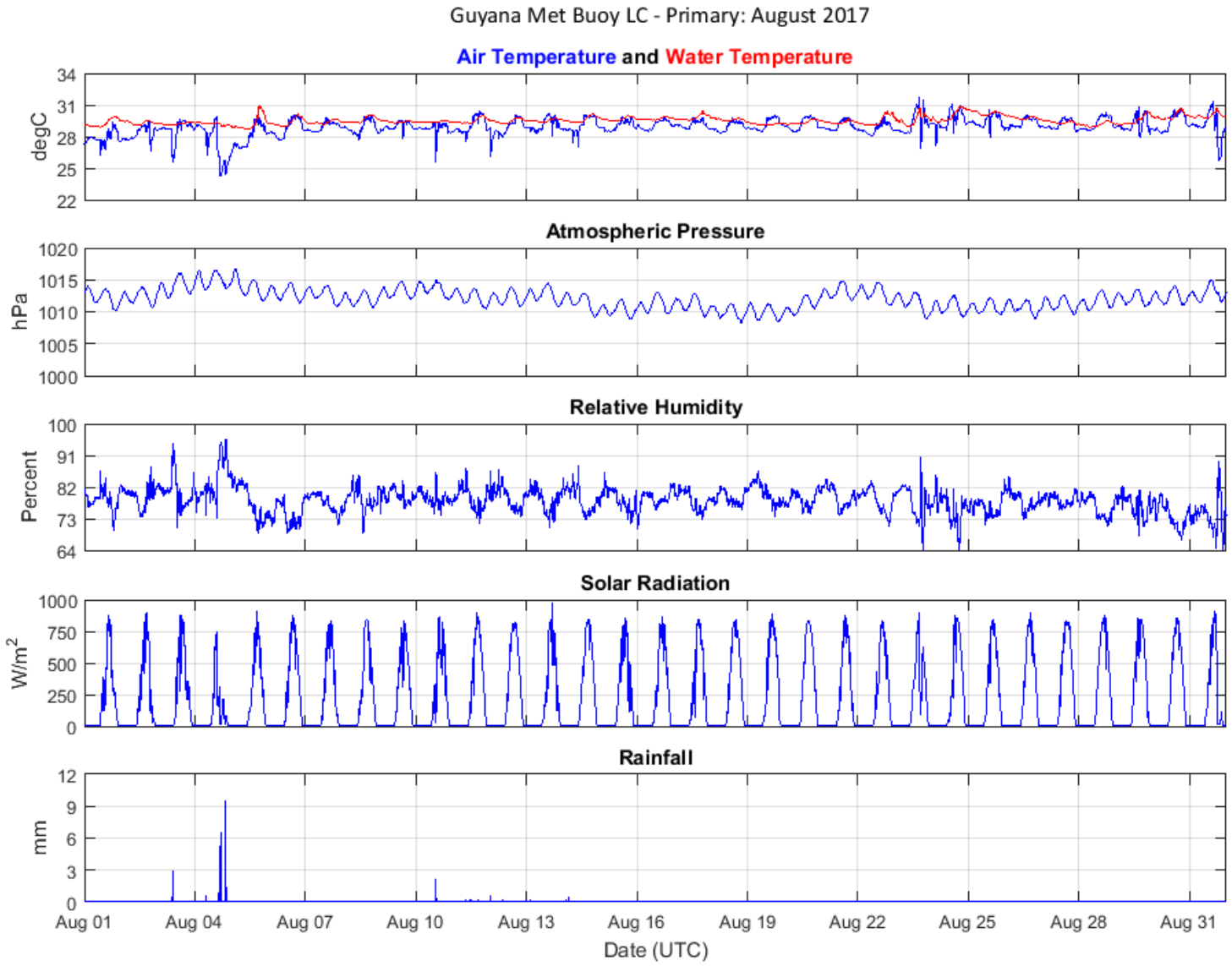

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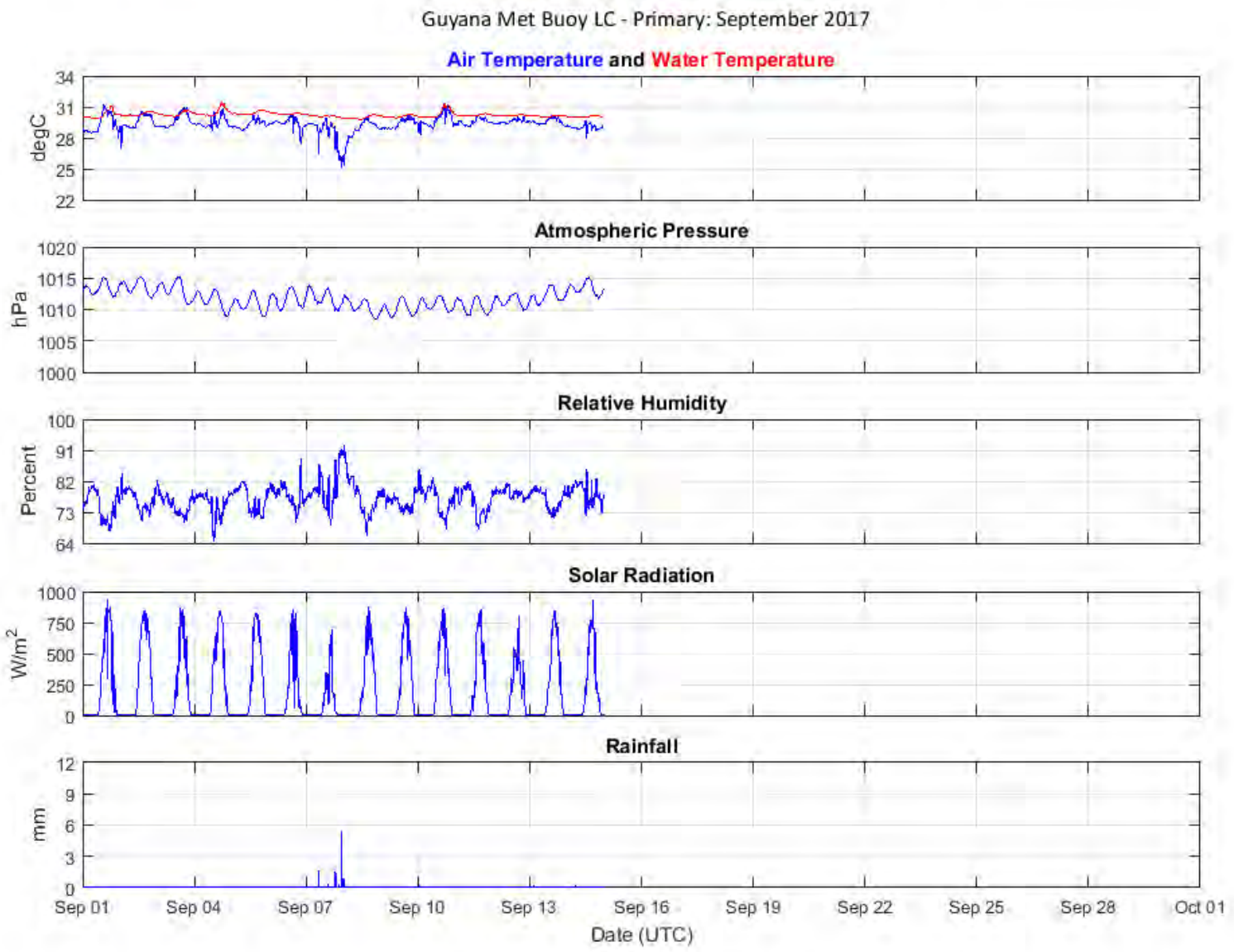

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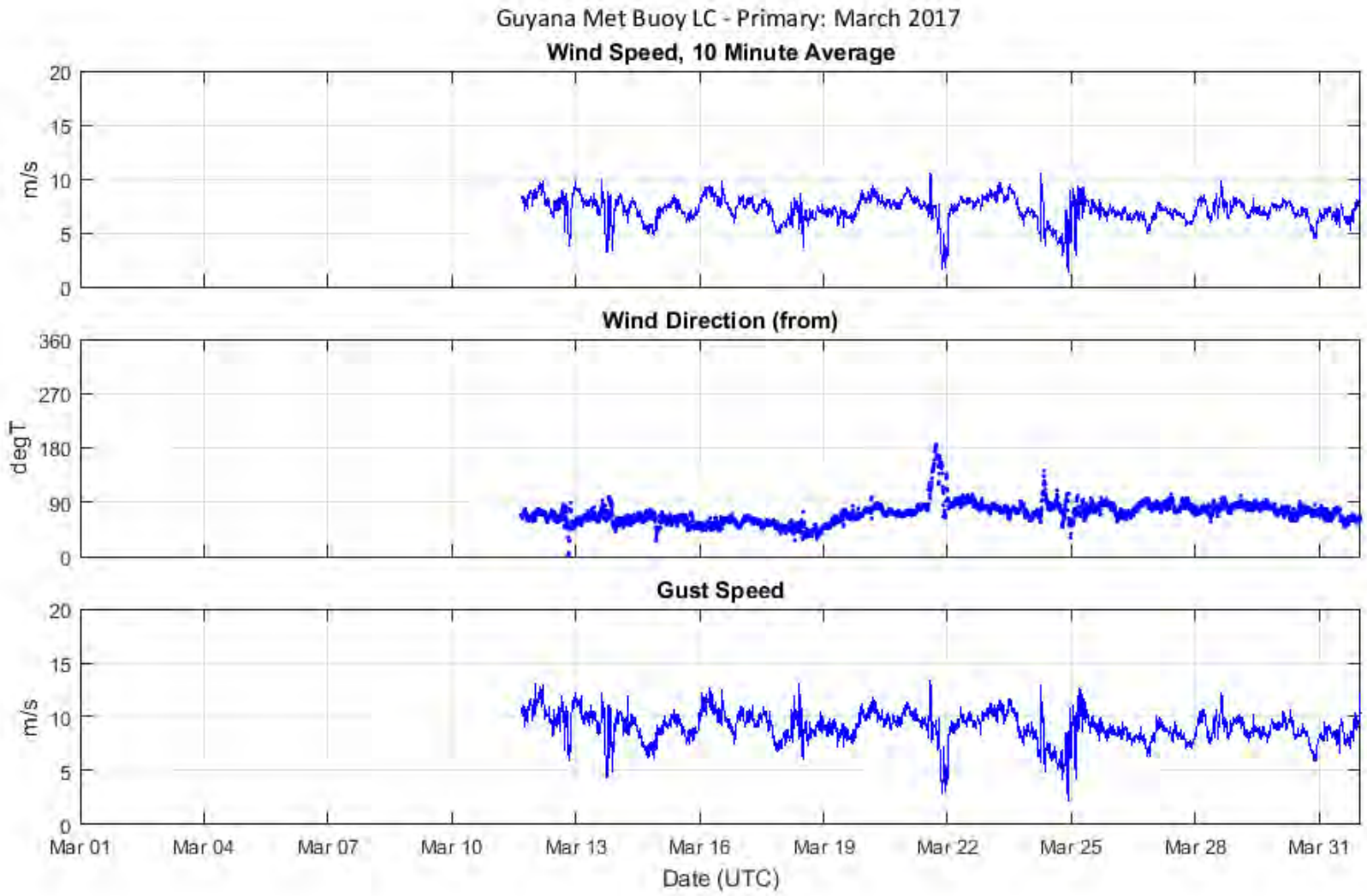

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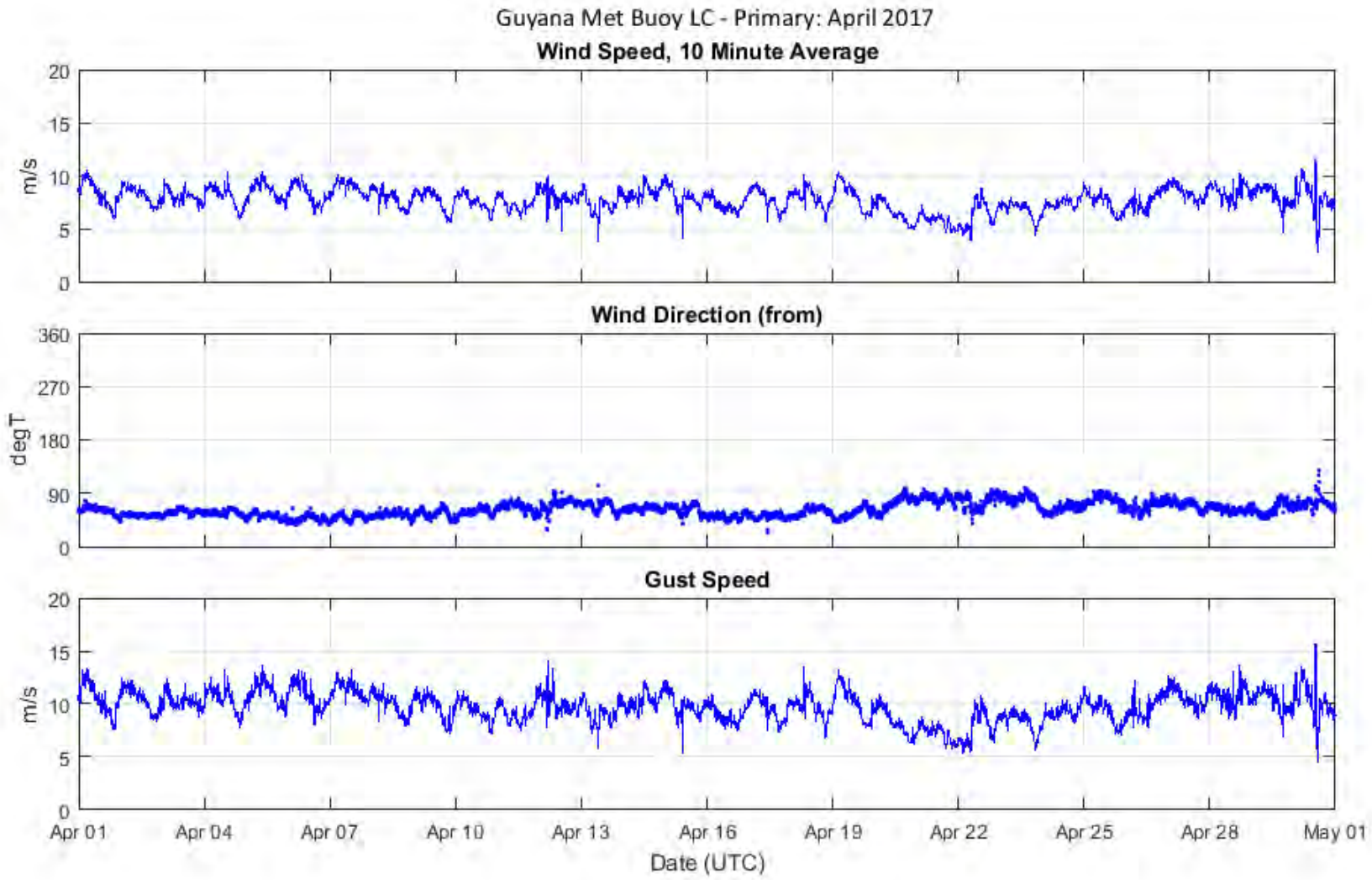

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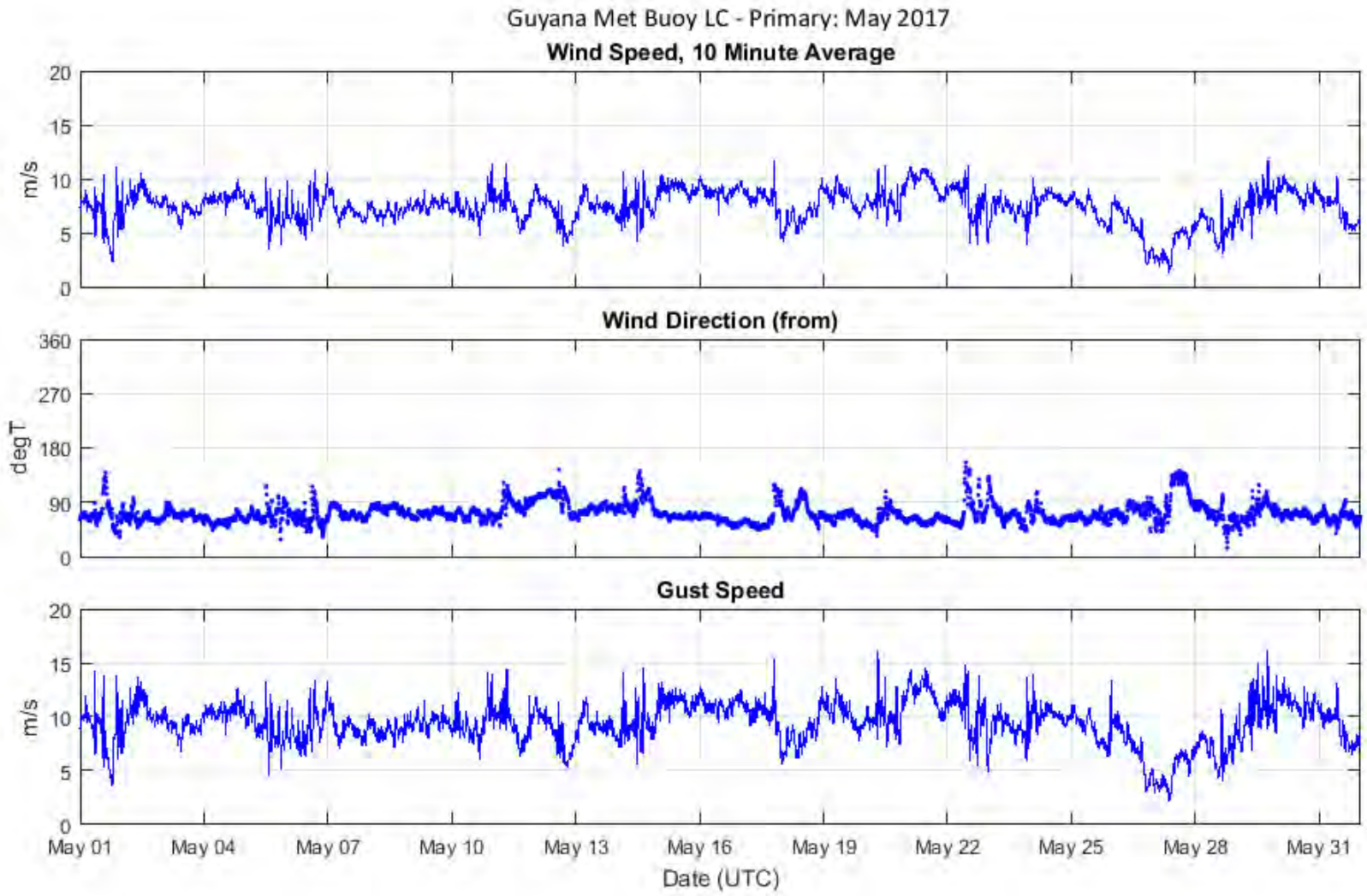

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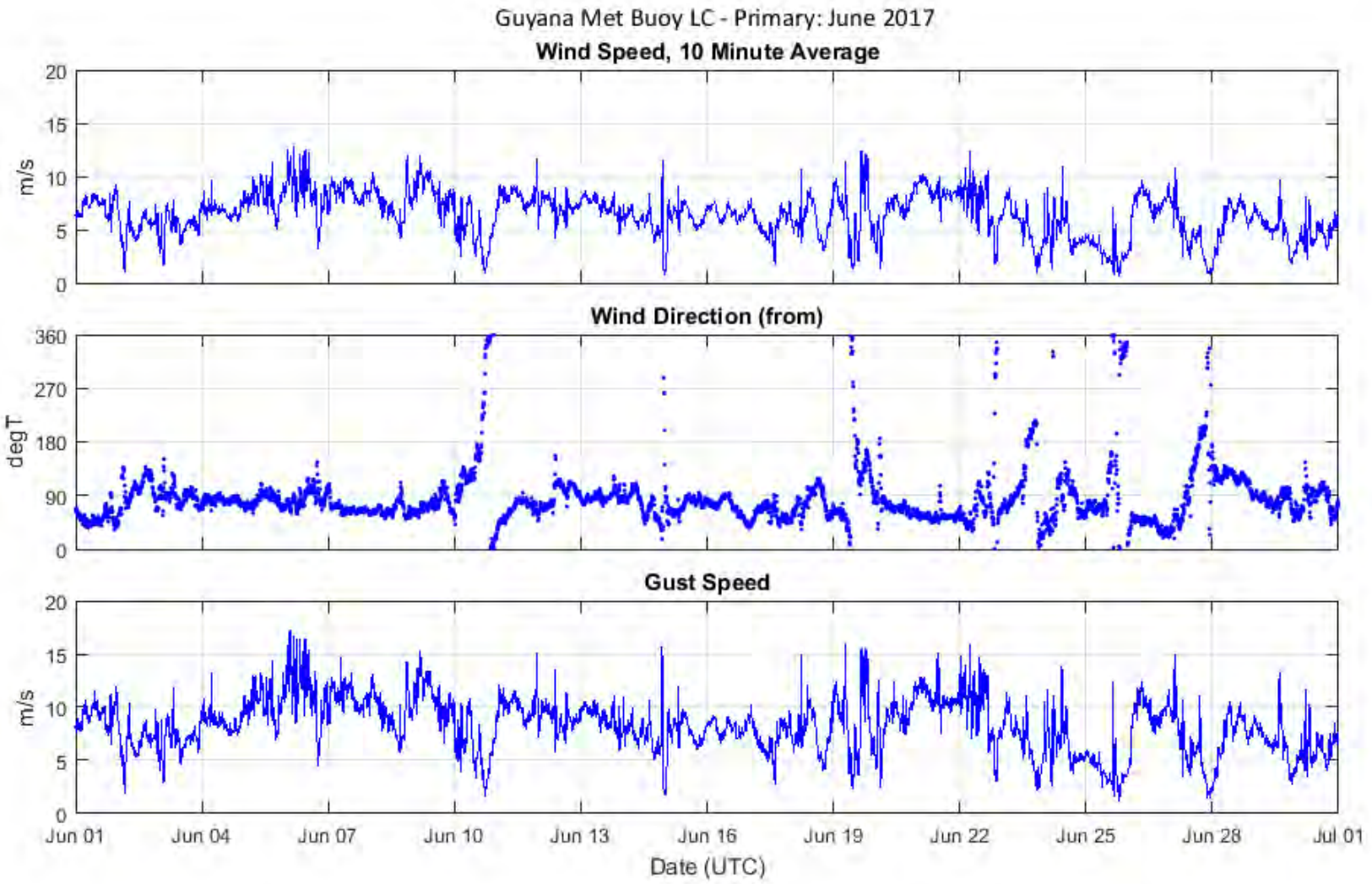

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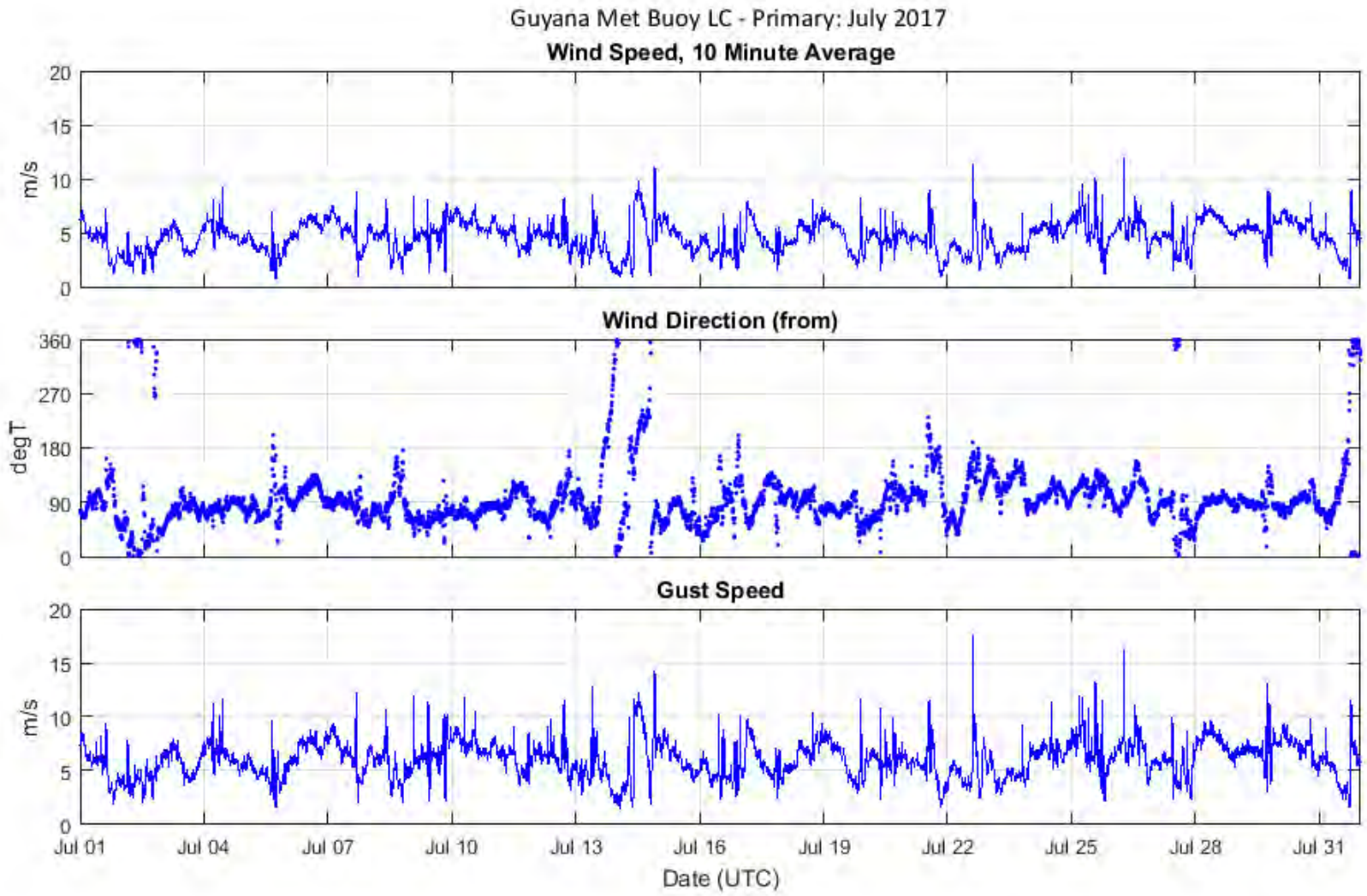

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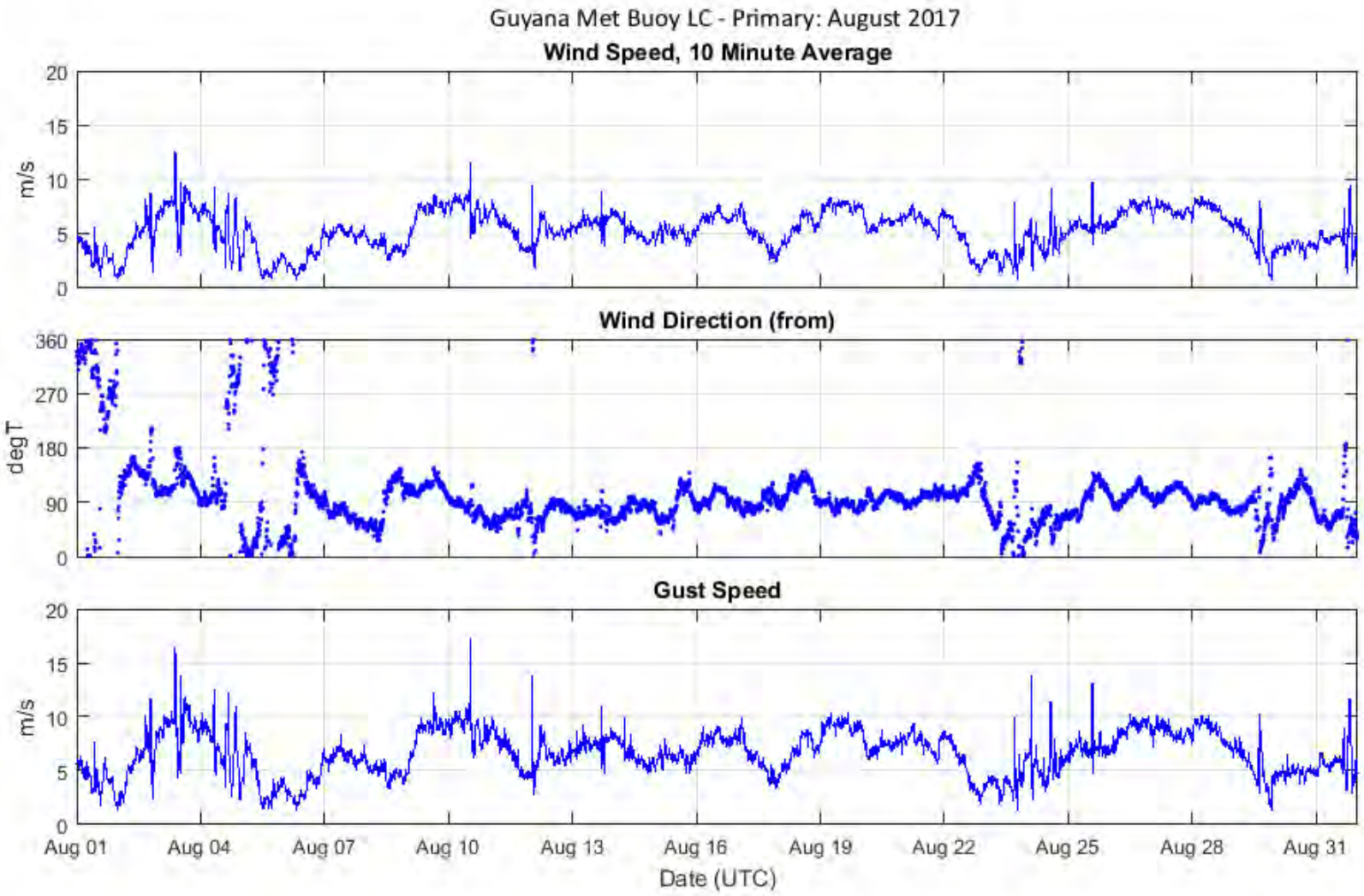

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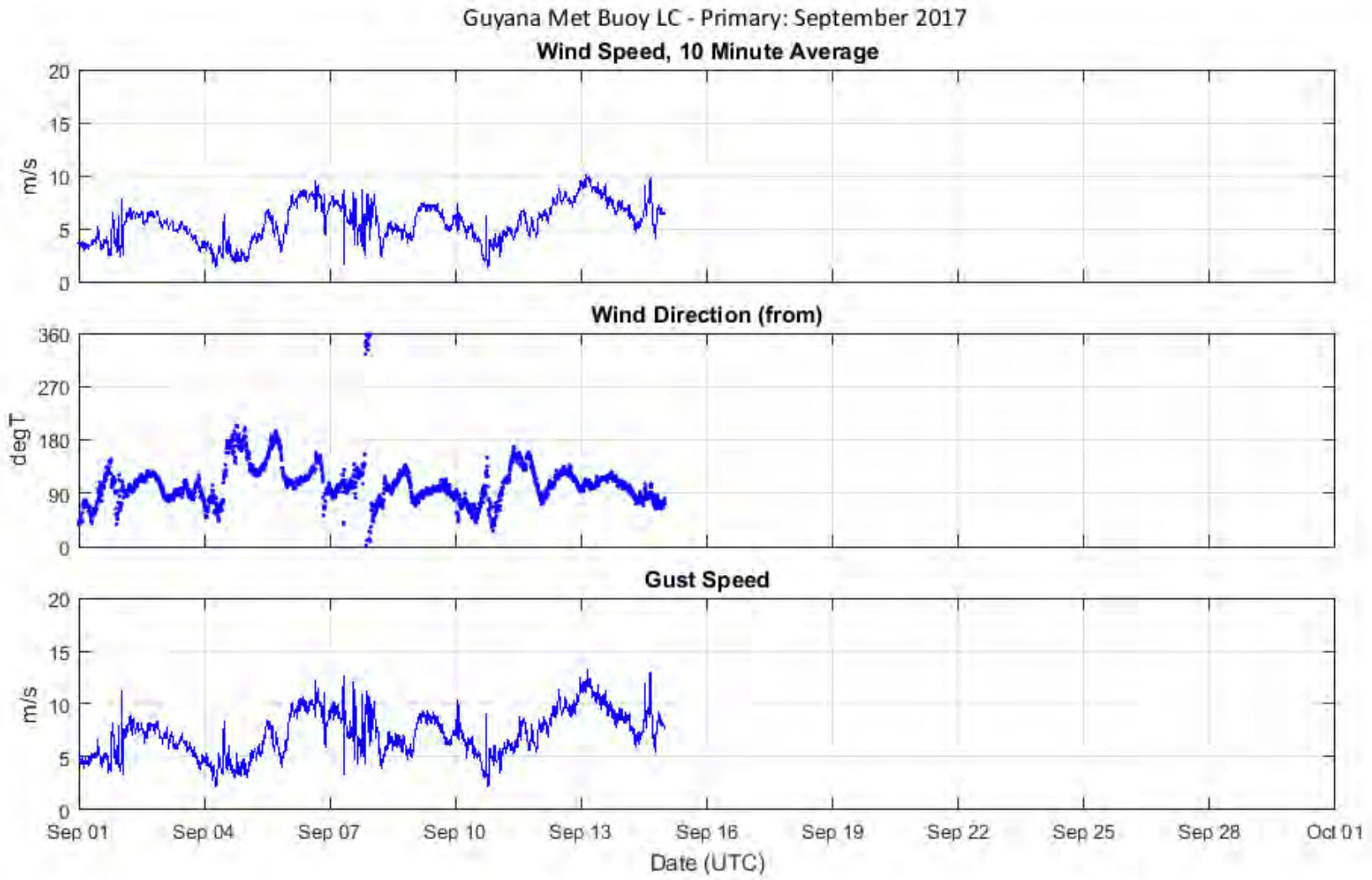

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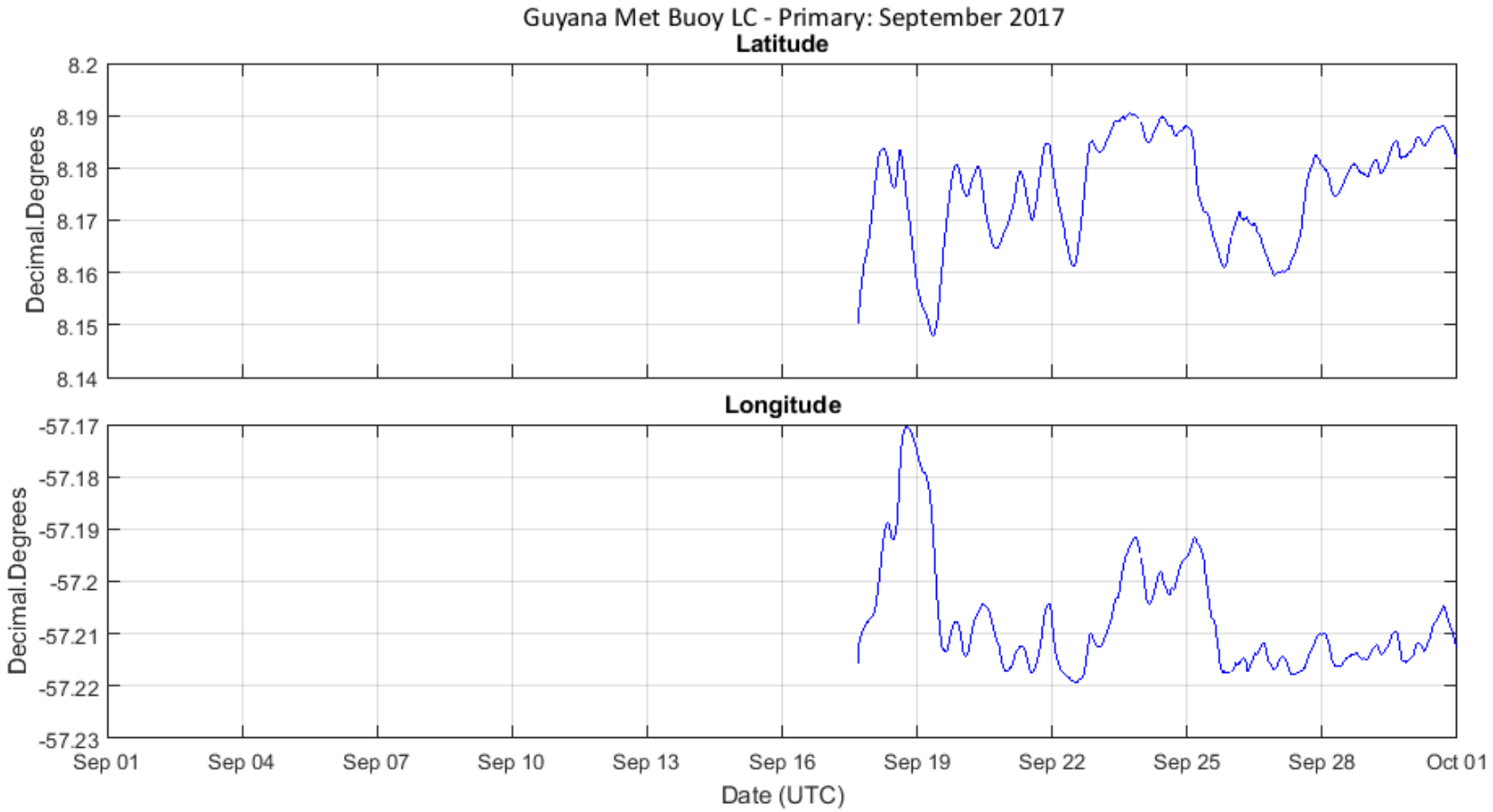

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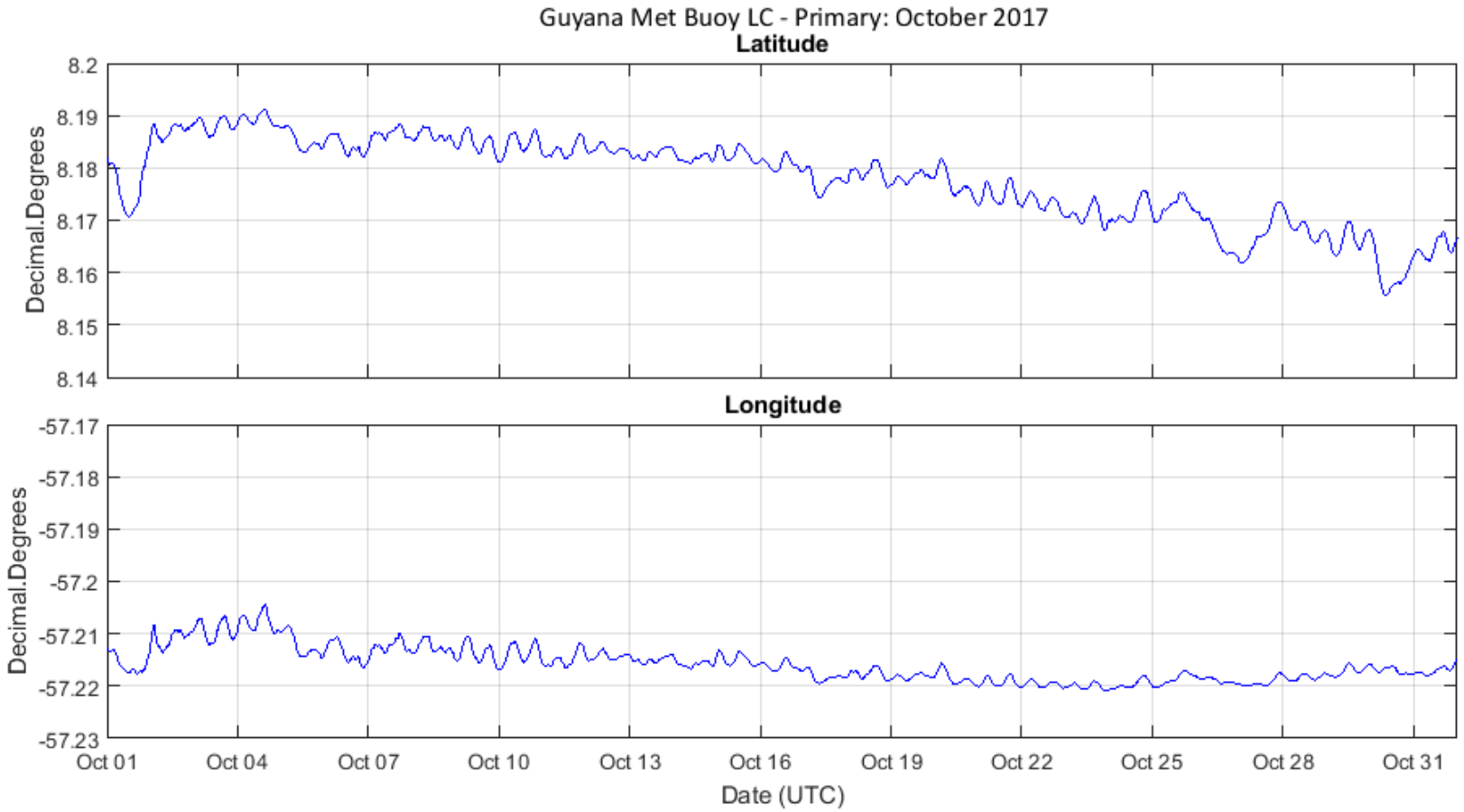

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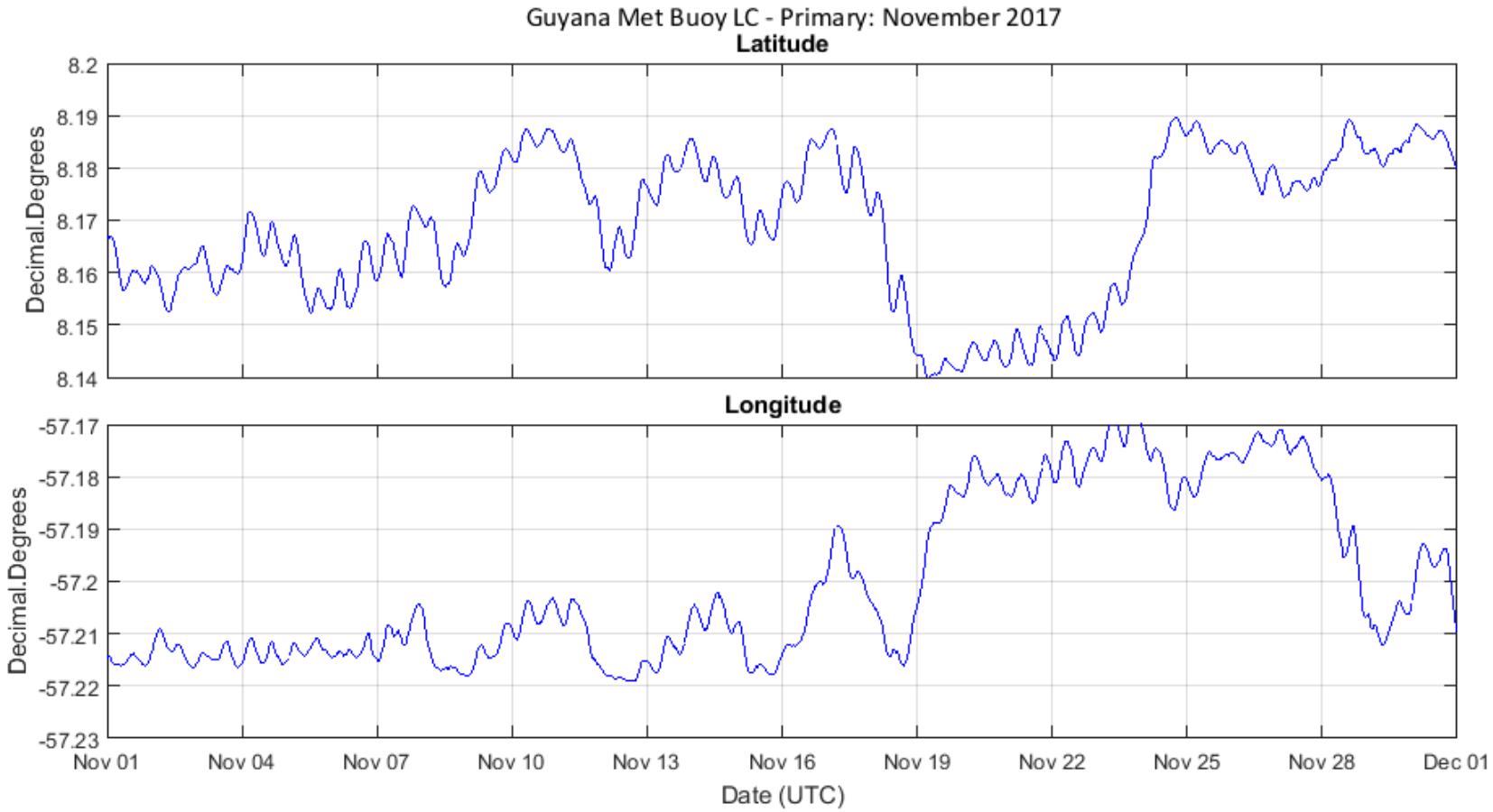

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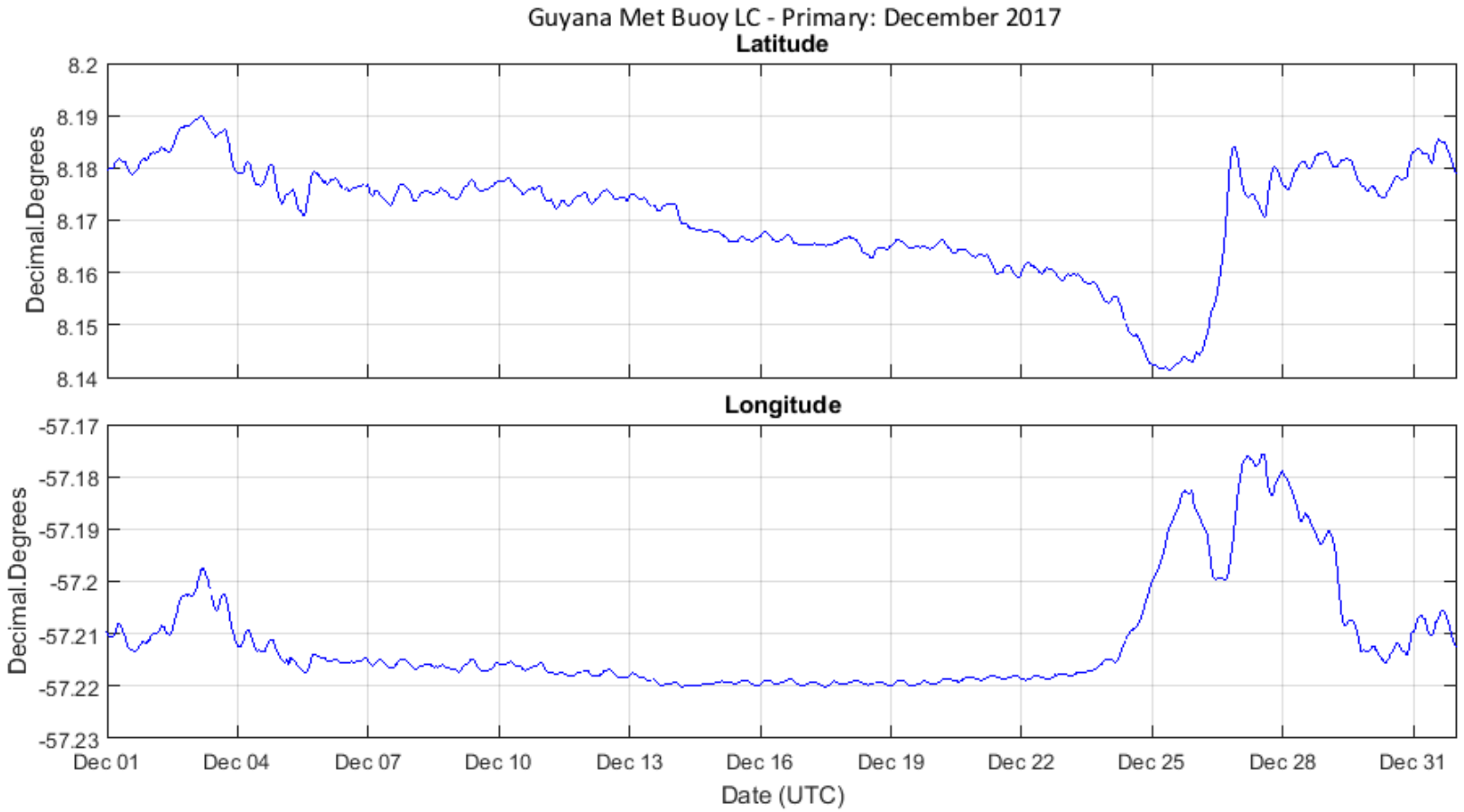

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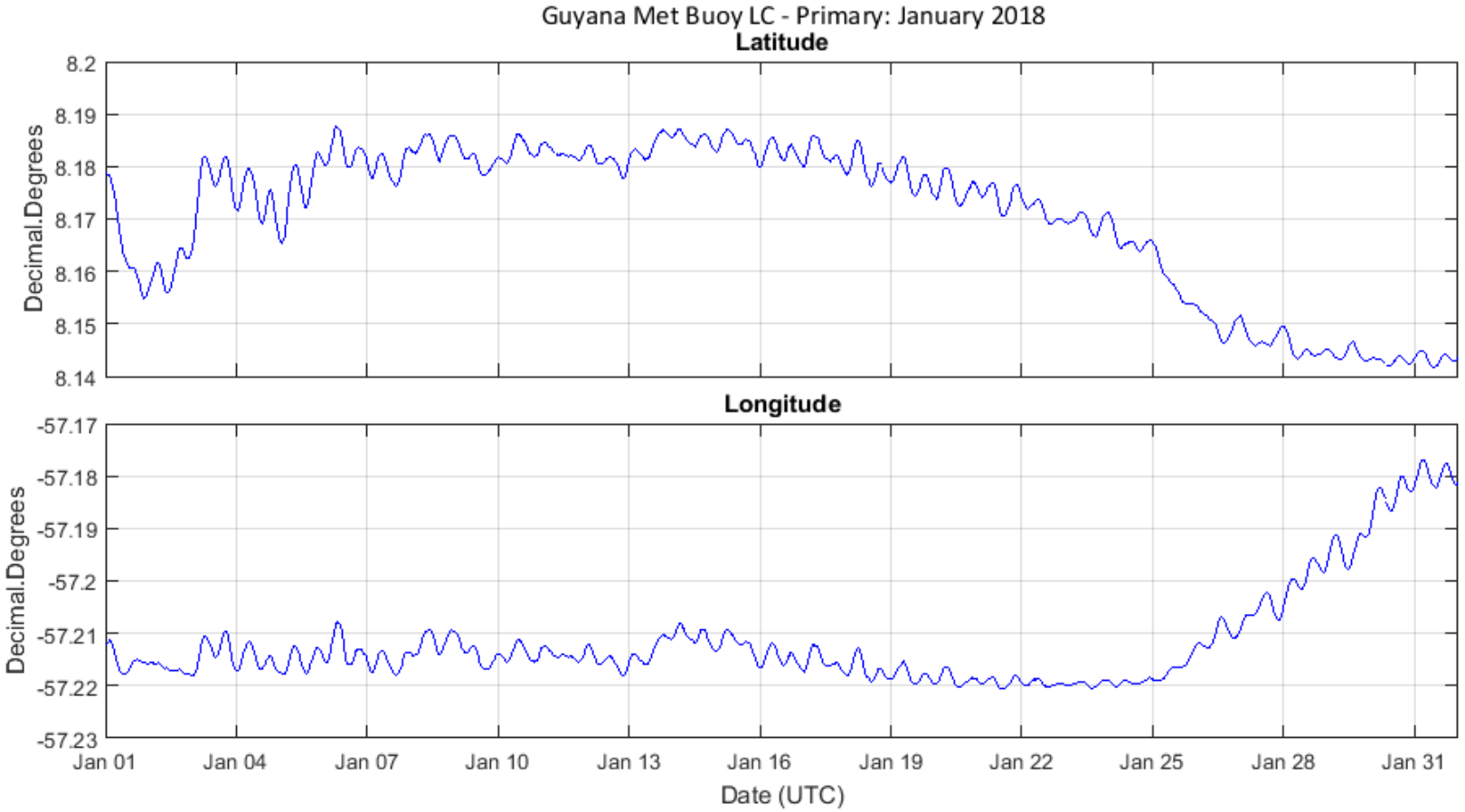

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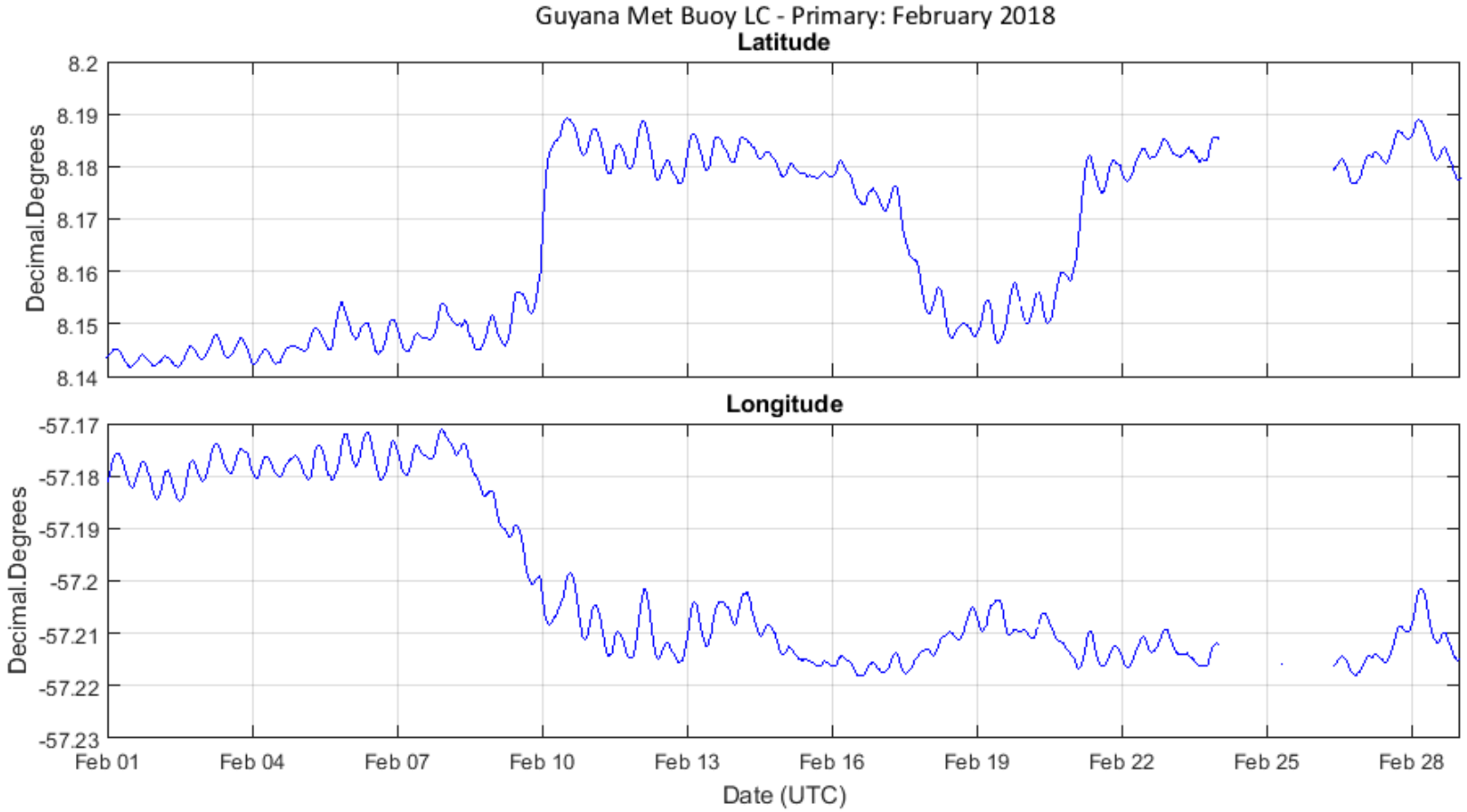

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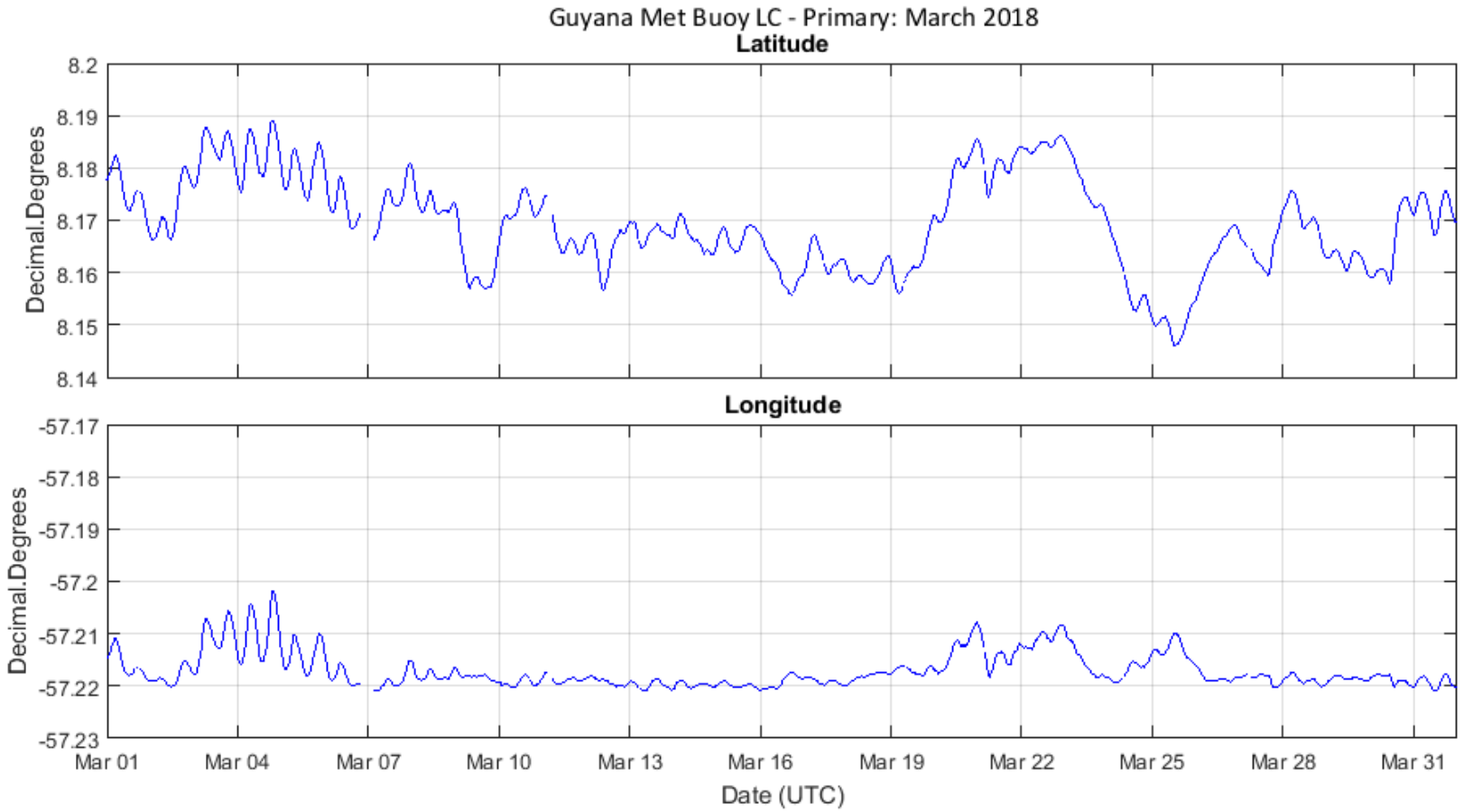

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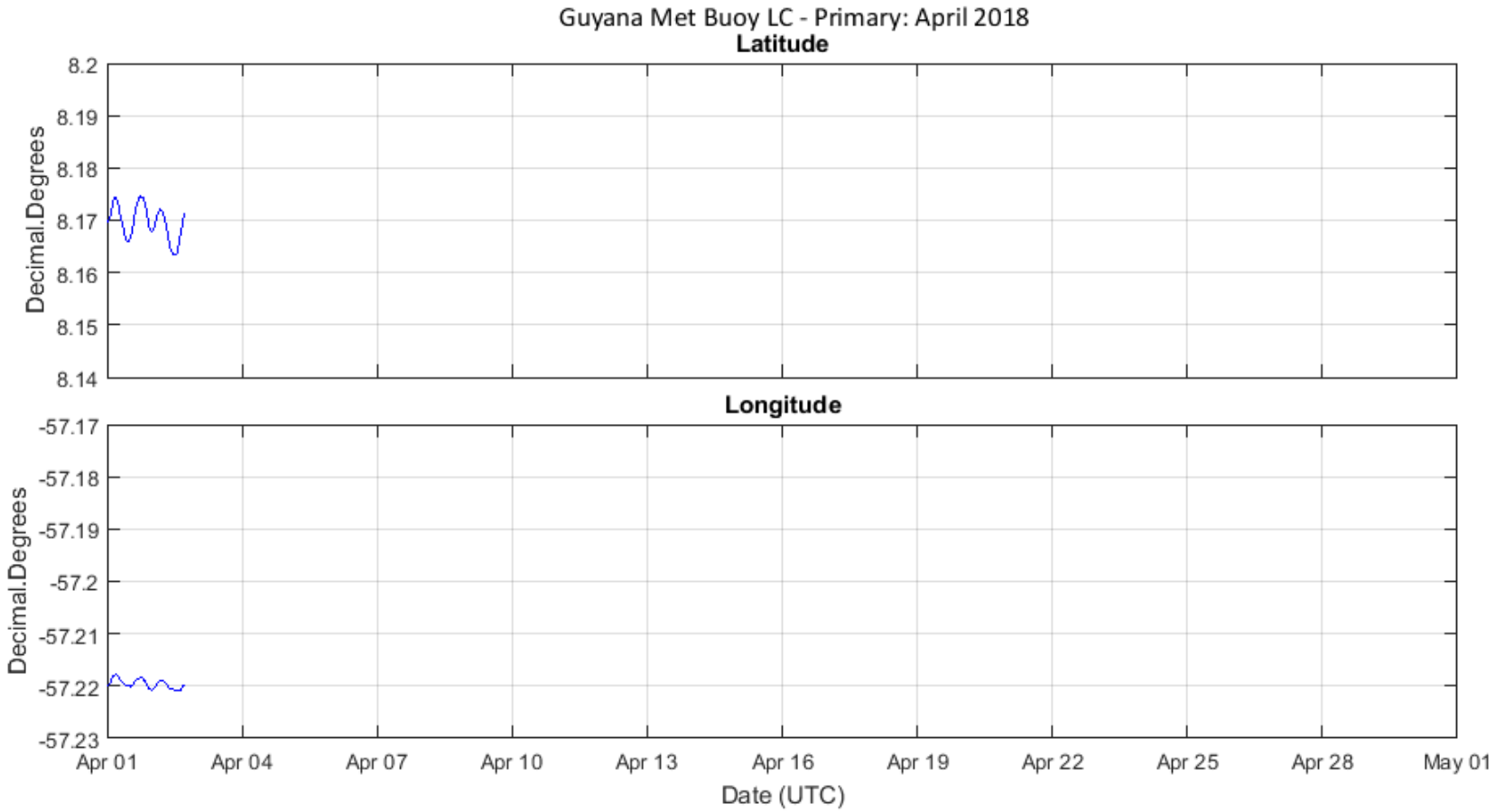

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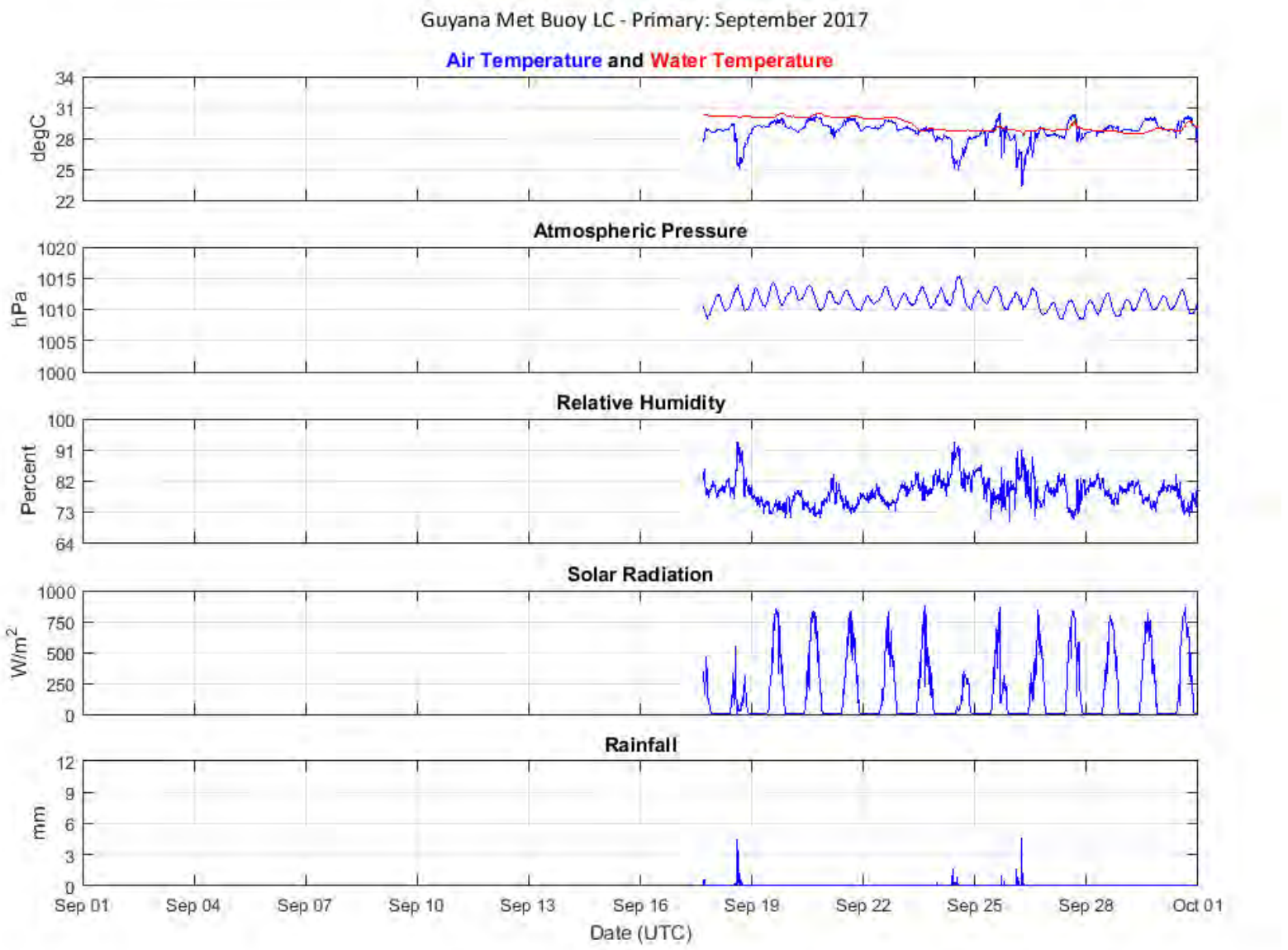

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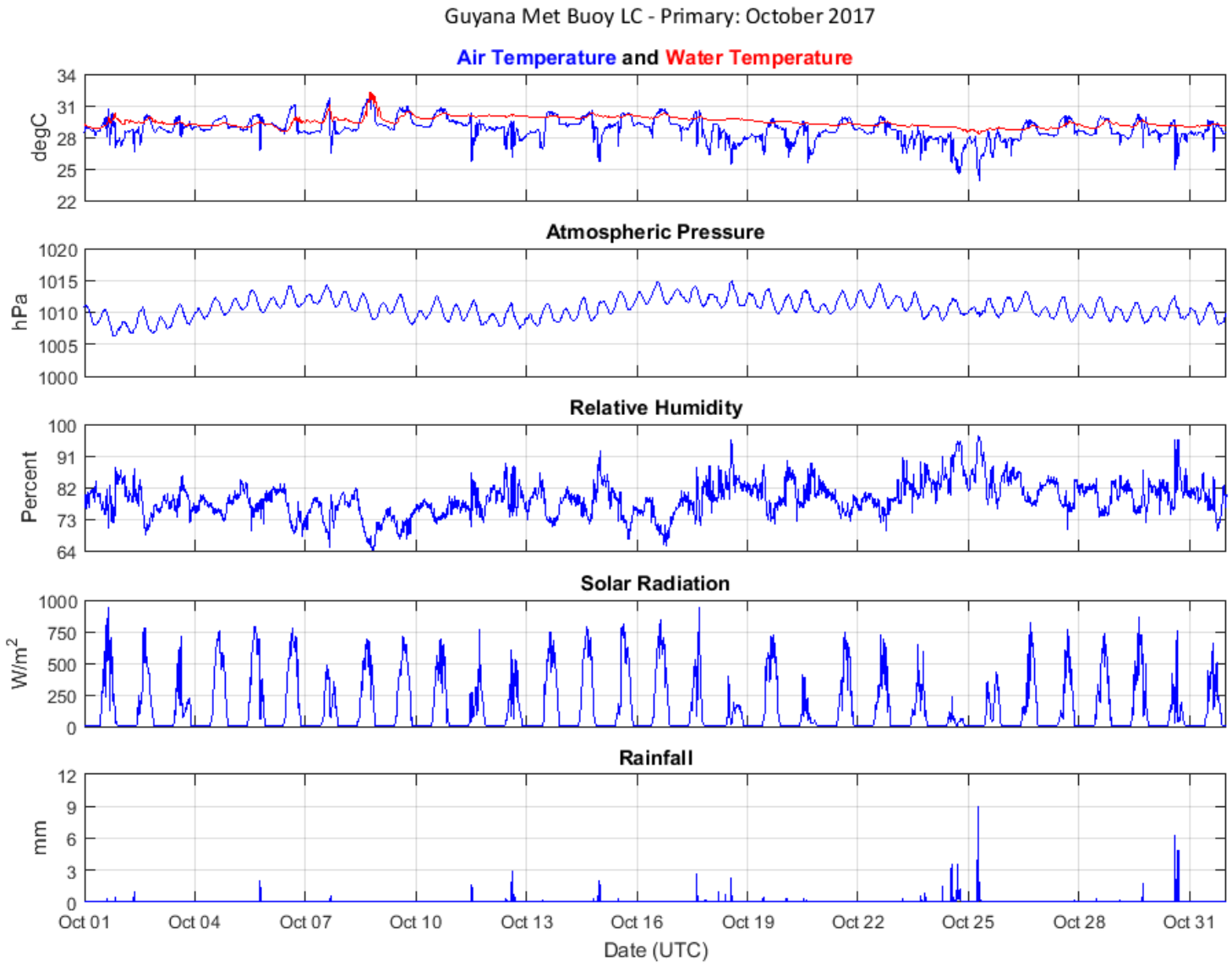

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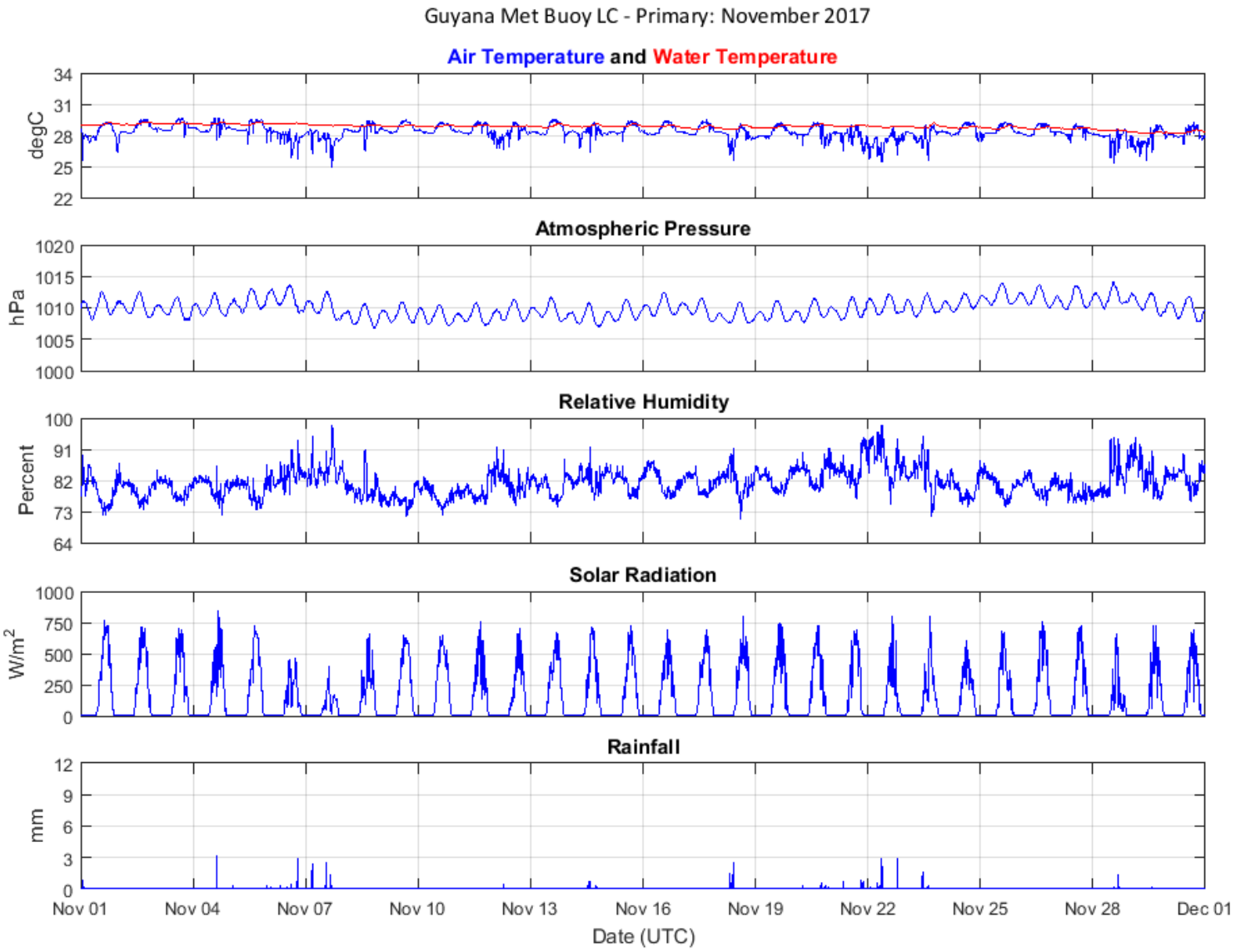

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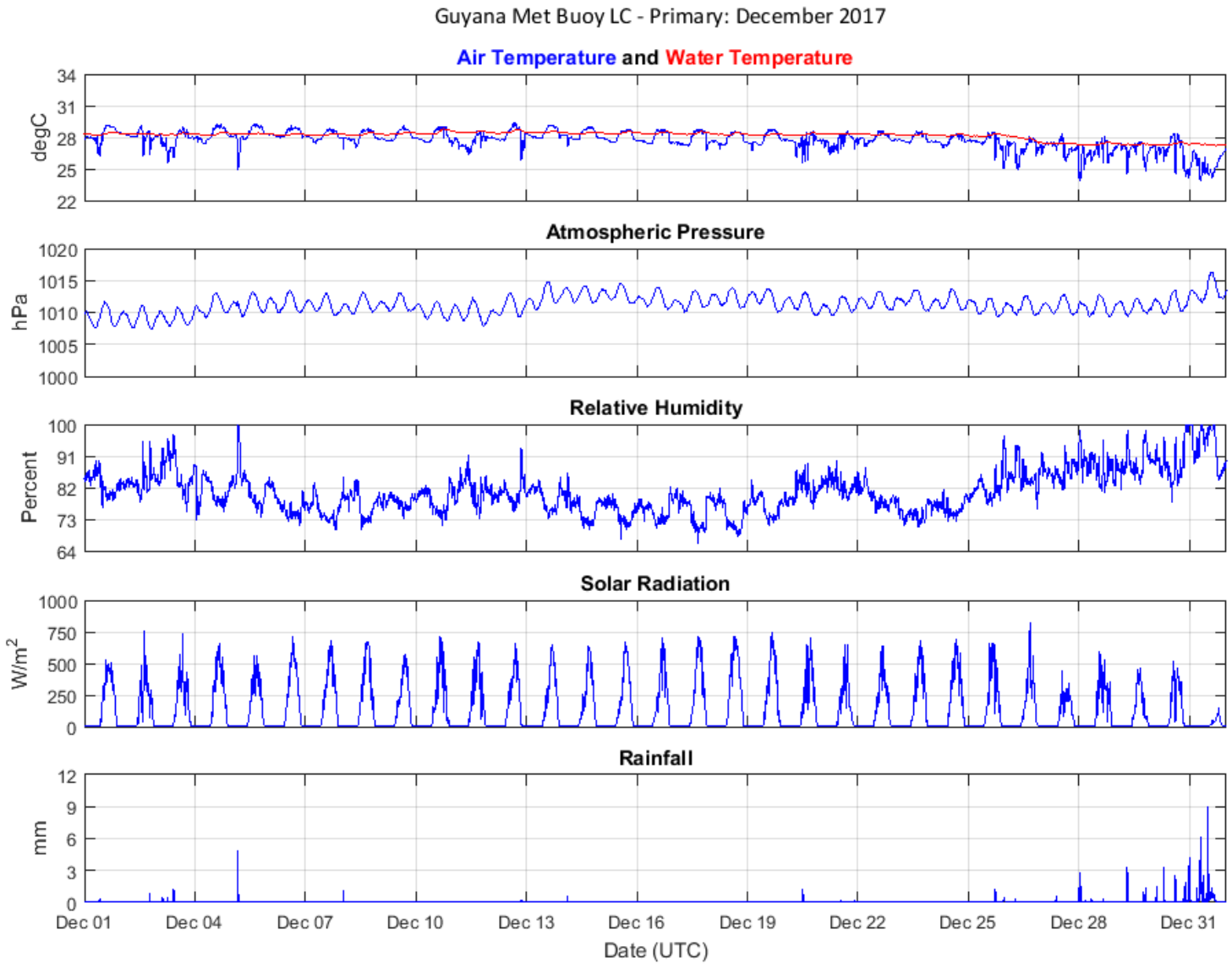

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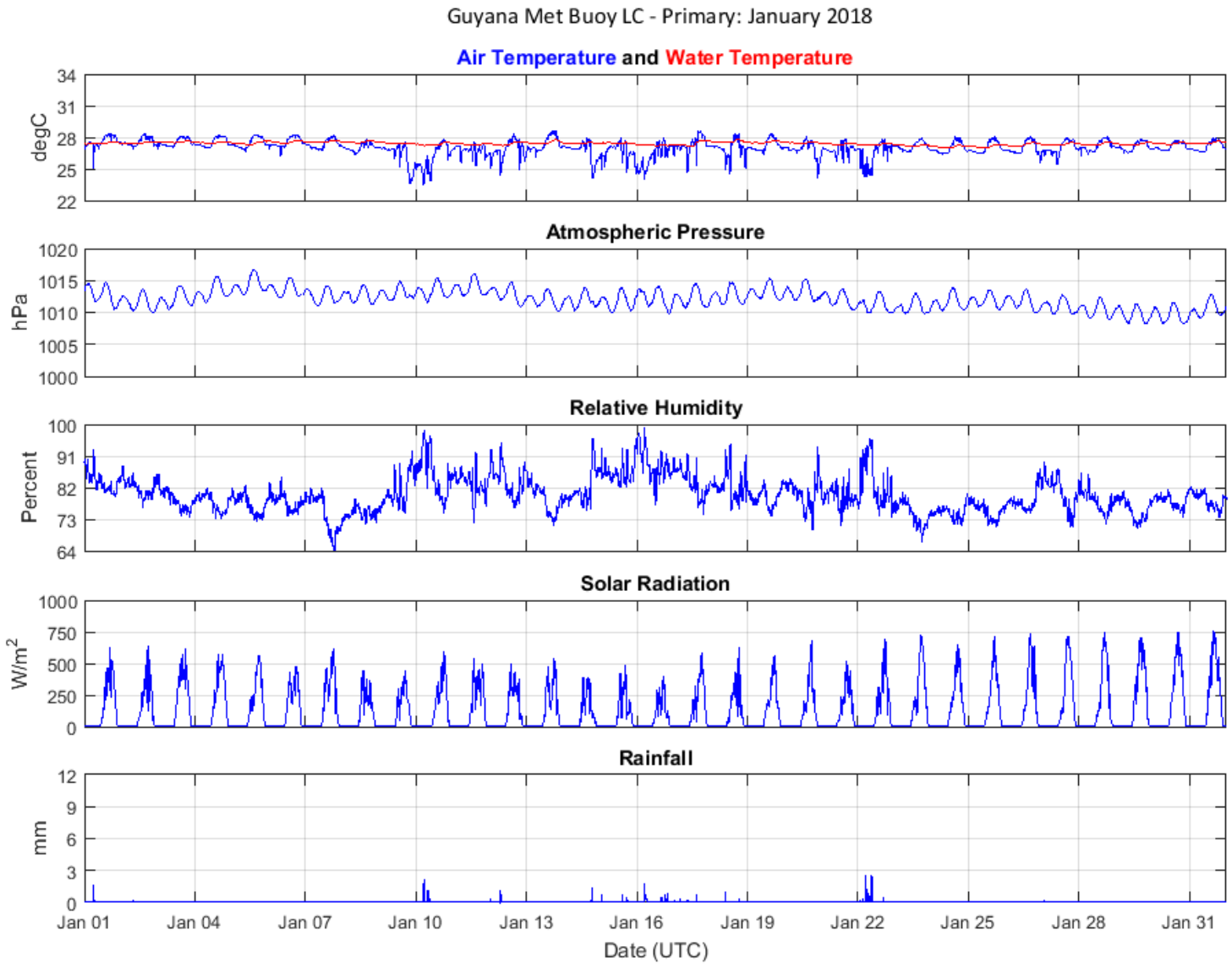

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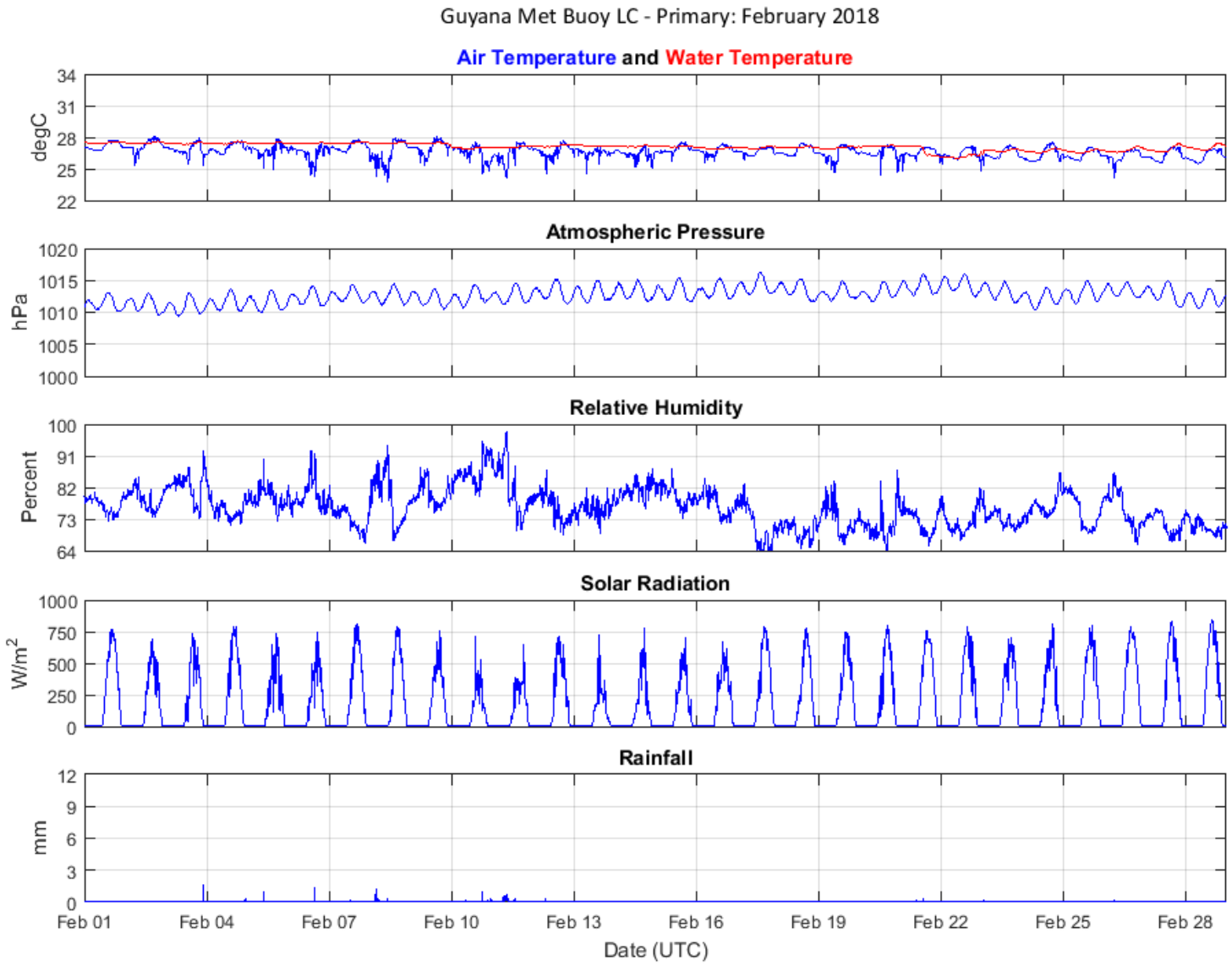

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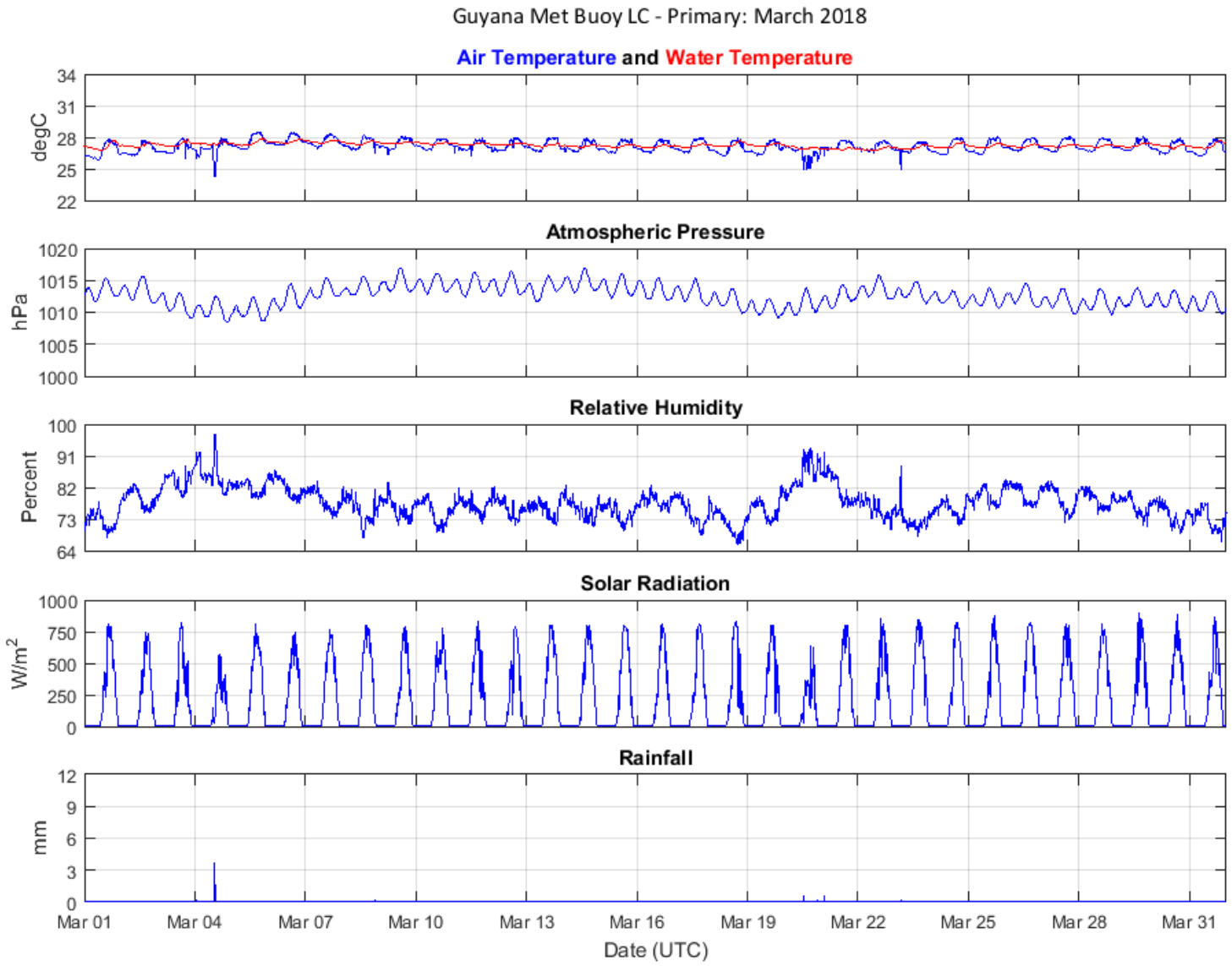

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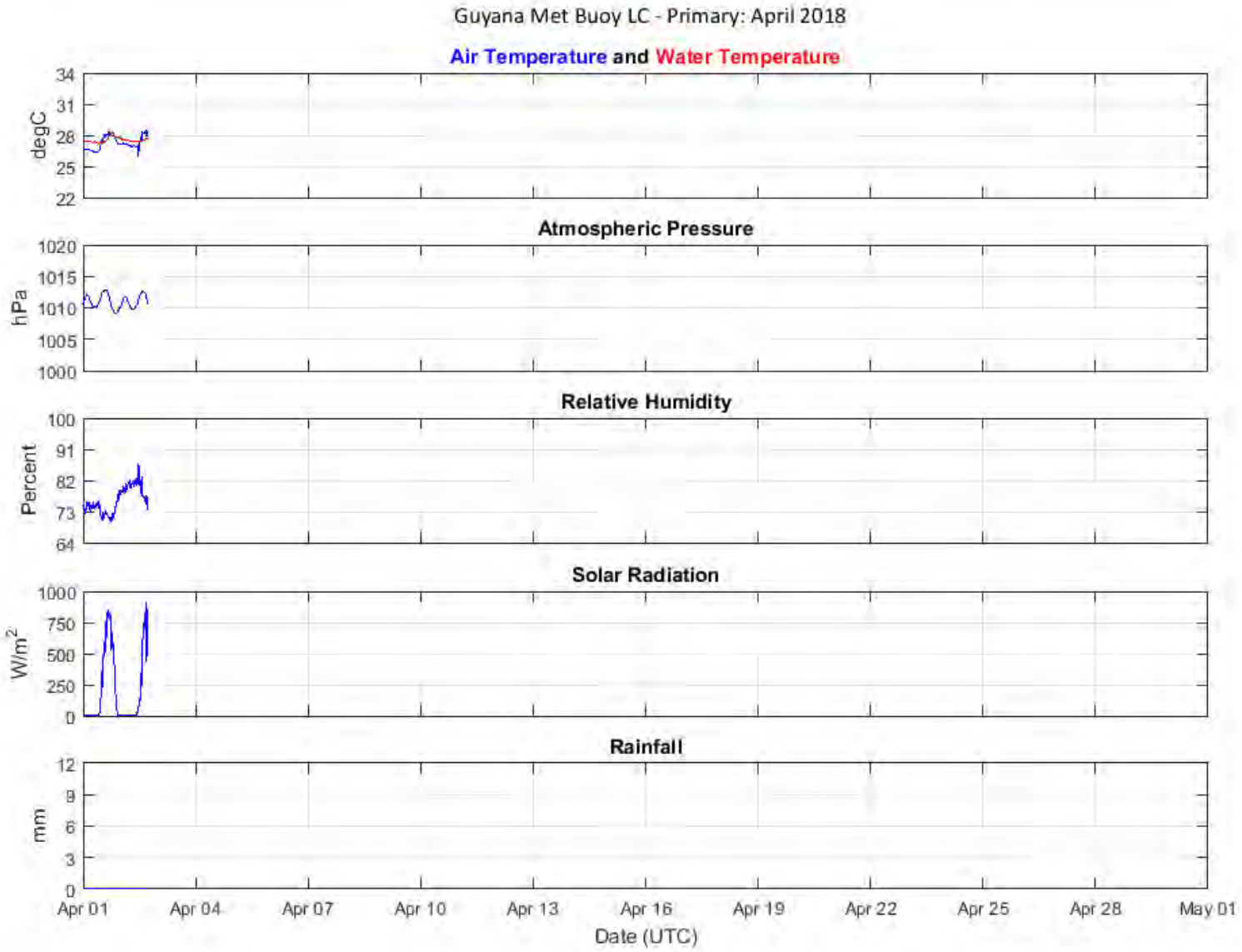

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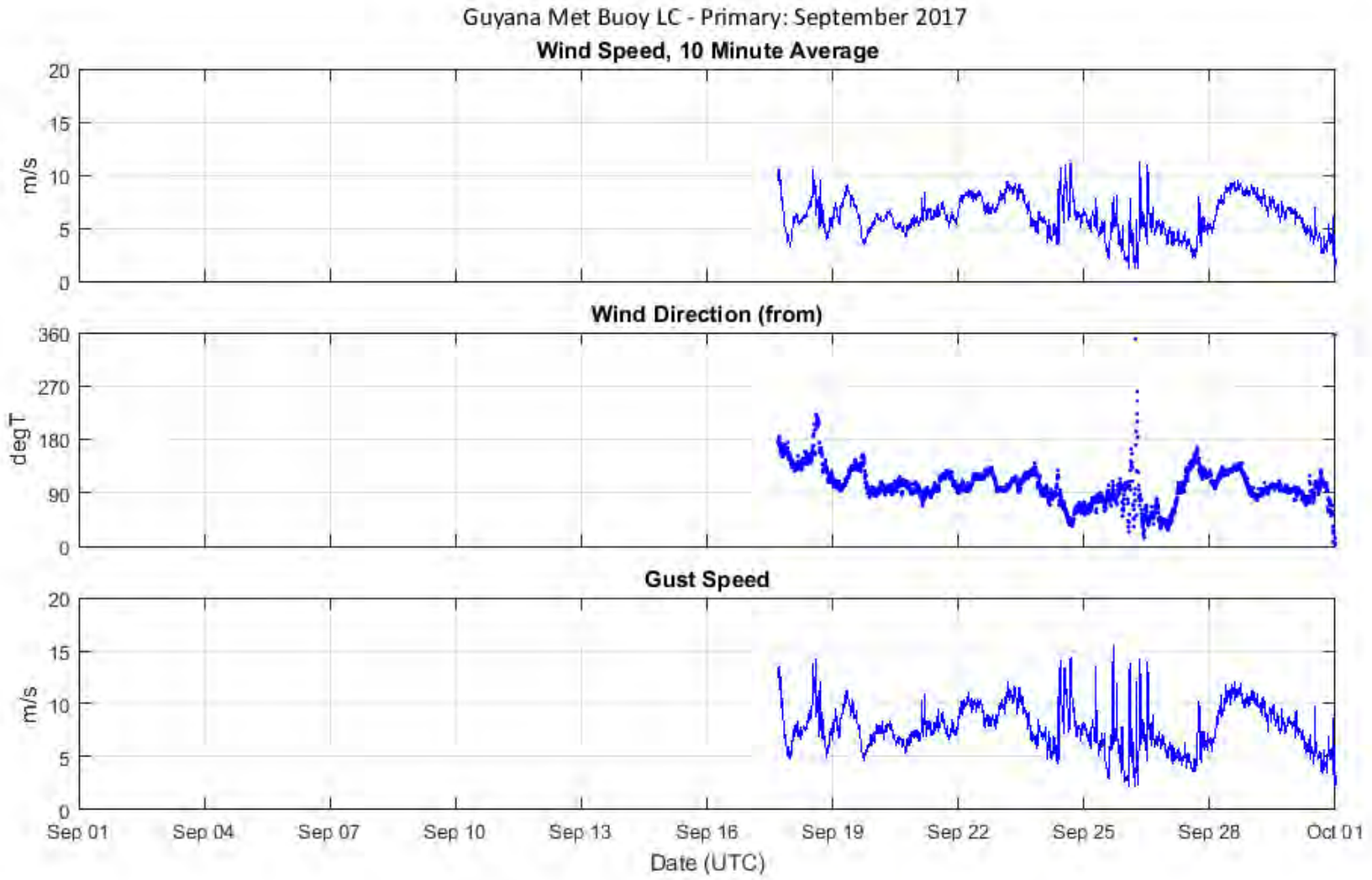

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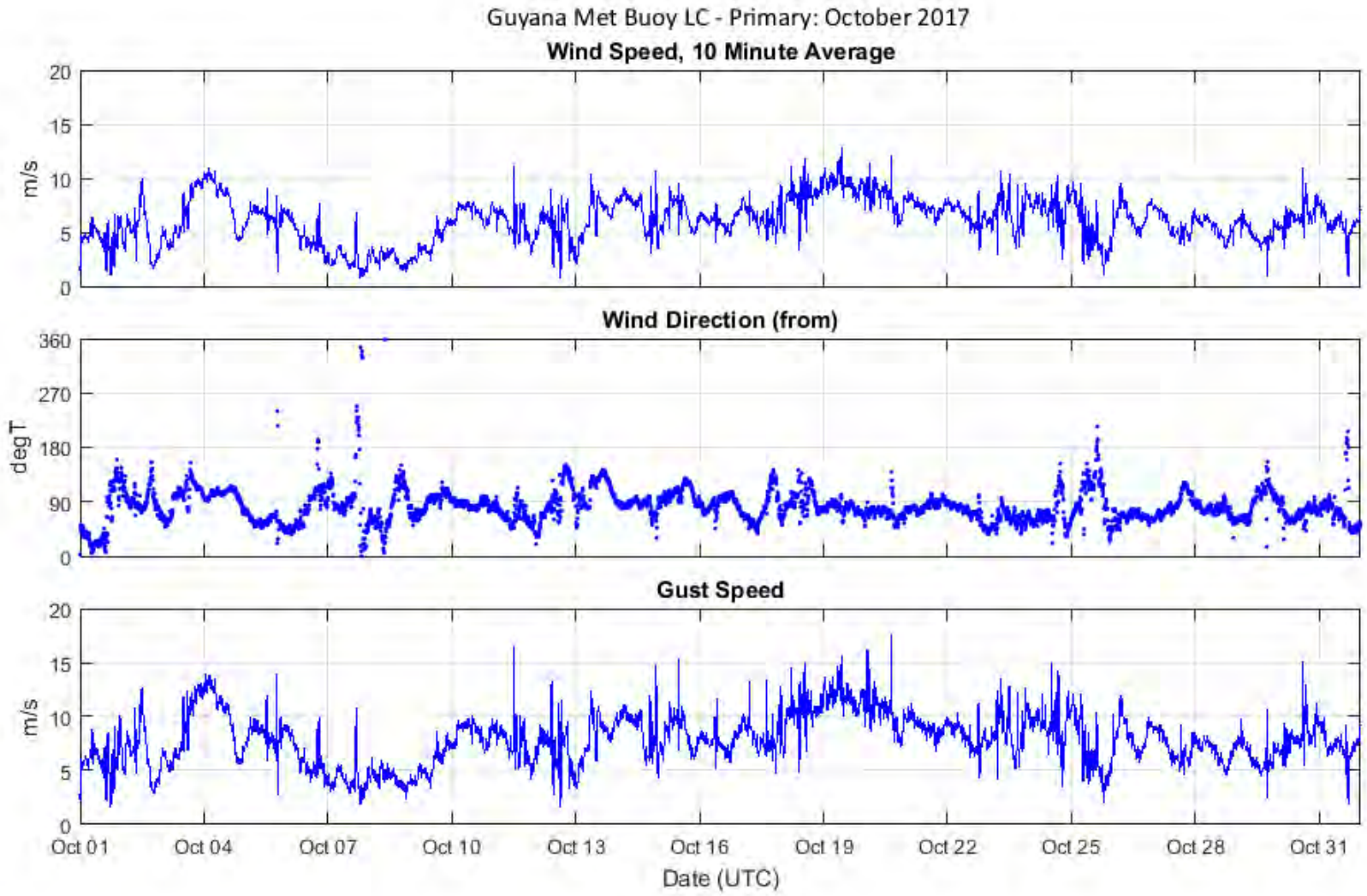

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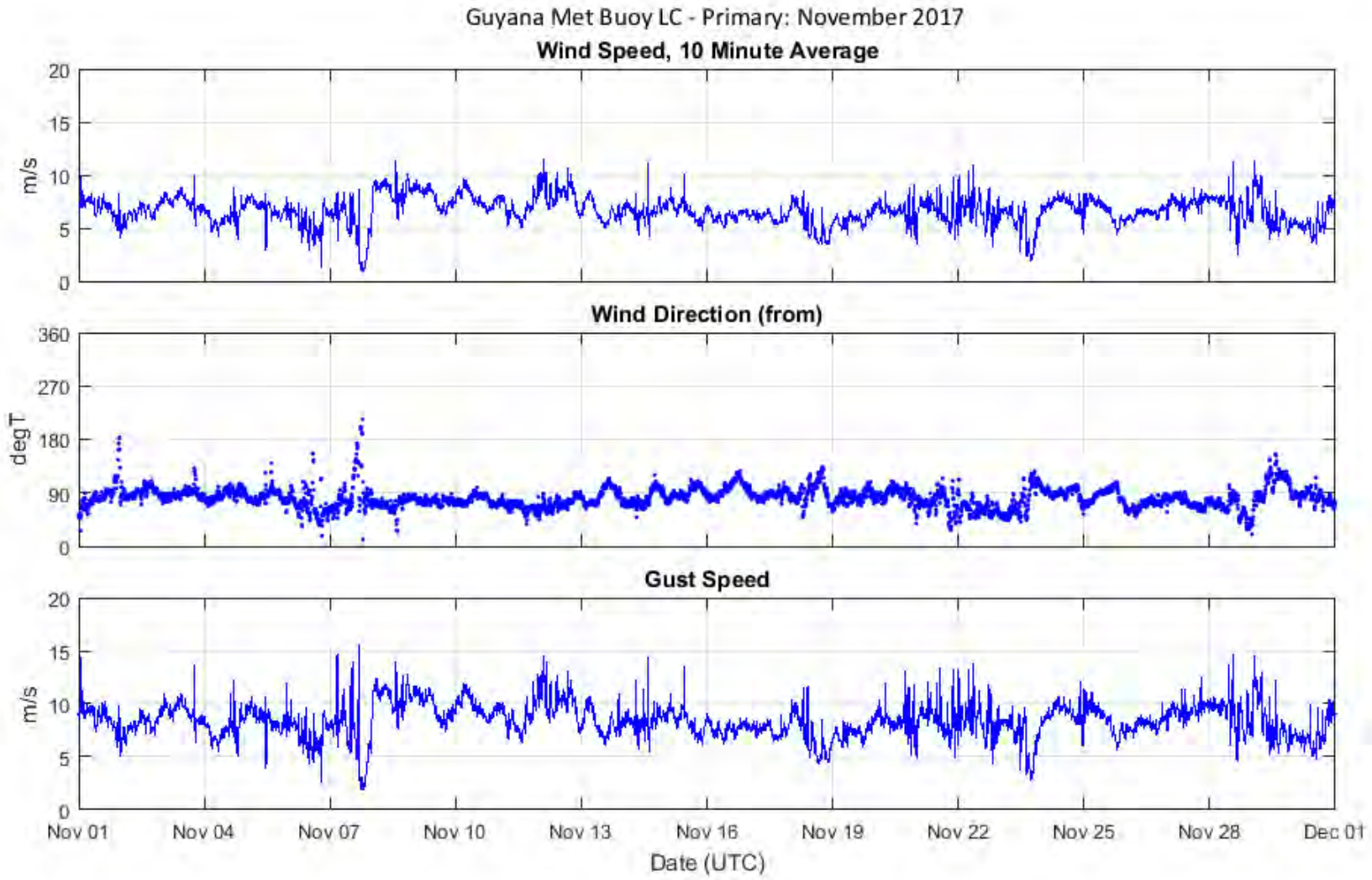

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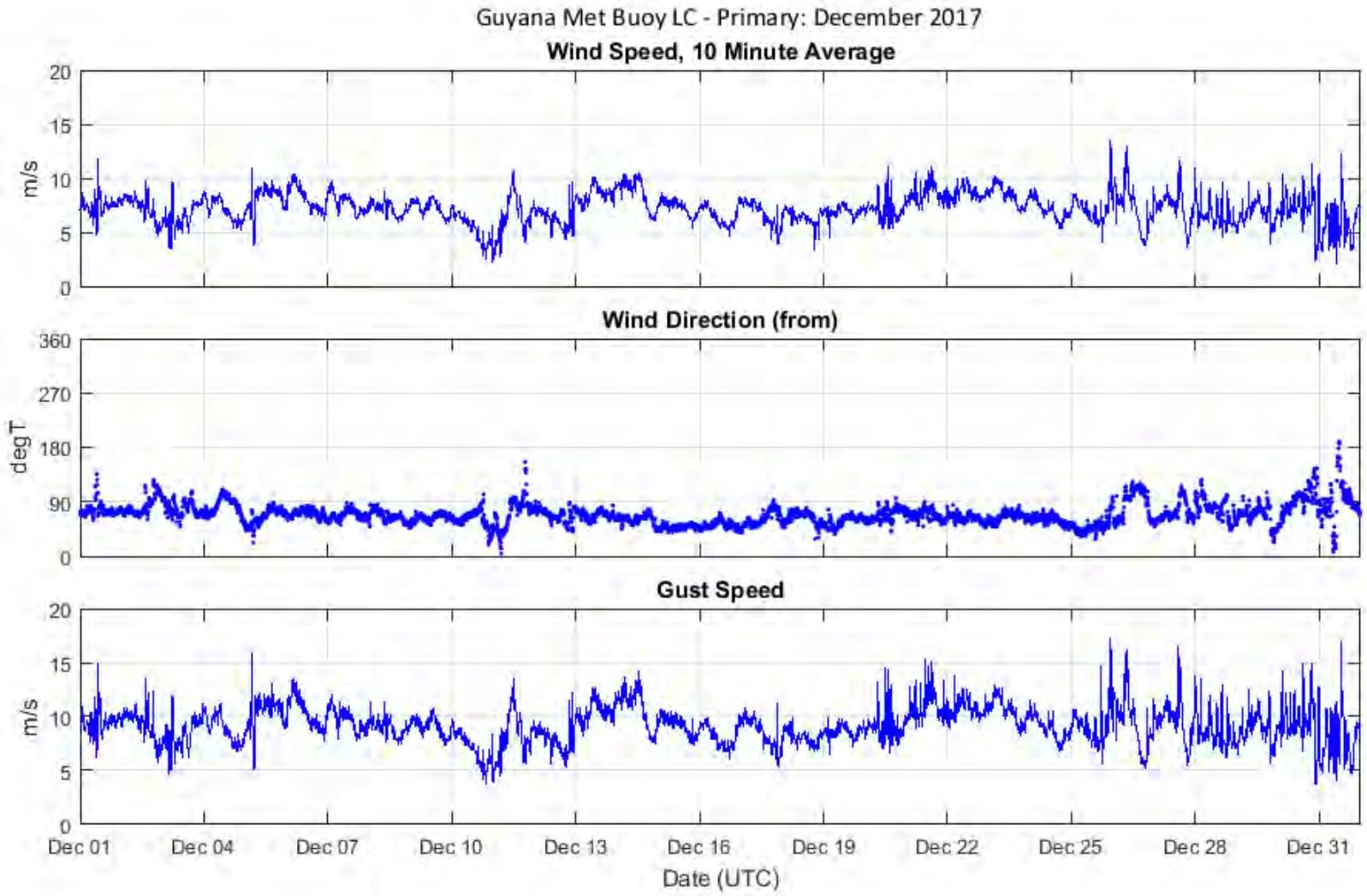

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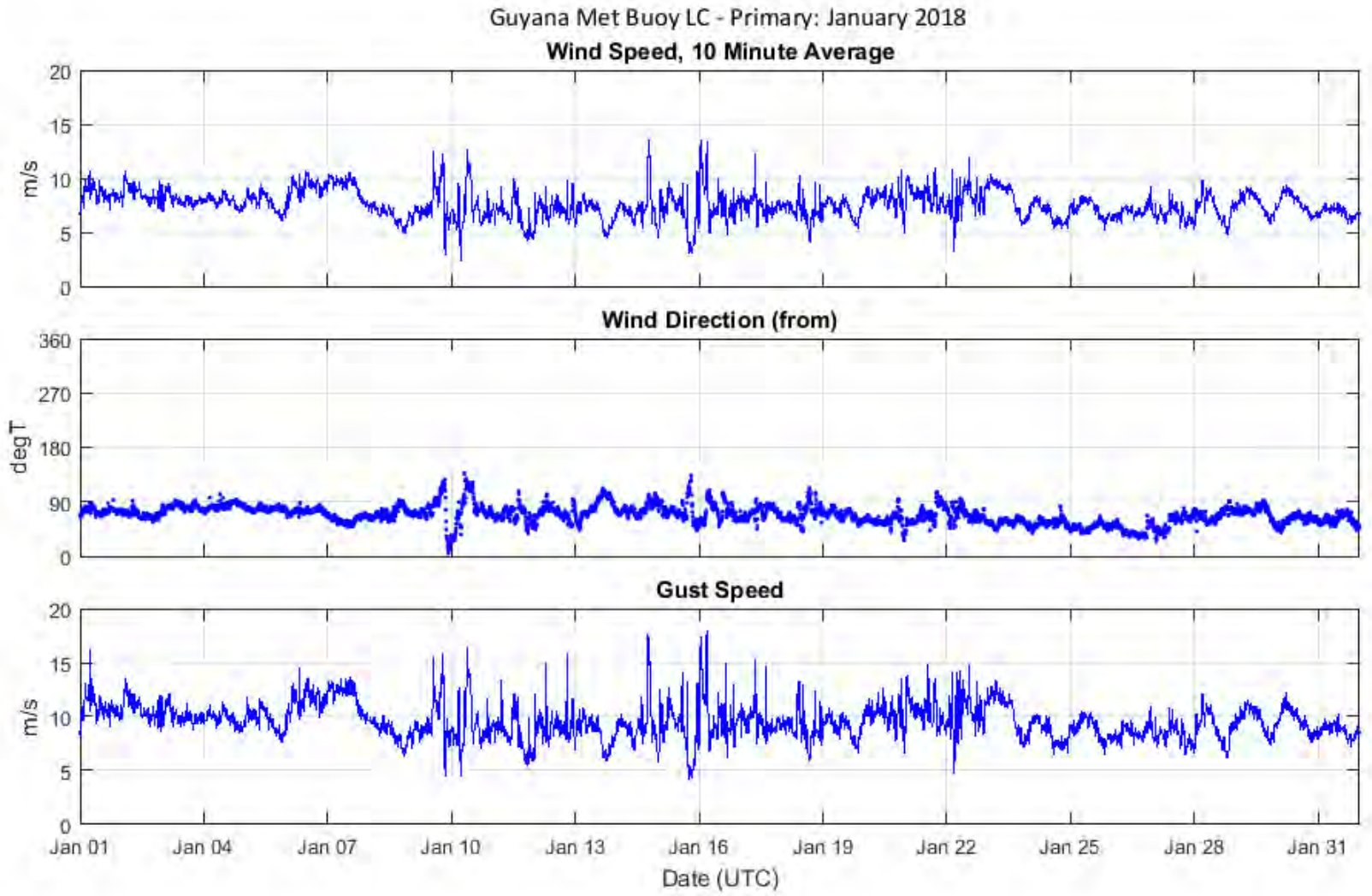

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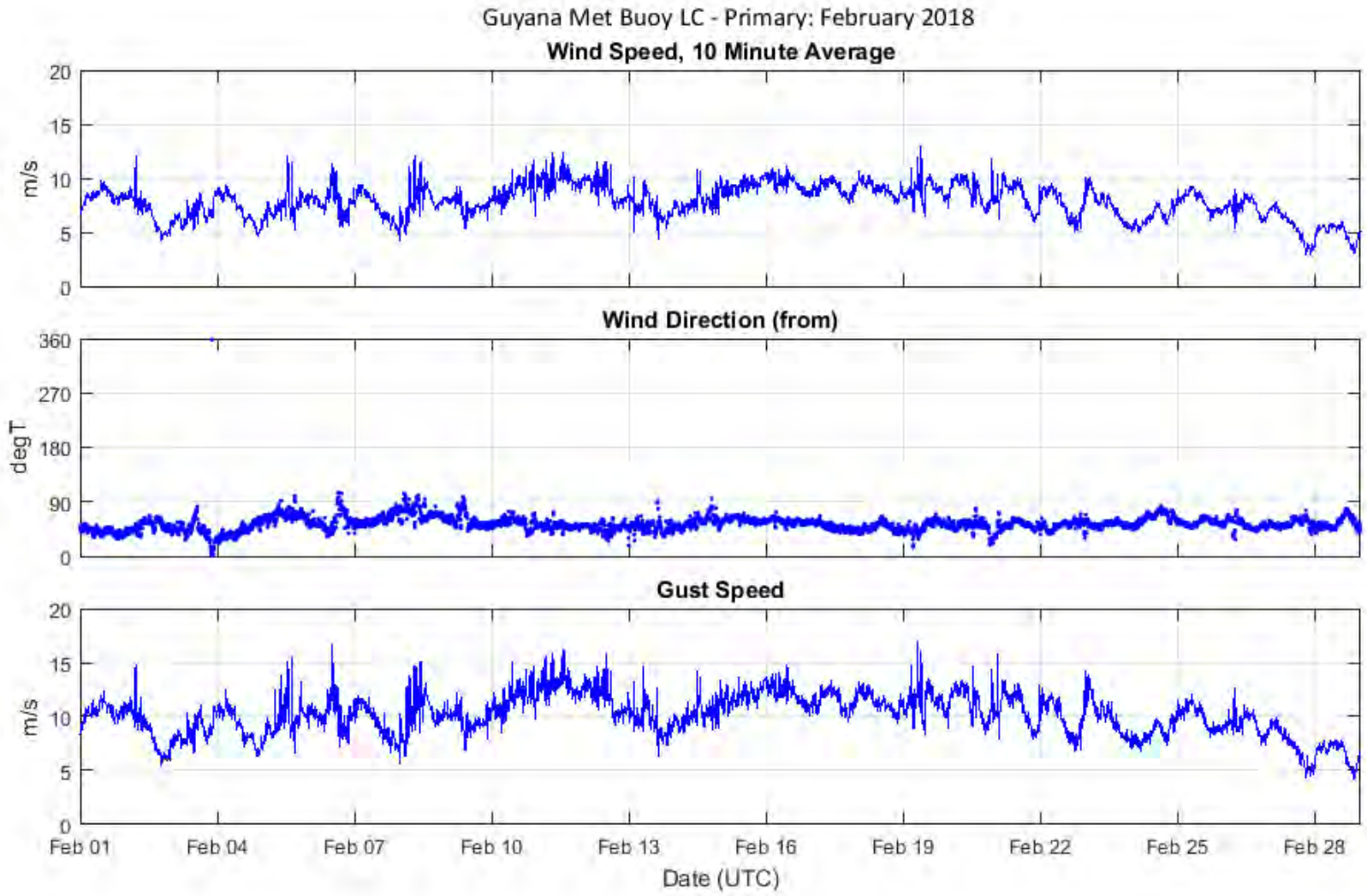

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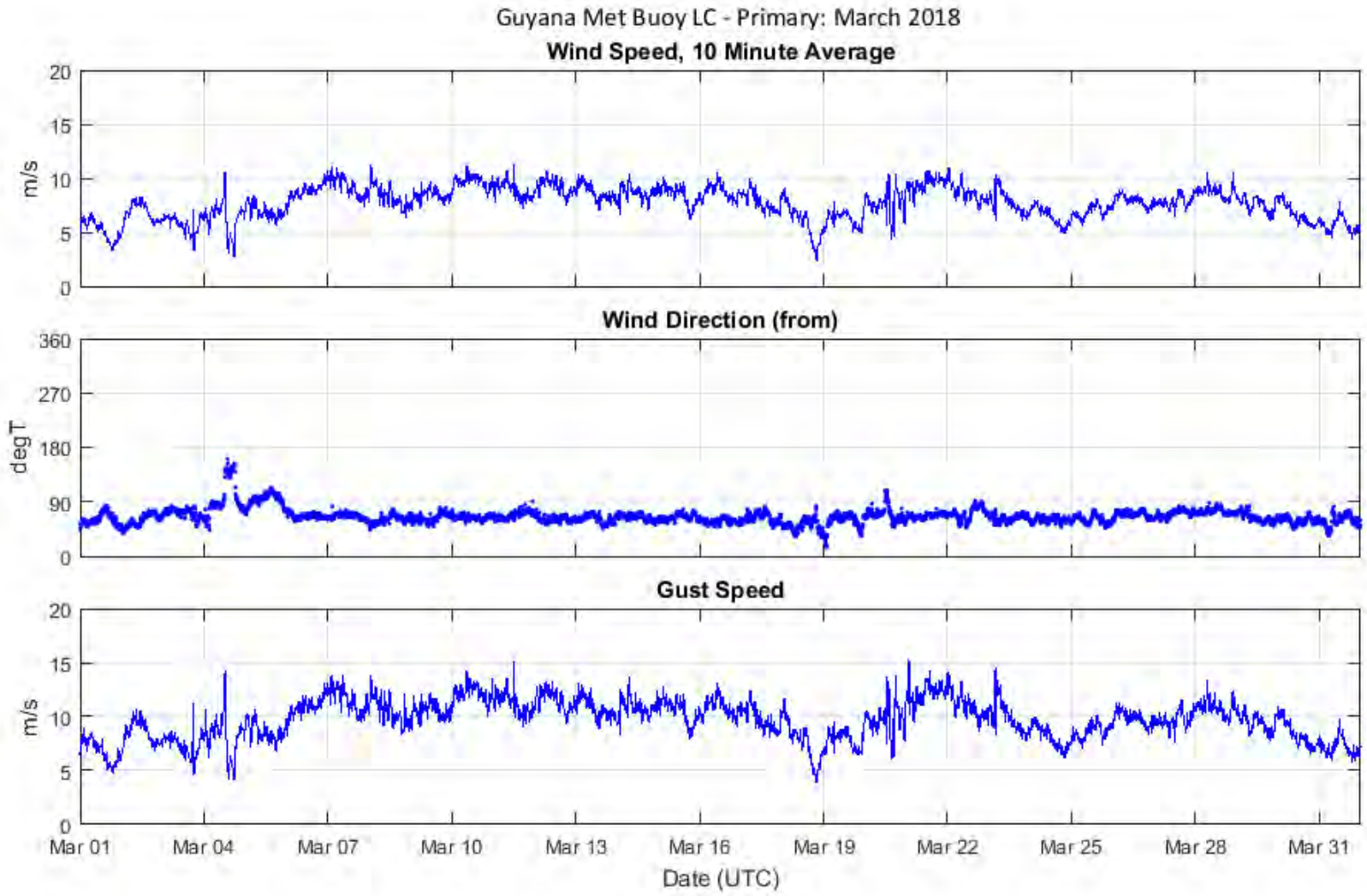

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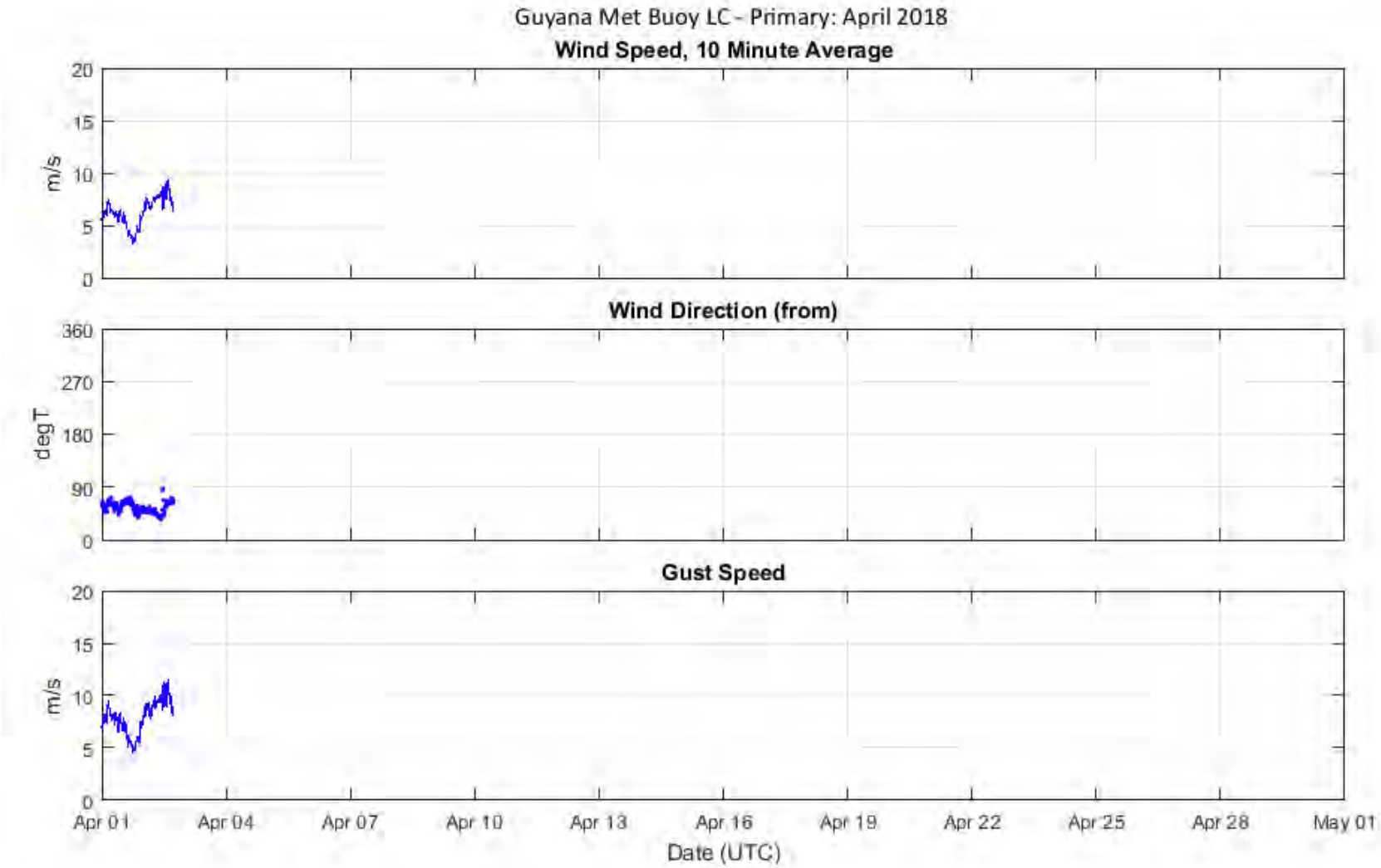

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APPENDIX G

Emissions Inventory and Air Quality Modeling Report

Submitted with changes

March 2022

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Esso Exploration and Production Guyana Limited

Emissions Inventory and Air Quality Modeling Report

Yellowtail Development Project

March 2022

Project No.: 0600620

The business of sustainability

ERM

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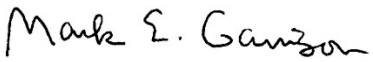
March 2022

Emissions Inventory and Air Quality Modeling Report

Yellowtail Development Project



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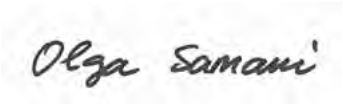

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Acronyms and Abbreviations

Name	Description
$\mu g/m^3$	micrograms per cubic meter
am^3/hr	actual cubic meters per hour
Btu/scf	British thermal units per standard cubic foot
cal/sec	calories per second
CALPUFF	California PUFF model
CFL	Courant–Friedrichs–Lewy
CO	carbon monoxide
CO_2	carbon dioxide
FPSO	Floating Production, Storage, and Offloading (vessel)
EEPGL	Esso Exploration and Production Guyana Limited
ERM	Environmental Resources Management
FDDA	four-dimensional data assimilation
FNL	final analysis
GDAS	Global Forecast System Data Assimilation System
GHG	greenhouse gas
H_2S	hydrogen sulfide
HHV	higher heating value
HP	high pressure
K	degrees Kelvin
LP	low pressure
LSBC	land-sea breeze circulation
LSM	land surface model
mb	millibar
m/s	meters per second
MMBtu/hr	million British thermal units per hour
MMscf/hr	million standard cubic feet per hour
NA	not applicable
NCAR	National Center for Atmospheric Research
NO_2	nitrogen dioxide
NOx	nitrogen oxides
PBL	planetary boundary layer
PM	particulate matter
PM_{10}	particulate matter (aerodynamic diameter less than 10 microns)
$PM_{2.5}$	particulate matter (aerodynamic diameter less than 2.5 microns)
RTG	Real-Time Gridded
SO_2	sulfur dioxide
UTM	Universal Transverse Mercator (East or North)
VOC	volatile organic compound
WHO	World Health Organization
WRF	Weather Research and Forecasting (meteorological model)

1. INTRODUCTION

In support of the Yellowtail Development Project (Project) Environmental Impact Assessment, Esso Exploration and Production Guyana Limited (EEPGL) commissioned Environmental Resources Management (ERM) to perform modeling of air emissions from planned Project activities. The purpose of this modeling was to estimate maximum Project-generated ground-level concentrations at onshore locations where community receptors could be exposed to these concentrations. Additionally, in support of the cumulative impact analysis for the Project, combined emissions from the Project and other reasonably foreseeable EEPGL offshore activities potentially coinciding with the Project were also modeled.

This report provides a description of the modeling methodology—including source characteristics and emissions, receptor locations, model selection, and meteorological data development—and a summary of modeling results. Figure 1-1 displays the modeling domain used in this analysis, showing the locations of the main Project point sources (the Floating Production, Storage, and Offloading vessel [FPSO] and the drill ships supporting the Project), and the boundary of Project-related area sources (including support vessels, construction vessels, and other sources without a fixed location), as configured for the modeling. A single drill ship location was used for modeling all Project drilling activities to provide a conservative estimate of onshore ground-level concentrations (i.e., closest Project drill center to shore). Onshore terrain elevations used in the modeling, as well as other EEPGL offshore activity point sources modeled in support of the cumulative impact assessment, are also depicted.

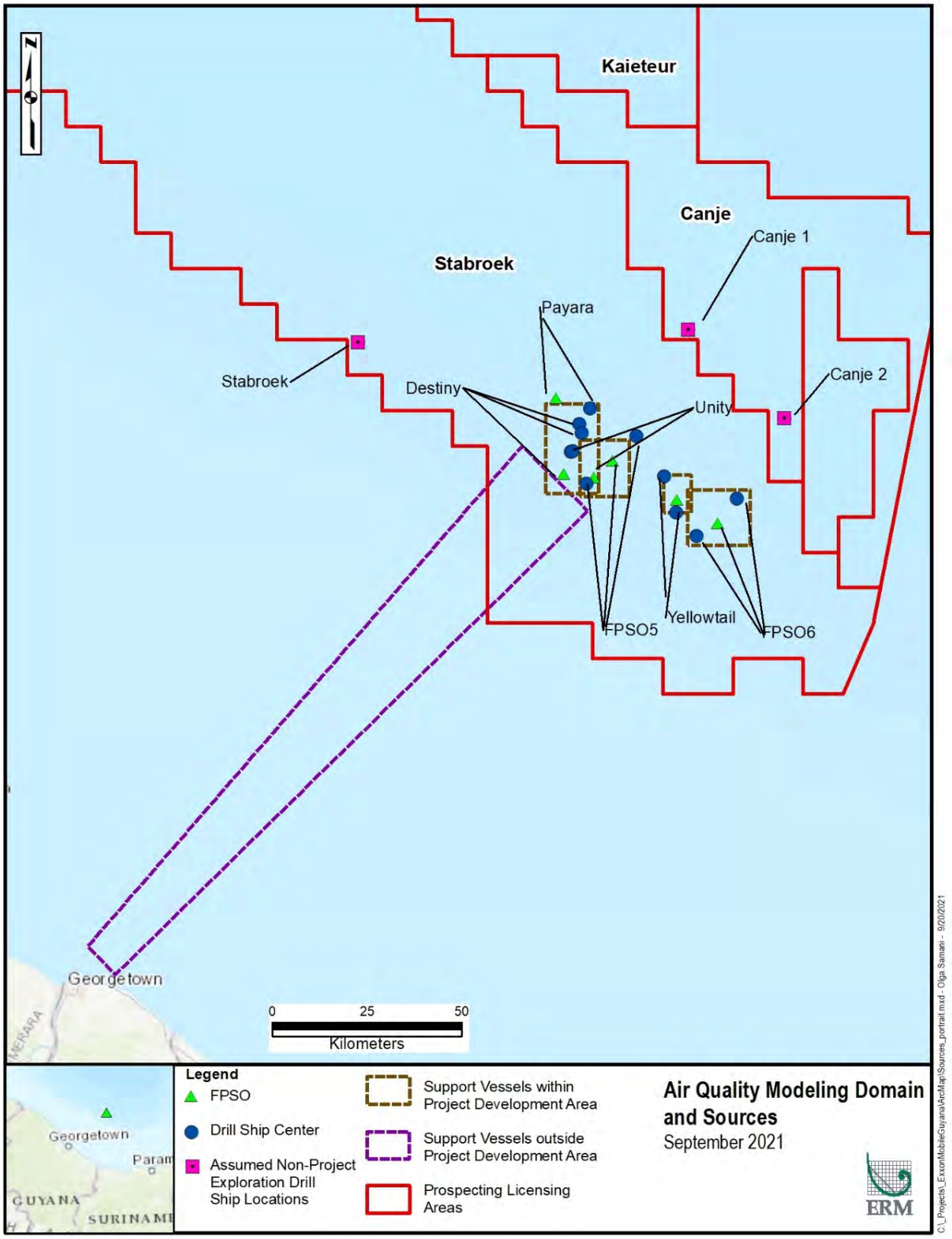

Figure 1-1: Air Quality Modeling Domain

2. AIR QUALITY MODELING METHODOLOGY

2.1 Modeled Activities

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, and flares used (non-routinely) to combust associated gas that is not consumed as fuel gas on the FPSO or re-injected; and (2) general area sources such as support vessels, construction vessels, tug boats, and helicopters.

For the cumulative impact assessment modeling, the following EEPGL offshore activities (in addition to the activities of Yellowtail) were modeled:

- Exploration drilling through end of 2028;
- Liza Phase 1 Development Project (FPSO operation);
- Liza Phase 2 Development Project (FPSO operation);
- Payara Development Project (development well drilling; installation, commissioning, and start-up; and FPSO operation);
- A fifth development project (referred to herein as “FPSO #5”; development well drilling; installation, commissioning, and start-up; and FPSO operation); and
- A sixth development project (referred to herein as “FPSO #6”; development well drilling; installation, commissioning, and start-up; and FPSO operation).

The specific source emissions modeled for these other EEPGL offshore activities were selected based on their currently forecasted timing (and assumed locations, in the case of exploration drilling) relative to that of the Project. Figure 2-1 presents the cumulative impact assessment basis used for this purpose.

With respect to other EEPGL activities assessed as part of the cumulative impact assessment, the cumulative impact assessment modeling excluded emissions from the Guyana Fiber Optic Enablement Project and Guyana Office Complex Project because the anticipated emissions from these projects are expected to be *de minimis* in comparison to those from the EEPGL development projects. The cumulative impact assessment modeling excluded emissions from the Gas to Energy (GTE) Project because the specific equipment for the GTE Project has not yet been determined. Emissions associated with the GTE Project will be modeled (together with cumulative emissions from other EEPGL activities, as appropriate) as part of the EIA that will be prepared separately for that project.

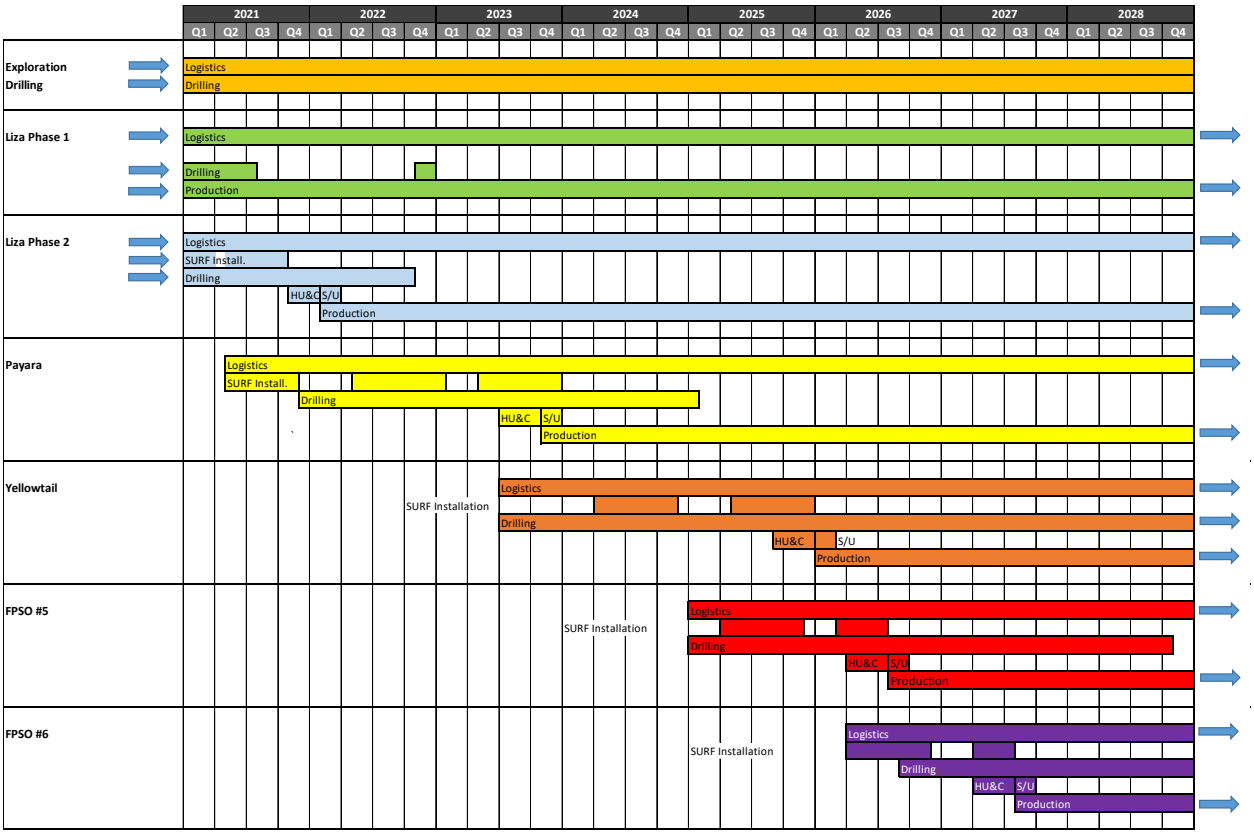

Figure 2-1: Cumulative Impact Assessment Basis for EEPGL Offshore Activities

2.2 Model Inputs: Source Characteristics and Emissions

Modeling “stack” sources involves first calculating plume rise (i.e., how high the plume rises due to momentum and buoyancy of the release). Plume rise is added to the physical stack height to determine final plume height, and the plume is tracked as it is transported downwind and dispersed by atmospheric turbulence. Stack parameters needed for model input include the physical stack height, internal diameter, exhaust velocity, elevation of the base of the stack, and exhaust temperature.

Table 2-1 displays the values for the Project parameters used in this analysis, along with the stack locations in Universal Transverse Mercator (UTM) coordinates. Table 2-1 also displays Project area source characteristics used for the modeling. These values are based on current knowledge of the Project design. It is noted that, due to the distance from Project sources to potential onshore receptors, modeled concentrations are not very sensitive to changes in stack parameters.

Table 2-1 also represents the parameters used for modeling the other five offshore EEPGL activities included in the cumulative impact assessment modeling, adjusted for locations as appropriate. Modeled locations for EEPGL activities are displayed on Figure 1-1.

Flares associated with the Project were modeled as point sources, with adjustments made to account for and maintain buoyancy of the hot plume. Table 2-2 displays the inputs and results of the calculations that were conducted to estimate an effective diameter and an effective stack height that accomplishes this goal. These parameters were used for all modeling that was conducted for non-routine flaring associated with the Project and for other EEPGL activities included in the cumulative impact assessment modeling, adjusted for locations as appropriate.

Table 2-1: Stack Parameters for Model Input

Name	UTM-E [a]	UTM-N [a]	Base Elevation	Height Above Base Elevation	Exhaust Flow	Exhaust Temp	Diameter	Exhaust Velocity
	meters	meters	meters	meters	am^3/hr	K	meters	m/s
FPSO Sources								
Combustion Turbines	531,290	879,566	30	28.00	638,716	803.15	3.100	23.507
Flare—Non-routine Flaring	531,290	879,566	30	153.00 [b]	NA	1,273.0	3.997 [b]	20.00
Essential Services Generators	531,290	879,566	30	15.50	14,791	578.15	0.305	56.234
Emergency Generators	531,290	879,566	30	3.20	15,229	719.15	0.300	59.845
Export Tanker	531,290	879,566	30	24.40	98,457	681.15	1.150	26.330
Drill Ship Sources								
Drill Center	531,218	876,269	0	22.00	73,470	682.60	0.800	40.601
Area Sources								
Support Vessels within Project Development Area	Note d		0	20.00	NA	NA	NA	NA
Support Vessels between Shore and Project Development Area	Note c		0	10.00	NA	NA	NA	NA
Helicopters between Shore and Project Development Area	Note c		0	300.00	NA	NA	NA	NA
General Project Development Area (Installation)	Note d Note e		0	10.00	NA	NA	NA	NA

am^3/hr = actual cubic meters per hour; HP = high pressure; K = degrees Kelvin; LP = low pressure; m/s = meters per second; NA = not applicable; UTM-E = Universal Transverse Mercator East; UTM-N = Universal Transverse Mercator North, Zone 21N, WGS84.
[a] Coordinates listed are for Yellowtail Project sources.

[b] Effective height/diameter calculated based on heat release to maintain buoyancy flux; physical height above base elevation is 134 meters.

[c] Area sources assumed to distribute emissions evenly between shore and Project Development Area.
[d] General area source in Project Development Area.
[e] Includes planned Project installation activities in the PDA.

Table 2-2: Flare Calculations

Description	Gas Usage	Gas HHV	Total Heat Release	Total Heat Release	Sensible Heat Release	Effective Stack Diameter [a]	Physical Stack Height	Effective Stack Height [a]
	MMscf/hr	Btu/scf	MMBtu/hr	cal/sec	cal/sec	meters	meters	meters
Non-Routine Flaring								
Flare	0.30	1,707.4	519.6	3.64E+07	1.64E+07	4.0	134	153.0

Btu/scf = British thermal units per standard cubic foot; cal/sec = calories per second; HHV = higher heating value; MMBtu/hr = million British thermal units per hour; MMscf/hr = million standard cubic feet per hour
[a] Effective diameter and effective stack height calculated based on U.S. Environmental Protection Agency guidance, using 20 meters per second exit velocity and 1,273 K exhaust temperature.

Emissions to air from the Project have been estimated based on a number of factors including activity levels, fuel types, equipment capacities, and standard emission factors that are published by the U.S. Environmental Protection Agency in the publication *AP-42: Compilation of Air Pollutant Emission Factors* (AP-42; USEPA Undated). As described in AP-42, an emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., milligrams of nitrogen oxides [NO_x] emitted per cubic meter of natural gas combusted). In most cases, these factors are averages of available data of an acceptable quality, and are generally assumed to be representative of long-term averages for a particular type of source (AP-42; USEPA Undated).

Table 2-3 provides a summary of expected annual emissions from various planned Project activities for three time periods: 2023–2024 (development well drilling; Subsea, Umbilicals, Risers, and Flowlines [SURF] installation and commissioning; FPSO installation; and operation of related support vessels); 2025–2027 (continued development well drilling; operation of related support vessels; FPSO start-up and associated temporary, non-routine flaring; beginning of production operations; and tanker loading); and 2028–2044 (production operations following start-up, including temporary, non-routine flaring; potential continued development well drilling; operation of related support vessels; and tanker loading). For each of the time periods, the annual emissions presented in Table 2-3 for each pollutant other than non-methane volatile organic compounds (VOCs) and greenhouse gases (GHGs) represent the maximum anticipated annual emissions for each source during the time period. These source-specific maximum values are not necessarily all from the same year in the time period. While there are some differences in pollutant emissions for different years within the time periods, they are relatively minor and the use of maximum emissions for the impact assessment provides a degree of conservatism in the results. In the case of non-methane VOCs, the source-specific emissions for each time period are all from the same year (i.e., 2024, 2026, and 2029). In the case of GHGs, the source-specific emissions for the first two time periods are all from the same year within the time period (i.e., 2024 and 2026). These are the years with the maximum anticipated annual GHG emissions for any of the years during the respective time periods. For the third time period, the GHG emissions are the average annual emissions across the time period.

The Project emissions estimates account for an assumed quantity of emissions from low-level continuous flaring of pilot gas, purge gas, and other *de minimis* streams described in Chapter 2, Description of the Project, as well as temporary, non-routine flaring associated in part with upsets and maintenance, and other non-routine and/or unplanned events during the Project life cycle. Estimated emissions from non-routine flaring are included together with estimated emissions from planned activities. These estimated emissions account for a reduced duration of flaring during these non-routine events as a result of the additional compression sparing that has been included in the Project design. With respect to start-up, the Project is targeting 60 cumulative days for start-up flaring, recognizing that this would represent industry-leading performance. For the purpose of modeling, the estimated emissions are based on the conservative assumption that start-up flaring for the Project will be temporary and may require flaring for 90 cumulative days at the rate of 120 million standard cubic feet per day (MMscfd). In the United States offshore, flaring may occur for up to 1 year with regulatory approval (30 Code of Federal Regulations §250.1161): “[An operator] must request and receive approval from the Regional Supervisor to flare or vent gas for an extended period of time. The Regional Supervisor will specify the approved period of time, which will not exceed 1 year.”

Table 2-3: Annual Air Emissions Summary—Yellowtail Project

Pollutant	Source Category	Design Case			Modeled Case		
		Maximum Annual Emissions (tonnes) [a,c]			Maximum Annual Emissions (tonnes) [a,c]		
		2023–2024	2025–2027	2028–2044 [f]	2023–2024	2025–2027	2028–2044 [f]
Nitrogen Oxides	FPSO	0	2,065	2,460	0	2,065	2,460
	FPSO Flaring (temporary, non-routine)	0	505	190	0	520	350
	Tanker Loading	0	240	240	0	240	240
	Area Sources [d]	2,135	1,785	880	2,135	1,785	880
	Drill Ships	1,835	945	1,415	1,835	945	1,415
	Total	3,970	5,540	5,185	3,970	5,555	5,345
Sulfur Dioxide	FPSO	0	110	125	0	110	125
	FPSO Flaring (temporary, non-routine)	0	90	35	0	90	60
	Tanker Loading	0	10	10	0	10	10
	Area Sources [d]	50	65	35	50	65	35
	Drill Ships	65	35	50	65	35	50
	Total	115	310	255	115	310	280
Particulate Matter (PM) [b]	FPSO	0	40	40	0	40	40
	FPSO Flaring (temporary, non-routine)	0	100	40	0	105	70
	Tanker Loading	0	20	20	0	20	20
	Area Sources [d]	100	130	65	100	130	65
	Drill Ships	130	70	100	130	70	100
	Total	230	360	265	230	365	295
Carbon Monoxide	FPSO	0	415	515	0	415	515
	FPSO Flaring (temporary, non-routine)	0	2,300	860	0	2,360	1,585
	Tanker Loading	0	65	65	0	65	65
	Area Sources [d]	565	470	230	565	470	230
	Drill Ships	490	255	380	490	255	380
	Total	1,055	3,505	2,050	1,055	3,565	2,775
Hydrogen Sulfide	FPSO Flaring (temporary, non-routine)	NA (no emissions)	<5	<1	NA (no emissions)	<5	<1

Pollutant	Source Category	Design Case			Modeled Case		
		Maximum Annual Emissions (tonnes) [a,c]			Maximum Annual Emissions (tonnes) [a,c]		
		2023–2024	2025–2027	2028–2044 [f]	2023–2024	2025–2027	2028–2044 [f]
Non-methane Volatile Organic Compounds (VOCs) [e]	All Sources	30	3,500	2,370	30	3,555	2,955
Greenhouse Gases (GHGs) (kilotonnes carbon dioxide-equivalents) [e,g]	All Sources	240	1,730	1,110	240	1,760	1,395

NA = not applicable
[a] The annual estimated totals generally reflect the current preliminary Project schedule and production profile and remain subject to adjustment. Source category-specific sub-totals are rounded up to the next 5 tonnes and the totals reflect the sum of the rounded sub-totals.
[b] PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} standards and $PM_{2.5}$ standards (a conservative assumption).
[c] The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period to reflect maximum possible short-term emission rates.
[d] Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling; installation, commissioning, and start-up; production operations; and decommissioning.
[e] Total non-methane VOC and GHG emissions are shown in this table but were not modeled, as there are no ambient air quality criteria for total non-methane VOC emissions.
[f] Development well drilling could occur for up to 5 years into the period.
[g] Estimated GHG emissions for 2028-2044 period represent average of estimated annual emissions for years 2028 to 2044.

Table 2-4: Annual Air Emissions Summary—Cumulative EEPGL Offshore Activities (Including Yellowtail Emissions)

Pollutant	Source Category	Design Case [a,c]			Modeled Case [a,c]		
		Annual Emissions (Tonnes)			Annual Emissions (Tonnes)		
		2023-2024	2025-2027	2028-2044 [e]	2023-2024	2025-2027	2028-2044 [e]
Nitrogen Oxides (NOx)	All Sources	22,020	22,880	24,505	22,020	22,895	24,770
Sulfur Dioxide (SO_2)	All Sources	1,540	1,380	1,285	2,235	1,385	1,330
Particulate Matter (PM) [b]	All Sources	1,040	1,395	1,205	1,115	1,400	1,235
Carbon Monoxide (CO)	All Sources	6,555	13,185	12,105	6,690	13,190	13,065
Hydrogen Sulfide (H_2S)	All Sources	10	10	5	3,170	10	5
Total Non-methane VOCs [d]	All Sources	20,955	19,325	18,860	20,955	19,380	19,545
Greenhouse Gases (kilotonnes CO_2-equivalents)	All Sources	5,635	5,905	7,815	5,635	5,935	8,710

CO_2 = carbon dioxide
[a] The annual estimated totals generally reflect the current preliminary Project schedule and production profile and remain subject to adjustment. Source category-specific sub-totals are rounded up to the next 5 tonnes and the totals reflect the sum of the rounded sub-totals.
[b] PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} standards and $PM_{2.5}$ standards (a conservative assumption).
[c] The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period to reflect maximum possible short-term emission rates.
[d] Total non-methane VOC and GHG emissions are shown in this table but were not modeled, as there are no ambient air quality criteria for total non-methane VOC emissions.
[e] Development well drilling could occur for up to 5 years into the period.

Emissions estimates are provided for two cases designated as the “Design Case” and “Modeled Case.” The Design Case emissions are based on estimated annual flaring, including an estimate of non-routine flaring in accordance with design basis assumptions for the Project. The Modeled Case emissions include an additional contingency for non-routine flaring volumes and are considered to reflect a credible worst case for non-routine flaring. Operational reliability performance is best described as a range of experience. Recognizing that range, a “low side” and “high side” estimation has been included to demonstrate the potential range for experience. For the purposes of modeling, only the High Case emissions estimates are assessed – reflecting the reasonable worst-case resulting ambient onshore concentrations of pollutants.

2.3 Receptors

A grid of potential receptor points was established for onshore areas, with a denser grid used in coastal areas (closer to the sources) and a coarser grid used in inland regions. For each pollutant, dispersion modeling was used to predict the maximum ground-level concentration at any time at any one of the onshore grid points; these maximum predicted concentrations were then compared to ambient air quality guidelines. Under this conservative approach, if the maximum predicted concentrations are determined to be less than the respective ambient air quality guidelines, it follows that ambient air quality guidelines would be met at any specific onshore receptor location. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling. Figure 2-2 illustrates the potential receptor location grid used. At each potential receptor grid node, terrain elevations were specified and used by the California PUFF model (CALPUFF) to model plume interaction with onshore terrain.

2.4 Model Selection

The CALPUFF model (Version 7.3.2, level 200113) used in the assessment is a non-steady-state model used in the United States and around the globe for long-range transport and complex wind modeling. CALPUFF is a Lagrangian “puff” model that treats a plume as a series of puffs that it tracks as the wind carries the plume toward potential receptor locations. The selection of CALPUFF was based on the relatively large distance between the Project Development Area and the potential onshore receptors. The distance from the Project Development Area to the coastline of Georgetown is approximately 203 kilometers (126 miles). At this distance, emission plumes released from the point sources modeled would travel for approximately 10 hours before reaching the Guyana shoreline, assuming an average wind speed of 5 meters (16.4 feet) per second (typical for the area). During this transport time, winds can change direction and speed. Accordingly, prediction of plume dispersion is most appropriately accomplished with a non-steady state model. Additionally, due to the vast differences in surface characteristics between open water and land, coastal areas frequently experience a classic meteorological phenomenon known as the land-sea breeze circulation (LSBC). This phenomenon is due to the diurnal surface temperature differences that develop between the land and the open water. LSBC effects can play an important role in the dispersion modeling analysis of emission sources as plumes interact with onshore receptors. CALPUFF, combined with gridded meteorological data, is capable of accounting for the LSBC phenomenon. CALPUFF was run for each source individually and post-processing was used to calculate pollutant-specific totals for applicable averaging periods.

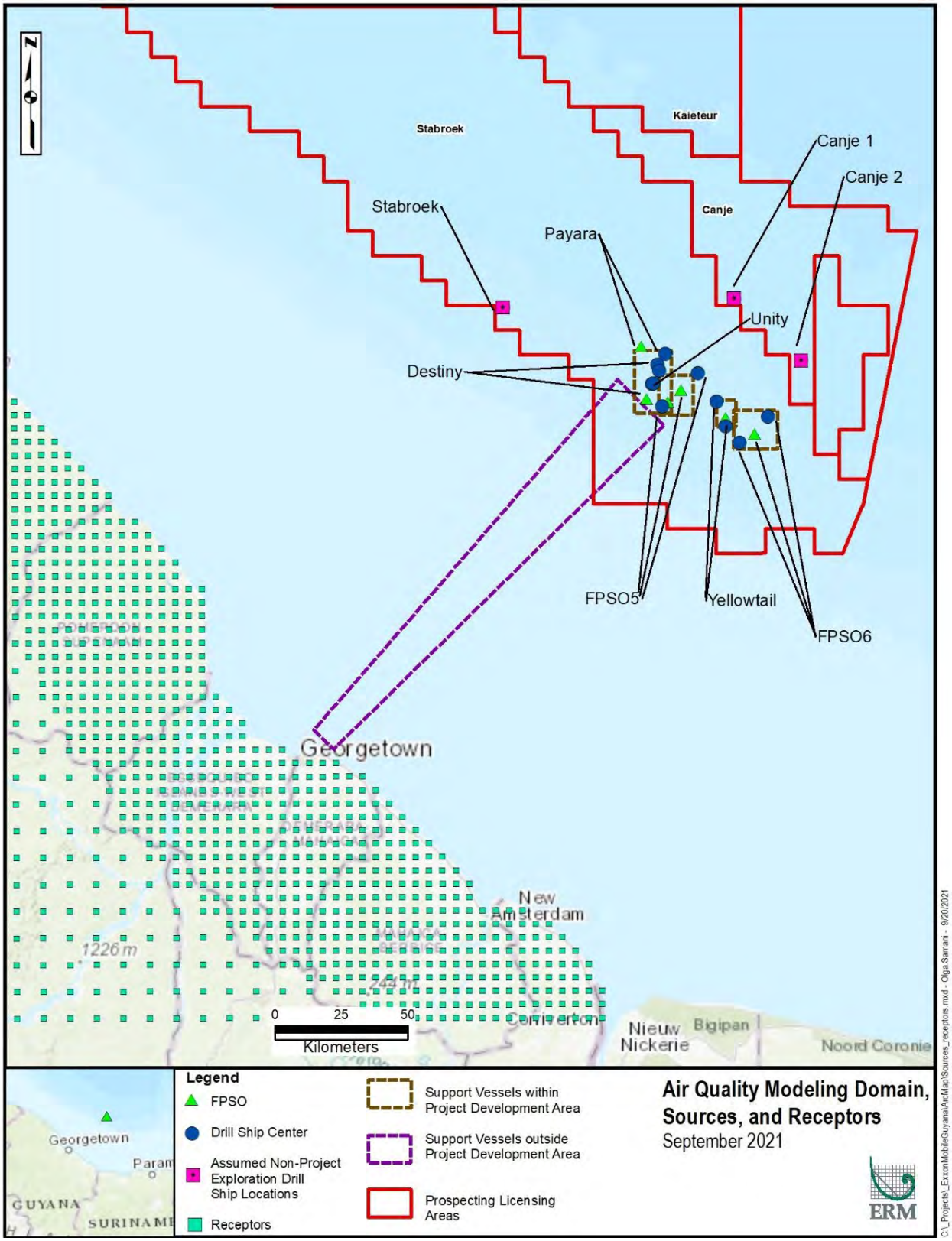

Figure 2-2: Receptor Grid Used for Air Quality Modeling

2.5 Meteorological Data

2.5.1 WRF Model Configuration

The Weather Research and Forecasting (WRF) model (WRF-ARW, Version 4.0; Skamarock 2019) was used to develop a simulated meteorological data set for the air quality modeling because there is limited suitable observational data available for the region. A full three-dimensional grid of WRF-simulated meteorological data was used for the CALPUFF simulations. These data include simulated meteorological conditions across the modeling domain at a resolution of 9 kilometers (5.6 miles). Observational data from 2017 through 2019 were used as input for the WRF model. This period was simulated to identify the worst-case dispersion conditions (i.e., leading to the maximum predicted onshore concentrations) that would be expected during the Project lifecycle. The WRF model is a state-of-the-science numerical meteorological model that is designed to simulate atmospheric systems on a wide range of spatial and temporal scales.

WRF is a widely used three-dimensional numerical meteorological model with a terrain following, hydrostatic pressure vertical coordinate. The model contains non-hydrostatic dynamics, and a variety of physics options for parameterizing moist convection, cloud microphysics, the planetary boundary layer (PBL) turbulence physics, atmospheric radiation, and land surface models (LSMs). The model is designed for simulating atmospheric phenomena across scales ranging from large eddies (~100 meters [328.1 feet]) to mesoscale circulations and waves (from ~100 meters [328.1 feet] to 1,000 kilometers [621.4 miles]) to synoptic-scale weather systems (>1,000 kilometers [>621.4 miles]). It is also used to generate three-dimensional gridded meteorological data (such as hourly wind and temperature fields) in the modeling domain through the treatment and assimilation of available surface and upper air observations. The methodology that was followed for the WRF modeling is described below.

WRF static geophysical data are available from the National Center for Atmospheric Research (NCAR) for terrain, vegetation/land use, land mask, soil moisture, and soil type. NCAR distributes various resolutions of global terrain and land-use databases to support WRF simulations. The databases are:

- 5-minute (about 9.25 kilometers [5.75 miles) in mid-latitudes)
- 2-minute (about 4.00 kilometers [2.5 miles] in mid-latitudes)
- 30-sec (about 0.900 kilometers [0.6 miles] in mid-latitudes)

These data are assigned to WRF simulations based on the resolution of the simulation domain. These data were used to develop the GEOGRID files on static terrain and land use data for the model simulations.

The WRF-ARW model was configured with multiple nested grids to achieve a grid resolution capable of resolving the land use and terrain characteristics of the Guyana region, as well as the meteorology over the ocean. A Mercator projection was used, which is suitable for simulations in the low-latitude tropics. The Mercator projection uses a reference latitude/longitude of 6.71 degrees north and 55.00 degrees west. Figure 2-3 shows the complete domain configuration used in the WRF simulations. The model used a large outer domain (Domain 1) at a grid resolution of 27 kilometers (16.8 miles) spanning the central and eastern portions of northern South America and over the Atlantic Ocean. This domain extent is necessary to properly simulate the evolution of larger-scale atmospheric features. Domain 2 consists of a smaller domain with a grid resolution of 9 kilometers (5.6 miles). This domain extends over the northeast portion of South America and east over the tropical Atlantic Ocean, encompassing the offshore Guyana area in which modeled activities occur.

Figure 2-3: WRF Model Domain Configuration

To properly depict the vertical structure of the atmosphere, WRF uses a mass-based terrain-following vertical coordinate system referred to as the eta (ŋ) coordinate system. This coordinate system is essentially the same as the sigma terrain-following coordinate used in WRF's predecessor model (MM5). The WRF simulations employed 40 eta vertical levels from the surface up to 50 millibars (mb). The vertical levels used in the WRF modeling are also shown in Table 2-5. Table 2-5 shows the WRF eta layer values and the layer and mid-layer heights.

Table 2-5: Vertical Layers Used in the WRF Simulations

Level No.	ETA Level	Layer Height (m)	ETA Half-Level	Mid Layer Height (m)		Level No.	ETA Level	Layer Height (m)	ETA Half-Level	Mid Layer Height (m)
1	1	0.00	1.000	0		21	0.3431	8047.66	0.365	7645
2	0.9938	52.87	0.997	26		22	0.3032	8835.04	0.323	8441
3	0.9860	120.47	0.990	87		23	0.2674	9603.52	0.285	9219
4	0.9760	206.46	0.981	163		24	0.2351	10351.69	0.251	9978
5	0.9636	315.15	0.970	261		25	0.2061	11078.77	0.221	10715
6	0.9481	451.48	0.956	383		26	0.1801	11785.28	0.193	11432
7	0.9291	620.89	0.939	536		27	0.1566	12473.29	0.168	12129
8	0.9062	829.25	0.918	725		28	0.1356	13144.25	0.146	12809
9	0.8789	1082.25	0.893	956		29	0.1166	13798.82	0.126	13472
10	0.8472	1384.78	0.863	1234		30	0.0996	14437.73	0.108	14118
11	0.8111	1740.26	0.829	1563		31	0.0842	15062.70	0.092	14750
12	0.7709	2149.99	0.791	1945		32	0.0704	15676.43	0.077	15370
13	0.7275	2612.62	0.749	2381		33	0.0580	16281.69	0.064	15979
14	0.6818	3123.92	0.705	2868		34	0.0469	16882.15	0.052	16582
15	0.6345	3679.82	0.658	3402		35	0.0369	17485.48	0.042	17184
16	0.5860	4283.09	0.610	3981		36	0.0278	18093.18	0.032	17789
17	0.5367	4938.59	0.561	4611		37	0.0197	18705.49	0.024	18399
18	0.4867	5649.25	0.512	5294		38	0.0125	19324.30	0.016	19015
19	0.4367	6418.58	0.462	6034		39	0.0059	19950.31	0.009	19637
20	0.3874	7241.94	0.412	6830		40	0.0000	20583.13	0.003	20267

Initial and lateral meteorological boundary conditions are provided to the WRF Preprocessing System as the initial data, both spatially and temporally, at the start of the WRF simulation. In general, initialization data sets are assimilated with a great deal of observational data, which include surface pressure, sea level pressure, geopotential height, temperature, sea surface temperature, soil values, ice cover, relative humidity, u and v wind components, vertical motion, vorticity, winds and in-situ data such as moisture from radiosondes and pressure from surface observations. Also included in these data sets are precipitation data, profiler data, dropsondes, pibals, aircraft temperatures and winds, land surface and moisture data, and cloud drift winds from geostationary satellites. There are numerous analysis datasets available to use with WRF at various spatial and temporal resolutions.

The WRF simulations for the modeling used the National Oceanic and Atmospheric Administration Global Forecast System Data Assimilation System (GDAS) 6-hourly final analysis (FNL) files at 0.25-degree resolution. The 1/12th degree resolution sea surface temperature data used were sourced from the Real-Time Gridded (RTG) data archive. Because the RTG data archive was terminated in late November 2019, the remainder of the 2019 WRF simulation period uses the skin temperature data from the GDAS analysis files.

2.5.2 Selected WRF Physics Suite

The WRF model was run using the Thompson microphysics scheme to account for cloud microphysical processes. The Thompson scheme accounts for snow, ice and graupel processes and it is suitable for high-resolution simulations. Atmospheric radiation processes for both short-wave and long-wave radiation are handled with the Rapid Radiative Transfer Model for Global Climate Models scheme. Land surface processes were presented using the MM5 Monin-Obhukov surface layer physics, the Noah unified LSM, and the Yonsie University PBL scheme physics. Both the outer 27-kilometer (16.8-mile) and 9-kilometer (5.6-mile) resolution domains (Domains 1 and 2) used the Tiedtke cumulus physics scheme to parameterize moist convection. The Tiedtke scheme was chosen since modeling studies using this scheme have shown good overall performance over the tropical latitude belt globally. The surface

physics, LSM, and PBL schemes chosen are generally well tested over many simulations in different geographical regions.

The WRF simulations initially showed problems with Courant–Friedrichs–Lewy (CFL) violations suggesting the vertical velocities were too large. Often this is caused by steep terrain slopes. However, an examination of the locations of the CFL violations[1] at specific grid cells showed a concentration of these in the upper layers of the model domain even over relatively flat terrain. This suggested that gravity wave activity at the top of the model domain may be responsible. Thus, the option to implement vertical velocity damping coupled with gravity wave damping was implemented. These settings resolved the CFL problems.

2.5.3 Four Dimensional Data Assimilation

The WRF modeling system also has four-dimensional data assimilation (FDDA) capabilities. FDDA is a method of performing WRF simulations with the full-physics model while blending local observations. By doing so, model equations maintain dynamic consistency while at the same time restraining the model's solutions from deviating too strongly from observations or a gridded analysis and make up for errors and gaps in the initial analysis and deficiencies in model physics. There are two types of what is known as "FDDA nudging" in WRF:

- ***Analysis nudging***—which gently forces the model solution toward gridded fields and also makes use of three-dimensional analyses and surface analyses.
- ***Observation nudging ("obs nudging")***—which gently forces the model solution toward individual observations, with the influence of the observations spread in space and time.

Meteorological observations from both upper air and the surface were included in the WRF FDDA simulation. Upper Air Observational Weather Data are composed of weather reports from radiosondes, pibals, and aircraft reports from the Global Telecommunications System and satellite data from the National Environmental Satellite Data and Information Service[2]. This dataset includes pressure, geopotential height, air temperature, dew point temperature, wind direction, and speed. Data may be available at up to 20 mandatory levels ranging from 1,000 mb to 1 mb, plus a few significant levels. Report intervals range from hourly to every 12 hours. Surface meteorological data[3] include variables such as pressure, air temperature, dew point temperature, and wind direction and speed at the ground level. Report intervals range from hourly to every three hours.

The WRF simulations implemented both analysis nudging and observation nudging on the outer largest domain (Domain 1) and observation nudging only on Domain 2. The analysis nudging was performed using the FNL 0.25-degree analysis data. Additionally, nudging moisture and temperature in the PBL was not performed. This is a common practice to prevent the nudging process from eroding important simulated temperature and moisture profiles within the PBL.

2.5.4 WRF Analysis

Inspection of the WRF 10-meter (32.8-foot) wind fields was performed at various points during the WRF simulations to ensure reasonable representation of the meteorology by the model. Overall, the WRF model represented the meteorology and the diurnal cycle reasonably well.

[1] A CFL condition is a necessary condition for convergence while solving certain partial differential equations numerically by the method of finite differences. WRF develops numerical instability, CFL errors, that cause high-resolution runs (not always necessary) to fail occasionally.

[2] http://rda.ucar.edu/datasets/ds351.0/index.html

[3] http://rda.ucar.edu/datasets/ds461.0/index.html

To develop more specific climate information regarding onshore climate conditions, EEPGL commissioned deployment of a meteorological station at a site in Carifesta where ambient onshore monitoring air quality data were being collected. The meteorological station collected hourly meteorological data from February 2018 through April 2019. This site was situated on the immediate shoreline but was surrounded by built-up and urban land used adjacent to the station and extending inland for some distance. The initial wind roses showed that the WRF model had a negative wind bias at the station location (i.e., simulated winds speeds were lower than observed). However, the wind directions are dominated by northeast flow, characteristic of the northeast trade winds. As a result, a grid cell slightly offshore was selected and this showed simulated wind speeds more similar to the observed data at the Georgetown station. Figure 2-4 shows two wind roses showing a comparison of the WRF-predicted and observed data. Figure 2-4 shows that for the WRF-predicted wind rose, there are somewhat higher wind speeds than observed. This appears to be due to the lower surface roughness in the offshore grid cell selected. The actual meteorological station sits on land adjacent to the coastline. These discrepancies are related to how well the coastal boundary and associated surface roughness is represented in the WRF grid resolution used. The wind roses show a relatively small wind direction bias such that WRF has a bit more northeast and east-northeast winds than observed. Overall, this wind rose shows that the WRF simulations are representing the overall wind distribution reasonably well.

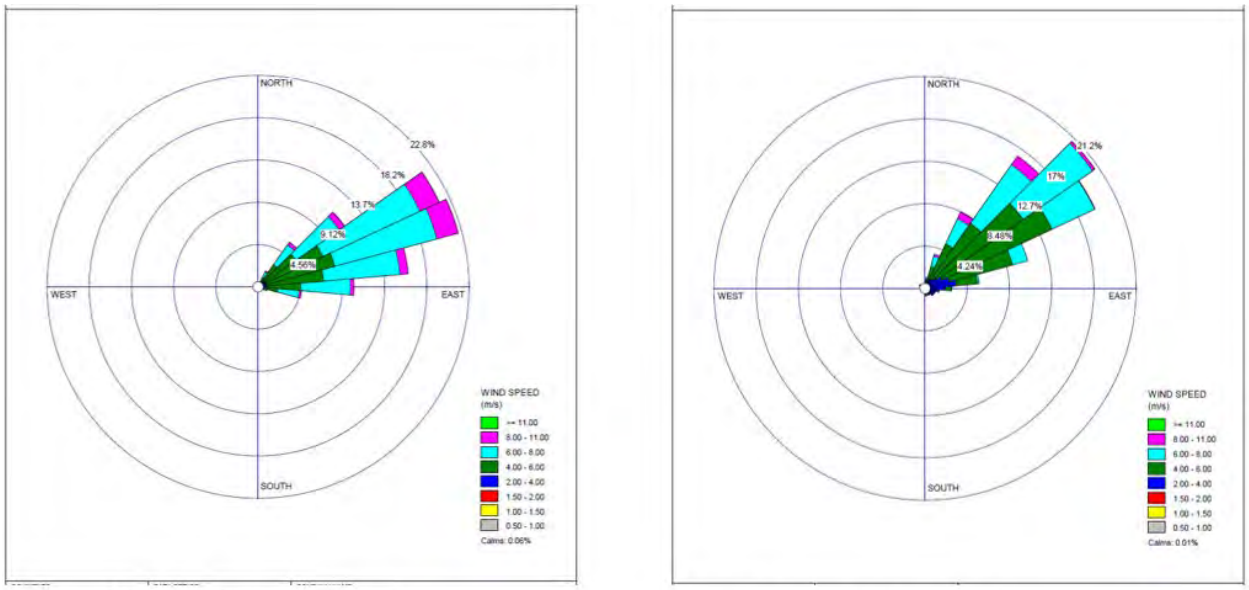

Figure 2-4: WRF-Predicted and Observed Wind Roses at Georgetown

Figure 2-5 shows two wind field plots on the 9-kilometer (5.6-mile) domain at two different dates. These plots show an example of the WRF-simulated 10-meter (32.8-foot) wind field. The northeast trade wind flow is clearly shown, with speeds on the order of 6 to 10 meters per second (19.7 to 32.8 feet per second) over the ocean. This is consistent with trade wind climatology. Also, note the reduction of wind speed as the flow crosses the coastline due to increased surface roughness and associated surface drag.

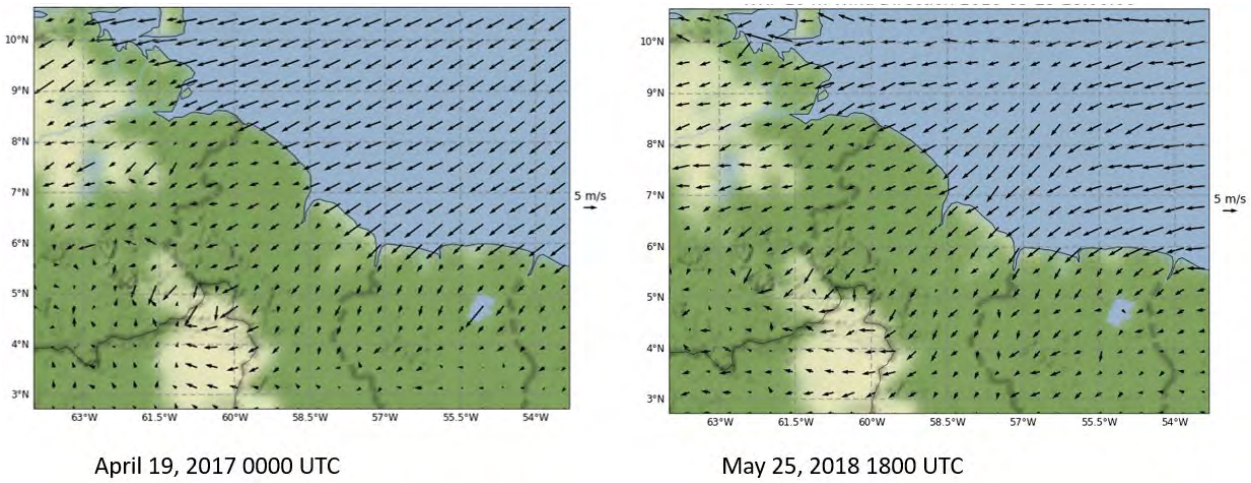

Figure 2-5: WRF-simulated 10-Meter (32.8-Foot) Wind Fields for 19 April 2017 and 25 May 2018

3. RESULTS

3.1 Ambient Air Quality Guidelines

Ambient air quality guidelines are concentration levels in air that are established to protect human health in locations where exposure can potentially occur. These generally include a margin of safety to ensure that vulnerable individuals are also protected. Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment are those established by the World Health Organization (WHO) and the U.S. Environmental Protection Agency (USEPA). WHO guidelines can be found in the WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005 (WHO 2005) and the more recent WHO Global Air Quality Guidelines (WHO 2021), except for hydrogen sulfide (H_2S) for which WHO guidelines were published in the WHO Air Quality Guidelines for Europe, 2nd edition (WHO 2000). The current USEPA National Ambient Air Quality Standards (NAAQS) as of 1 October 2021 are summarized in USEPA 2021. The ambient air quality guidelines considered for assessment of existing conditions and the cumulative impact assessment are summarized in Table 3-1.

The WHO 2000 and WHO 2005 guidelines do not specify a “ranking” for values to be compared to short-term (10-minute to 8-hour) guidelines (e.g., the highest value, the second highest value, etc.); accordingly, the maximum observed or modeled concentration is used for comparison to WHO 2000 and WHO 2005 guidelines. Modeling for 1-hour standards involves predicting concentrations for every hour of the year; this means that out of 8,760 concentration predictions per modeled year, the single highest value is used for comparison to a WHO 2005 1-hour guideline. By contrast, the WHO 2021 and USEPA NAAQS guidelines employ a statistically based metric for comparison to some guidelines (e.g., the 98th percentile value for 1-hour NO_2; the 99th percentile value for 24-hour NO_2; the 99th percentile value for 1-hour SO_2). For the air quality modeling presented herein, the WHO 2005 guideline and the USEPA

NAAQS guideline for 1-hour NO_2 are both used for comparison purposes; the USEPA NAAQS guideline provides a more robust comparison that does not assess the single highest hourly value, while the WHO 2005 guideline considers the single highest hourly value—effectively representing an extreme upper bound estimate. Similarly, the WHO guideline and the USEPA NAAQS guideline for 24-hour PM_{10} and $PM_{2.5}$ are both used for comparison purposes. For each pollutant and averaging time, if more than one guideline for a given averaging period is listed in the table above (e.g., annual average $PM_{2.5}$), the lowest was used in the assessment.

Table 3-1: Ambient Air Quality Guidelines Considered in the Assessment

Pollutant	Averaging Period	Guideline Concentration (µg/m³ except as noted)			
		WHO 2000	WHO 2005	WHO 2021	USEPA 2021
NO_2	1-hour[j]	-	200	-	-
	1-hour (98th percentile)[a]	-	-	-	188 (100 ppb)
	24-hour (99th percentile)[b]	-	-	25	-
	Annual [f]	-	-	10	100 (53 ppb)
SO_2	10-minute[h]	-	500	-	-
	1-hour (99th percentile)[c]	-	-	-	196 (75 ppb)
	24-hour (99th percentile)[b]	-	-	40	-
PM_{10}	24-hour (99th percentile)[b]	-	-	45	-
	24-hour (second high)[g]	-	-	-	150
	Annual [f]	-	-	15	-
$PM_{2.5}$	24-hour (99th percentile)[b]	-	-	15	-
	24-hour (98th percentile)[d]	-	-	-	35
	Annual	-	-	5[f]	12[e]
CO	15-minute[i]	-	100,000	-	-
	1-hour	-	35,000[j]	-	40,000 (35 ppm)[l]
	8-hour	-	10,000[k]	-	10,000 (9 ppm)[m]
	24-hour (99th percentile)[b]	-	-	4,000	
H_2S	24-hour[n]	150	-	-	-

µg/m³ = micrograms per cubic meter; CO = carbon monoxide NO_2 = nitrogen dioxide; PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); ppb: parts per billion; ppm: parts per million; SO_2 = sulfur dioxide
[a] Average of the 98th percentile 1-hour average concentrations for each of the modeled years.
[b] Maximum of the 99th percentile 24-hour average concentrations across all modeled years.
[c] Average of the 99th percentile 1-hour average concentrations for each of the modeled years.
[d] Average of the 98th percentile 24-hour average concentrations for each of the modeled years.
[e] Average of the annual average concentrations for each of the modeled years.
[f] Maximum of the annual average concentrations across all modeled years.
[g] Maximum of the second-highest 24-hour average concentrations across all modeled years.
[h] Maximum of the 10-minute average concentrations across all modeled years.
[i] Maximum of the 15-minute average concentrations across all modeled years.
[j] Maximum of the 1-hour average concentrations across all modeled years.
[k] Maximum of the 8-hour average concentrations across all modeled years.
[l] Maximum of the second-highest 1-hour average concentrations across all modeled years.
[m] Maximum of the second-highest 8-hour average concentrations across all modeled years.
[n] Maximum of the 24-hour average concentrations across all modeled years.

3.2 Assessment of Existing Airshed

To support interpretation of the result of air dispersion modeling, the guidelines shown in Table 3-1 were used to characterize existing conditions in the ambient airshed. As part of a prior study, EEPGL facilitated measurement of ambient onshore air concentrations of various pollutants at three locations in Guyana (Carifesta, New Amsterdam, and New Guyana School). For each of the parameters subjected to modeling and each of the averaging periods for which a guideline is provided in Table 3-1, Table 3-2 shows the maximum measured concentrations for the same averaging periods. These measured concentrations were developed based on combining the separate monitoring campaigns into a single data set (i.e., combining data from the three ambient air quality monitoring sites). These maximum measured concentrations were used to represent the existing ambient air concentrations where an onshore receptor could potentially be located.

Table 3-2: Summary of Maximum Measured Baseline Ambient Air Concentrations

Pollutant	Averaging Period	Maximum Concentration ($\mu g/m^3$)	Applicable Guideline ($\mu g/m^3$)
Nitrogen dioxide (NO_2)	1-hour	40.8[j] / 24.1[a]	200[j] / 188[a]
	24-hour	9.4	25[b]
	Full Period (318 days)	1.1	10[f]
Sulfur dioxide (SO_2)	10-minute	38.7	500[h]
	1-hour	18.9	196[c]
	24-hour	4.7	40[b]
Particulate matter (PM_{10})	24-Hour	154.3[b] / 140.4[g]	45[b] / 150[g]
	Full Period (320 days)	25.9	15[f]
Particulate matter ($PM_{2.5}$)	24-Hour	53.1[b] / 21.6[d]	15[b] / 35[d]
	Full Period (320 days)	9.6	5[f]
Carbon monoxide (CO)	15-minute	2,767	100,000[i]
	1-hour	1,660[n]/1,562[k]	35,000[j]/40,000[k]
	8-hour	1,316[n]/1,156[m]	10,000[l]/10,000[m]
	24-hour	905	4,000[b]
Hydrogen sulfide (H_2S)	24-hour	22.3	150[o]

[a] Average of the 98th percentile 1-hour average concentrations for each of the modeled years.
[b] Maximum of the 99th percentile 24-hour average concentrations across all modeled years.
[c] Average of the 99th percentile 1-hour average concentrations for each of the modeled years.
[d] Average of the 98th percentile 24-hour average concentrations for each of the modeled years.
[e] Average of the annual average concentrations for each of the modeled years.
[f] Maximum of the annual average concentrations across all modeled years.
[g] Maximum of the second-highest 24-hour average concentrations across all modeled years.
[h] Maximum of the 10-minute average concentrations across all modeled years.
[i] Maximum of the 15-minute average concentrations across all modeled years.
[j] Maximum of the highest 1-hour average concentrations across all modeled years.
[k] Maximum of the second-highest 1-hour average concentrations across all modeled years.
[l] Maximum of the highest 1-hour average concentrations across all modeled years.
[m] Maximum of the second-highest 1-hour average concentrations across all modeled years.
[n] First highest was used as the background concentration for 1-hour and 8-hour CO.
[o] Maximum of the 24-hour average concentrations across all modeled years.

The method used herein to consider existing background concentrations along with the results of modeling is based on the approach followed under the USEPA's New Source Review Prevention of Significant Deterioration (PSD) program. Under the PSD program, the USEPA establishes a screening level (referred to in the program as the Significant Impact Level or SIL) to determine whether a source's modeled ambient impact is "significant" such that it warrants what the USEPA refers to as a "cumulative air quality analysis" to demonstrate compliance with guidelines. Where a proposed source's modeled impact is deemed "insignificant or *de minimis*" using the SIL as a threshold for significance, the proponent is not required to model anything besides its own proposed emissions increase to show that the proposed source will not result in an exceedance of a guideline. If the source's modeled impact is found to be "significant" (i.e., exceeding a SIL), the proponent is required to complete a comprehensive, cumulative air quality impact analysis to demonstrate that the source's emissions will not cause or contribute to an exceedance of a guideline. The cumulative air quality impact analysis in this use includes modeling impacts of other sources to account for the cumulative air quality impacts that are predicted to occur, as well as potential inclusion of ambient monitoring data. This approach is based on the USEPA's position that when a proposed source's impact by itself is not considered "significant," any further effort on the part of the proponent to complete a cumulative source impact analysis involving other source impacts would only yield information of trivial or no value with respect to the required evaluation of the proposed source.

Consistent with the approach described above, a value equal to 10 percent of the applicable guideline for each averaging period was adopted as the screening criterion (i.e., the equivalent of the USEPA's "SIL"). The EIA already models from the outset both a Project-only and a "cumulative" case (involving modeling of Project emissions and other EEPGL project emission). Therefore, the screening criterion was used solely to determine whether existing background concentrations were added to the modeled concentrations for each scenario (i.e., Project-only and cumulative). Accordingly, for any pollutant with modeled impacts (not considering existing background concentrations) greater than 10 percent of an applicable guideline for an averaging period, this report provides the predicted concentration (without background) as well as the predicted concentration including background.

3.3 Predicted Concentrations and Comparison to Guidelines

Using the methodology described above, modeling was conducted with CALPUFF to predict maximum onshore ground-level concentrations of each pollutant as a result of emissions from Project sources. Model results were developed for each modeled pollutant, for each averaging period with an associated guideline concentration (Table 3-1). Additionally, the cumulative impact analysis modeling scenario combined the results from the Project with modeled emissions from the other EEPGL offshore activities identified above. Note that the "Modeled Case" emissions identified in Tables 23 and 2-4 were considered in both the Project only and cumulative modeling.

All results are summarized in Table 3-3 (Project-only) and Table 3-4 (Cumulative Scenario). For the Project-only modeling, maximum predicted concentrations (without background) at any potential onshore receptor location are no more than 6.3 percent of the applicable guideline for all pollutants and averaging periods.

For the cumulative scenario, maximum predicted concentrations (without background) at any potential onshore receptor location are no more than 28.4 percent of the applicable guideline for all pollutants and averaging periods.

Table 3-3: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Project Only)

Pollutant	Averaging Period	Ranking	Guideline Concentration (µg/m³) [a]	Maximum Predicted Onshore Concentration (µg/m³) [b]			Percent of Guideline		
				2023–2024	2025–2027	2028–2044	2023–2024	2025–2027	2028–2044
NO_2	1-hour	Max	200	11.96	12.19	10.51	6.0%	6.1%	5.3%
	1-hour	98th percentile	188	3.64	3.39	2.84	1.9%	1.8%	1.5%
	24-hour	99th percentile	25	1.58	1.43	1.30	6.3%	5.7%	5.2%
	Annual	Max	10	0.23	0.26	0.24	2.3%	2.6%	2.4%
SO_2	10-minute	Max	500	0.57	0.93	0.80	0.1%	0.2%	0.2%
	1-hour	99th percentile	196	0.17	0.22	0.18	0.1%	0.1%	0.1%
	24-hour	99th percentile	40	0.05	0.09	0.07	0.1%	0.2%	0.2%
PM_{10}	24-hour	99th percentile	45	0.11	0.13	0.10	0.2%	0.3%	0.2%
	24-hour	Second high	150	0.20	0.20	0.17	0.1%	0.1%	0.1%
	Annual	Max	15	0.02	0.02	0.02	0.1%	0.1%	0.1%
$PM_{2.5}$	24-hour	99th percentile	15	0.11	0.13	0.10	0.7%	0.8%	0.7%
	24-hour	98th percentile	35	0.08	0.10	0.08	0.2%	0.3%	0.2%
	Annual	Max	5	0.02	0.02	0.02	0.4%	0.4%	0.4%
CO	15-minute	Max	100,000	5.24	8.27	6.33	0.01%	0.01%	0.01%
	1-hour	Max	35,000	3.97	6.27	4.80	0.01%	0.02%	0.01%
	1-hour	Second high	40,000	3.82	5.69	4.28	0.01%	0.01%	0.01%
	8-hour	Max	10,000	2.55	2.89	2.32	0.03%	0.03%	0.02%
	8-hour	Second high	10,000	2.34	2.68	2.09	0.02%	0.03%	0.02%
	24-hour	99th percentile	4,000	0.52	1.35	0.98	0.01%	0.03%	0.02%
H_2S	24-hour	Max	150	NA	0.0008	0.0005	NA	0.001%	0.0003%

µg/m³ = micrograms per cubic meter; CO = carbon monoxide; NA = not applicable; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

[a] WHO 2000; WHO 2005; WHO 2021; USEPA 2021

[b] Concentrations are the maximum predicted onshore concentrations across the modeled meteorological conditions.

[c] NOx to NO_2 conversion for model-predicted concentrations was based on the Tier 2 Ambient Ratio Method, which uses a 0.8 scaling factor for short-term averaging period and 0.75 for annual averaging.

Table 3-4: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Cumulative Scenario) Excluding Background Concentrations

Pollutant	Averaging Period	Ranking	Guideline Concentration (µg/m³) [a]	Maximum Predicted Onshore Concentration (µg/m³) [b]			Percent of Guideline		
				2023–2024	2025–2027	2028–2044	2023–2024	2025–2027	2028–2044
NO_2 [c]	1-hour	Max	200	42.80	37.79	24.52	21.4%	18.9%	12.3%
	1-hour	98th percentile	188	12.58	14.40	11.20	6.7%	7.7%	6.0%
	24-hour	99th percentile	25	6.86	7.11	4.83	27.5%	28.4%	19.3%
	Annual	Max	10	1.02	1.12	0.96	10.2%	11.2%	9.6%
SO_2	10-minute	Max	500	5.43	3.72	2.40	1.1%	0.7%	0.5%
	1-hour	99th percentile	196	1.92	1.23	0.95	1.0%	0.6%	0.5%
	24-hour	99th percentile	40	0.65	0.38	0.33	1.6%	1.0%	0.8%
PM_{10}	24-hour	99th percentile	45	0.57	0.59	0.41	1.3%	1.3%	0.9%
	24-hour	Second high	150	0.83	0.87	0.65	0.6%	0.6%	0.4%
	Annual	Max	15	0.08	0.08	0.07	0.5%	0.6%	0.5%
$PM_{2.5}$	24-hour	99th percentile	15	0.57	0.59	0.41	3.8%	3.9%	2.8%
	24-hour	98th percentile	35	0.30	0.34	0.30	0.9%	1.0%	0.9%
	Annual	Max	5	0.08	0.08	0.07	1.5%	1.7%	1.4%
CO	15-minute	Max	100,000	18.02	16.20	15.31	0.0%	0.0%	0.0%
	1-hour	Max	35,000	13.65	12.27	11.61	0.0%	0.0%	0.0%
	1-hour	Second high	40,000	13.05	11.77	10.56	0.0%	0.0%	0.0%
	8-hour	Max	10,000	10.09	9.62	8.29	0.1%	0.1%	0.1%
	8-hour	Second high	10,000	6.18	6.53	6.56	0.1%	0.1%	0.1%
	24-hour	99th percentile	4,000	2.46	2.62	3.16	0.1%	0.1%	0.1%
H_2S	24-hour	Max	150	0.001	0.02	0.002	0.001%	0.02%	0.001%

µg/m³ = micrograms per cubic meter; CO = carbon monoxide; NA = not applicable; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

[a] WHO 2000; WHO 2005; WHO 2021; USEPA 2021

[b] Concentrations are the maximum predicted onshore concentrations across the modeled meteorological conditions.

[c] NOx to NO_2 conversion for model-predicted concentrations was based on the Tier 2 Ambient Ratio Method, which uses a 0.8 scaling factor for short-term averaging period and 0.75 for annual averaging.

All predicted concentration contributions for the Project-only scenario (Table 3-3) are less than 10 percent of the applicable guidelines. Accordingly, as per the methodology described above, background concentrations were not added to the predicted Project-only concentrations. For the cumulative scenario, predicted concentration contributions for the NO_2 1-hour (maximum), 24-hour (fourth highest), and annual (maximum) averaging periods exceeded 10 percent of the applicable guidelines. Accordingly, the maximum measured baseline concentrations from Table 3.2 for NO_2 (40.8 µg/m³ for the 1-hour averaging period, 24.07 µg/m³ for the 1-hour 98th percentile averaging period, 9.4 µg/m³ for the 24-hour averaging period, and 5.8 µg/m³ for the annual averaging period) were added to the predicted cumulative scenario concentrations, with the resulting total (with background) cumulative scenario concentrations summarized in Table 3-5.

Table 3-5: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Cumulative Scenario) for NO_2 Including Background Concentrations

Pollutant	Averaging Period	Ranking	Guideline Concentration (µg/m³) [a]	Ambient Background Concentration (µg/m³)	Maximum Predicted Onshore Concentration (µg/m³) [b]			Percent of Guideline		
					2023–2024	2025–2027	2028–2044	2023–2024	2025–2027	2028–2044
NO_2 [c]	1-hour	Max	200	40.8	83.60	78.59	65.32	41.8%	39.3%	32.7%
	1-hour	98th Percentile	188	24.1	36.68	38.50	35.30	19.5%	20.5%	18.8%
	24-hour	99th Percentile	25	9.4	16.26	16.51	14.23	65.0%	66.0%	56.9%
	Annual	Max	10	1.1	2.12	2.22	2.06	21.2%	22.2%	20.6%

µg/m³ = micrograms per cubic meter; NA = not applicable; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

[a] WHO 2000; WHO 2005; WHO 2021; USEPA 2021

[b] Concentrations are the maximum predicted onshore concentrations across the modeled meteorological conditions.

[c] NOx to NO_2 conversion for model-predicted concentrations was based on the Tier 2 Ambient Ratio Method, which uses a 0.8 scaling factor for short-term averaging period and 0.75 for annual averaging.

4. REFERENCES

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ATTACHMENT A DETAILED YELLOWTAIL PROJECT EMISSIONS BY YEAR

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Table A-1: NO_x Emissions by Year—Yellowtail Project

Source Sector	Emissions (tonnes) Modeled for Each Period			Emissions (tonnes) Per Year																				
	2023-2024	2025-2027	2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	1,961	2,448	0	0	41	1,449	1,961	2,204	2,290	2,448	2,440	2,427	2,440	2,376	2,293	1,888	2,094	1,820	1,875	1,668	1,641	1,321	1,460	1,392
Flare— Background and Non-routine (Design Case)	0	504	188	0	0	135	504	129	150	165	185	186	188	188	184	183	155	176	135	147	132	135	93	106	101
Flare— Background and Non-routine (Modeled Case)	0	518	347	0	0	136	518	239	277	304	341	344	346	347	340	338	287	324	249	271	243	250	173	196	188
Essential Services Generators	0	102	8	0	0	102	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Emergency Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Tanker	0	238	238	0	0	1	196	238	238	237	219	172	143	130	115	96	71	76	60	60	53	45	31	33	33
Drill Ships	1,832	942	942	549	1,832	942	942	942	942	550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels in Project Development Area	724	483	425	724	724	483	483	483	425	425	425	425	425	425	425	425	425	425	425	425	425	425	425	425	425
Support Vessels between Shore and Project Development Area	362	241	425	362	362	241	241	241	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
General Project Development Area (Installation)	1,028	1,028	0	1,028	1,028	1,028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicopters between Shore and Project Development Area	17	30	25	17	17	30	30	30	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Sum (Design Case)	**3,963**	**5,530**	**5,170**	**2,680**	**3,963**	**3,003**	**3,854**	**4,032**	**4,204**	**4,304**	**3,522**	**4,882**	**4,293**	**3,429**	**3,346**	**3,243**	**2,785**	**3,016**	**2,685**	**2,752**	**2,524**	**2,491**	**2,116**	**2,269**	**2,197**
Sum (Modeled Case)	**3,963**	**5,543**	**5,329**	**2,680**	**3,963**	**3,004**	**3,867**	**4,142**	**4,331**	**4,444**	**3,678**	**5,040**	**4,451**	**3,588**	**3,502**	**3,398**	**2,916**	**3,165**	**2,800**	**2,876**	**2,636**	**2,606**	**2,196**	**2,359**	**2,283**

NOx = nitrogen oxides

Table A-2: SO_2 Emissions by Year—Yellowtail Project

Source Sector	Emissions (tonnes) Modeled for Each Period			Emissions (tonnes) Per Year																				
	2023-2024	2025-2027	2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	105	121	0	0	5	89	105	113	116	121	121	121	121	119	116	103	110	101	103	96	95	84	89	87
Flare— Background and Non-routine (Design Case)	0	86	32	0	0	23	86	22	25	28	31	32	32	32	31	31	26	30	23	25	22	23	16	18	17
Flare— Background and Non-routine (Modeled Case)	0	88	59	0	0	23	88	41	47	52	58	58	59	59	58	57	49	55	42	46	41	42	29	33	32
Essential Services Generators	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Tanker	0	8	8	0	0	0	7	8	8	8	7	6	5	4	4	3	2	3	2	2	2	1	1	1	1
Drill Ships	61	32	32	18	61	32	32	32	32	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels in Project Development Area	0	16	14	24	24	16	16	16	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Support Vessels between Shore and Project Development Area	12	8	14	12	12	8	8	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
General Project Development Area (Installation)	34	34	0	34	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicopters between Shore and Project Development Area	2	4	3	2	2	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sum (Design Case)	**110**	**296**	**240**	**91**	**134**	**125**	**241**	**195**	**203**	**208**	**185**	**231**	**211**	**182**	**179**	**175**	**156**	**167**	**150**	**154**	**144**	**144**	**126**	**133**	**130**
Sum (Modeled Case)	**110**	**299**	**267**	**91**	**134**	**125**	**243**	**214**	**225**	**232**	**211**	**257**	**238**	**209**	**205**	**202**	**179**	**192**	**170**	**175**	**163**	**163**	**139**	**148**	**144**

SO_2 = sulfur dioxide

Table A-3: H_2S Emissions by Year—Yellowtail Project

Source Sector	Emissions (tonnes) Modeled for Each Period			Emissions (tonnes) Per Year																				
	2023-2024	2025-2027	2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flare— Background and Non-routine (Design Case)	0.00	1.26	0.47	0.00	0.00	0.34	1.26	0.32	0.37	0.41	0.46	0.46	0.47	0.47	0.46	0.46	0.39	0.44	0.34	0.37	0.33	0.34	0.23	0.26	0.25
Flare— Background and Non-routine (Modeled Case)	0.00	1.29	0.86	0.00	0.00	0.34	1.29	0.60	0.69	0.76	0.85	0.86	0.86	0.86	0.85	0.84	0.72	0.81	0.62	0.68	0.61	0.62	0.43	0.49	0.47
Essential Services Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Tanker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drill Ships	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels in Project Development Area		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels between Shore and Project Development Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
General Project Development Area (Installation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicopters between Shore and Project Development Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum (Design Case)	**0.00**	**1.26**	**0.47**	**0.00**	**0.00**	**0.34**	**1.26**	**0.32**	**0.37**	**0.41**	**0.46**	**0.46**	**0.47**	**0.47**	**0.46**	**0.46**	**0.39**	**0.44**	**0.34**	**0.37**	**0.33**	**0.34**	**0.23**	**0.26**	**0.25**
Sum (Modeled Case)	**0.00**	**1.29**	**0.86**	**0.00**	**0.00**	**0.34**	**1.29**	**0.60**	**0.69**	**0.76**	**0.85**	**0.86**	**0.86**	**0.86**	**0.85**	**0.84**	**0.72**	**0.81**	**0.62**	**0.68**	**0.61**	**0.62**	**0.43**	**0.49**	**0.47**

H_2S = hydrogen sulfide

Table A-4: PM Emissions by Year—Yellowtail Project

Source Sector	Emissions (tonnes) Modeled for Each Period			Emissions (tonnes) Per Year																				
	2023-2024	2025-2027	2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	30	37	0	0	1	23	30	33	34	37	36	36	36	36	34	29	32	28	29	26	26	21	23	22
Flare— Background and Non-routine (Design Case)	0	99	37	0	0	26	99	25	29	32	36	36	37	37	36	36	30	34	26	29	26	26	18	21	20
Flare— Background and Non-routine (Modeled Case)	0	101	68	0	0	27	101	47	54	59	67	67	68	68	67	66	56	63	49	53	48	49	34	38	37
Essential Services Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Generators	0	7	1	0	0	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Export Tanker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drill Ships	0	17	17	0	0	0	14	17	17	17	15	12	10	9	8	7	5	5	4	4	4	3	2	2	2
Support Vessels in Project Development Area	129	66	66	39	129	66	66	66	66	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels between Shore and Project Development Area	0	34	30	51	51	34	34	34	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
General Project Development Area (Installation)	25	17	30	25	25	17	17	17	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Helicopters between Shore and Project Development Area	72	72	0	72	72	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum (Design Case)	**228**	**344**	**251**	**188**	**279**	**226**	**255**	**192**	**193**	**197**	**135**	**231**	**191**	**130**	**127**	**124**	**111**	**119**	**106**	**109**	**103**	**102**	**89**	**93**	**91**
Sum (Modeled Case)	**228**	**346**	**283**	**188**	**279**	**226**	**258**	**213**	**217**	**224**	**166**	**262**	**222**	**161**	**157**	**154**	**137**	**148**	**128**	**133**	**124**	**125**	**104**	**111**	**108**

PM = particulate matter

Table A-5: CO Emissions by Year—Yellowtail Project

Source Sector	Emissions (tonnes) Modeled for Each Period			Emissions (tonnes) Per Year																				
	2023-2024	2025-2027	2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	386	511	0	0	1	255	386	449	471	511	509	506	509	493	472	368	420	350	364	311	304	222	258	240
Flare— Background and Non-routine (Design Case)	0	2,300	857	0	0	616	2,300	589	683	751	843	850	855	857	841	836	708	801	614	668	600	616	425	481	461
Flare— Background and Non-routine (Modeled Case)	0	2,360	1,582	0	0	622	2,360	1,090	1,262	1,387	1,555	1,568	1,578	1,582	1,552	1,542	1,308	1,479	1,136	1,235	1,110	1,139	790	892	856
Essential Services Generators	0	27	2	0	0	27	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Emergency Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Tanker	0	63	63	0	0	0	52	63	63	63	58	46	38	35	31	25	19	20	16	16	14	12	8	9	9
Drill Ships	487	250	250	146	487	250	250	250	250	146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels in Project Development Area	192	128	113	192	192	128	128	128	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
Support Vessels between Shore and Project Development Area	96	64	113	96	96	64	64	64	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
General Project Development Area (Installation)	273	273	0	273	273	273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicopters between Shore and Project Development Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum (Design Case)	**1,048**	**3,492**	**2,035**	**707**	**1,048**	**1,360**	**3,052**	**1,484**	**1,617**	**1,707**	**1,584**	**1,952**	**1,801**	**1,573**	**1,536**	**1,504**	**1,266**	**1,414**	**1,152**	**1,220**	**1,097**	**1,104**	**828**	**920**	**882**
Sum (Modeled Case)	**1,048**	**3,552**	**2,759**	**707**	**1,048**	**1,365**	**3,112**	**1,984**	**2,195**	**2,343**	**2,296**	**2,670**	**2,523**	**2,297**	**2,247**	**2,211**	**1,866**	**2,092**	**1,674**	**1,787**	**1,607**	**1,627**	**1,192**	**1,331**	**1,277**

CO = carbon monoxide

Table A-6: VOC Emissions by Year—Yellowtail Project

Source Sector	Emissions (tonnes) Modeled for Each Period			Emissions (tonnes) Per Year																				
	2023-2024	2025-2027	2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	7	12	0	0	0	7	10	12	12	13	13	13	13	13	12	10	11	9	9	8	8	6	7	6
Flare— Background and Non-routine (Design Case)	0	2,112	690	0	0	566	2,112	541	627	690	774	781	786	787	772	767	650	736	564	614	551	566	391	442	424
Flare— Background and Non-routine (Modeled Case)	0	2,167	1,274	0	0	571	2,167	1,001	1,159	1,274	1,428	1,440	1,449	1,452	1,425	1,416	1,201	1,359	1,043	1,134	1,019	1,046	725	819	786
Essential Services Generators	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanks	0	212	256	0	0	1	212	257	257	256	237	186	155	141	124	104	77	82	65	65	58	48	34	36	36
Vessel Loading	0	1,156	1,397	0	0	6	1,156	1,403	1,403	1,397	1,291	1,016	847	769	679	567	421	449	353	353	314	264	185	196	196
Export Tanker	0	1	2	0	0	0	1	2	2	2	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0
Drill Ships	12	6	4	4	12	6	6	6	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels in Project Development Area	5	3	3	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Support Vessels between Shore and Project Development Area	2	2	1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
General Project Development Area (Installation)	7	0	0	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicopters between Shore and Project Development Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum (Design Case)	**27**	**3,499**	**2,368**	**18**	**27**	**594**	**3,499**	**2,224**	**2,311**	**2,368**	**2,320**	**2,011**	**1,813**	**1,716**	**1,594**	**1,455**	**1,163**	**1,283**	**997**	**1,046**	**936**	**891**	**620**	**686**	**667**
Sum (Modeled Case)	**27**	**3,554**	**2,952**	**18**	**27**	**598**	**3,554**	**2,684**	**2,843**	**2,952**	**2,975**	**2,671**	**2,476**	**2,381**	**2,247**	**2,104**	**1,714**	**1,906**	**1,476**	**1,567**	**1,404**	**1,371**	**955**	**1,063**	**1,029**

VOC = volatile organic compound

Table A-7: Greenhouse Gas (Kilotonnes CO_2-equivalents)

Source Sector	Emissions (kilotonnes) Estimated			Emissions (kilotonnes) Per Year																					
	2024 (peak of 2023-2024)	2026 (peak of 2025-2027)	Average of 2028-2044	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0	468	685	0	0	8	468	668	763	796	858	854	850	855	829	797	639	720	613	634	554	543	418	472	446
Flare—Background and Non-routine (Design Case)	0	1,103	336	0	0	296	1,103	283	328	360	404	408	410	411	403	401	340	384	295	321	288	296	204	231	221
Flare—Background and Non-routine (Modeled Case)	0	1,132	620	0	0	298	1,132	523	605	665	746	753	757	759	745	740	627	710	545	593	532	547	379	428	411
Essential Services Generators	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Generators	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanks	0	35	19	0	0	0	35	43	43	43	39	31	26	23	21	17	13	14	11	11	10	8	6	6	6
Vessel Loading	0	5	3	0	0	0	5	6	6	6	6	4	4	3	3	3	2	2	2	2	1	1	1	1	1
Export Tanker	0	12	6	0	0	0	12	14	14	14	13	10	9	8	7	6	4	5	4	4	3	3	2	2	2
Drill Ships	109	56	15	33	109	56	56	56	56	56	0	84	52	0	0	0	0	0	0	0	0	0	0	0	0
Support Vessels in Project Development Area	43	29	25	43	43	29	29	29	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Support Vessels between Shore and Project Development Area	22	14	13	22	22	14	14	14	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
General Project Development Area (Installation)	61	0	0	61	61	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicopters between Shore and Project Development Area	3	6	5	3	3	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Sum (Design Case)	**239**	**1,729**	**1,106**	**162**	**239**	**476**	**1,729**	**1,119**	**1,253**	**1,319**	**1,363**	**1,435**	**1,393**	**1,344**	**1,307**	**1,267**	**1,041**	**1,167**	**967**	**1,014**	**899**	**893**	**674**	**755**	**719**
Sum (Modeled Case)	**239**	**1,758**	**1,391**	**162**	**239**	**478**	**1,758**	**1,360**	**1,530**	**1,624**	**1,705**	**1,780**	**1,740**	**1,691**	**1,648**	**1,606**	**1,329**	**1,493**	**1,217**	**1,286**	**1,143**	**1,144**	**848**	**952**	**908**

CO_2 = carbon dioxide

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APPENDIX H

Underwater Sound Modeling Report

Resubmitted without changes

March 2022

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Underwater Sound Assessment for Yellowtail Development Project; Offshore Guyana; Stabroek Block

Submitted to: Jason Willey, ERM.

Request: Asses the Applicability of the previously modelled underwater sound levels associated with the Liza Phases 1 and 2 and Payara Development Projects for the Yellowtail Development Project.

In December 2016, JASCO Applied Sciences (JASCO) carried out a modeling study for Esso Exploration and Production Guyana Limited (EEPGL) to predict underwater sound levels associated with the Liza Phase 1 Development Project located within the Stabroek Block (Matthews et al. 2016). This analysis was also applied to the Liza Phase 2 Development Project in 2018, due to the two projects being virtually identical at adjacent sites and with very similar environmental conditions. The recently proposed Yellowtail development project will be a new sound source in the region, centered about the FPSO 30 km ESE of the Liza Phase 1 FPSO. Seabed infrastructure will be installed at depths between 1,690 and 1,910 m, with pilling occurring between 1,690 and 1,780 m (Figure 1).

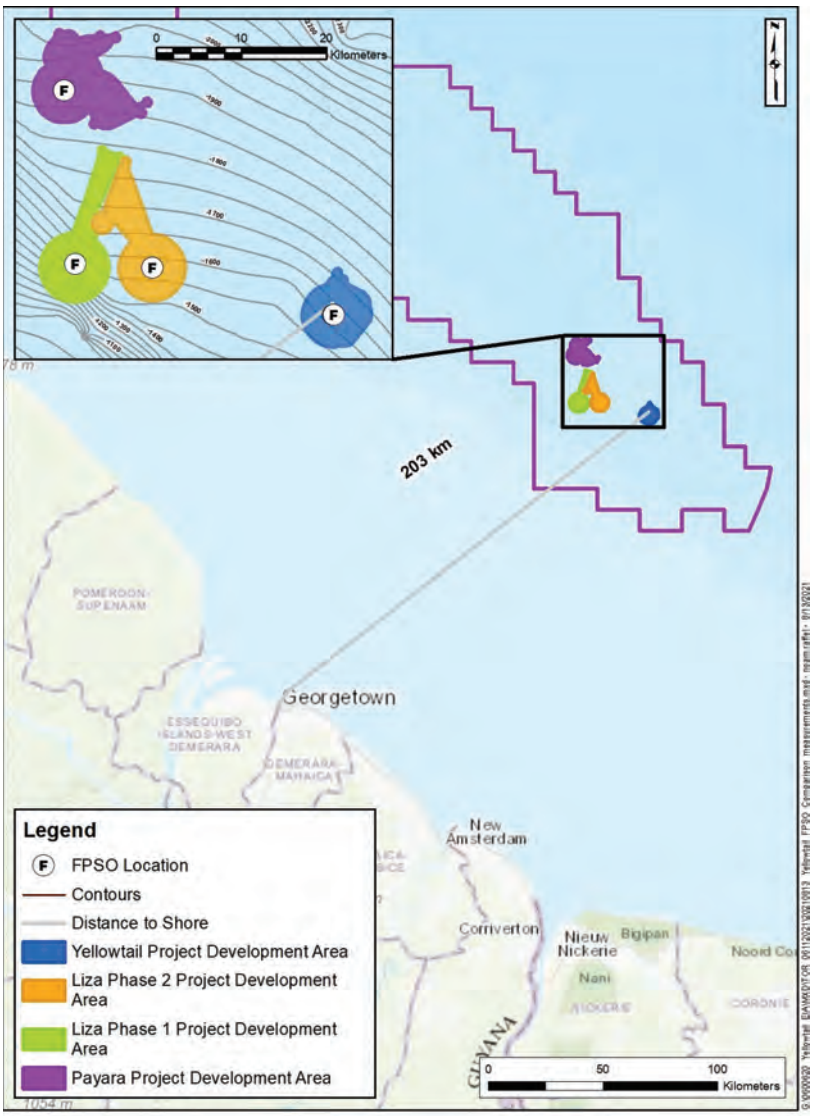

Figure 1. Locations of EEPGL sites in the Starbroek Block.

The sound footprints for the Liza Phase 1 scenarios were modeled to estimate distances to sound level threshold criteria for marine mammals based on:

- Injury, as defined by Southall et al. (2007), Wood et al. (2012), and Finneran (2015). These sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SEL) for 24 hours of operation.
- Behavioral disturbance, as defined by the U.S. National Marine Fisheries Service (HESS 1999, NMFS 2013). These sound footprints were calculated as unweighted sound pressure level (SPL) thresholds of 120 dB re 1 µPa (nonimpulsive sources) and 160 dB re 1 µPa (impulsive sources).

We assume that the same criteria would be used for the Yellowtail project to assess the effects on marine mammals.

EEPGL advised JASCO that the planned Yellowtail infrastructure and work activities would be comparable to those previously modelled for Liza phase 1. As such, we assume the source levels and scenarios would remain applicable for the Yellowtail development.

In 2016, we modeled sound propagation with JASCO's Marine Operations Noise Model (MONM) and JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM). These models produce depth-, range- and azimuth-dependent sound fields associated with environmental parameters (including bathymetry, geoacoustic properties, and underwater sound speed profiles) that are specific to the Stabroek Block area. At the time, no site-specific information was available for developing geoacoustic properties or sound speed profiles. Thus, generic profiles for the modeled region were developed based on publicly available data (Rucker 1967, Hamilton 1980, Teague et al. 1990, Carnes 2009, Maxon Consulting Inc. 2014). These profile estimates provided conservative sound propagation results within the modeled area, which extended up to 100 km from the Liza Phase 1 FPSO vessel. No updated geoacoustic information is available.

As the original modelling for Liza Phase 1 occurred five years ago, more recent water-column sound speed profiles are now available to quantify the environment, but they do not affect the conclusions from the previous modeling. Sound speed profiles were extracted from the Global Ice Ocean Prediction System (GIOPS ECCC) for 2020 (Figure *2*) for the Yellowtail development region. These compare favorably to the profiles employed during the original modelling from 2016 for the Liza Phase 1 and 2 locations, Payara, and in the deep ocean off the continental shelf (Figure *3*). The differences in the sound speed profiles for the new data vs the older data were distributed about zero m/s and thus unlikely to affect overall sound propagation as the refraction of sound is determined by the shape of the profile which remains the same. The seabed development and operations at the Yellowtail project will be slightly deeper than the Liza P1 development. However, as the main source of sound for the pile driving operations is near the seabed, the similarity in sound speed profile at the seabed re-enforces our conclusion that the profiles are sufficiently equivalent, and that no new modelling is required.

Therefore, based on the bathymetric relationship between the Liza Phase 1 and Yellowtail sound source locations, the homogeneous environmental properties over a large area that encompasses both the Liza and Yellowtail projects development areas, and the similarity in noise-producing activities for the two projects, we estimate that model results for the Yellowtail scenarios would present little changes in the distances to marine mammal injury thresholds provided for Liza Phase 1. Indeed, due to the deeper waters at Yellowtail, sounds emitted there will attenuate spherically for greater distances than in shallower waters so that the effects distances are likely to be shorter than at Liza Phase 1. A new assessment of effects distances would be recommended if updated criteria to assess the effect on marine life are used (e.g. the guidance for US water contained in NMFS (2018)), new (more site-specific) geoacoustic information is available, or the nature of the Yellowtail operations differ from Liza Phase 1.

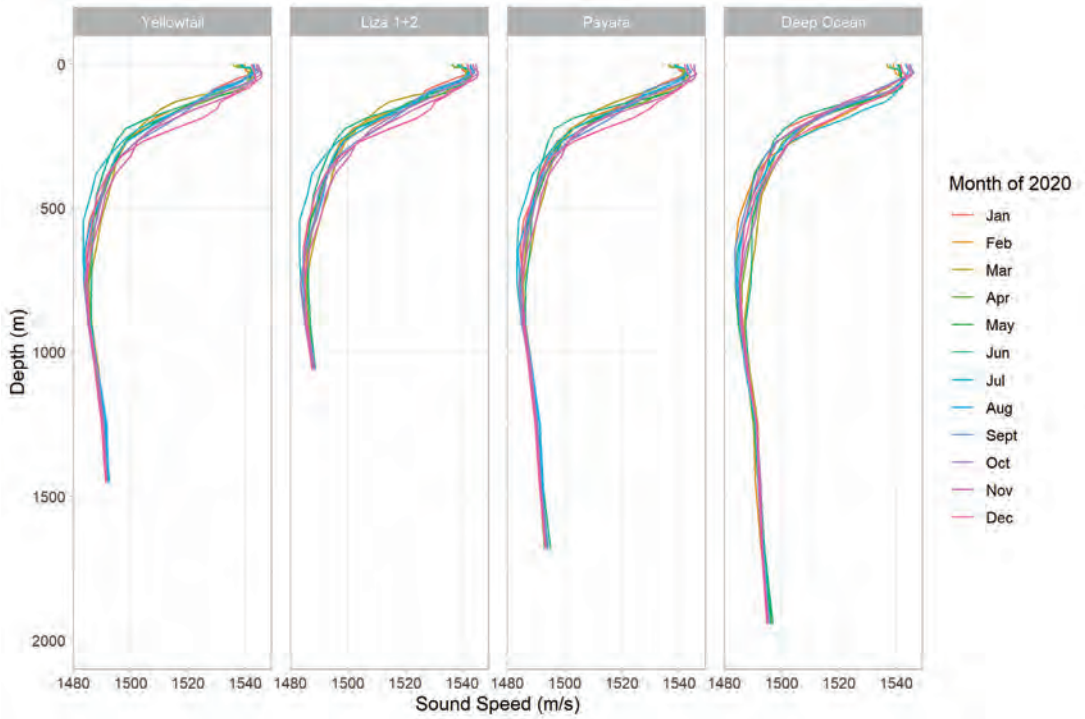

Figure 2. Modelled local and regional sound speed profiles (from GIOPS) used in the similarity assessment for the proposed yellowtail development from 2020.

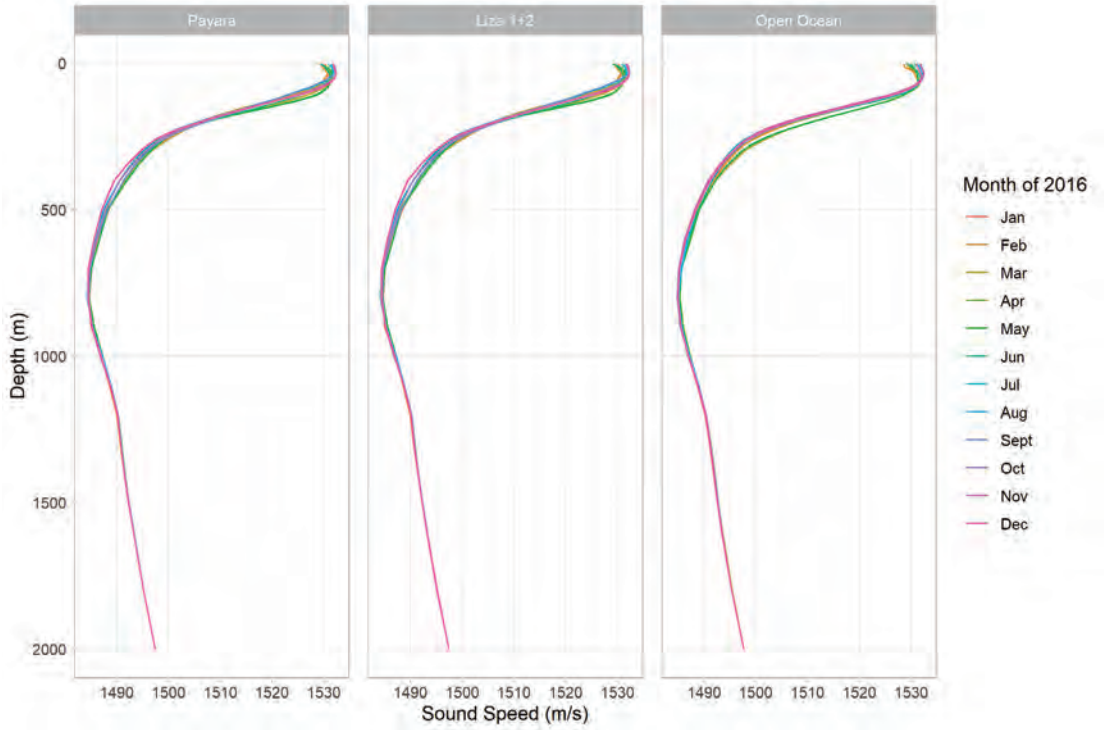

Figure 3. Local and regional sound speed profiles used in the original acoustic modelling impact assessment for the Liza phase 1 development in 2016.

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Underwater Sound Associated with Liza Phase 1 Project Activities

Offshore Guyana Stabroek Block

Submitted to:

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Executive Summary

This underwater sound modeling study predicts underwater sound levels associated with the Liza Phase 1 Development Project (hereinafter referred to as the Project). The Project is designed to develop and produce oil in the ExxonMobil Liza field, located within the Stabroek Block, approximately 190 km offshore central Guyana. The modeled Project activities include drilling development wells, installing and operating a Floating Production Storage and Offloading (FPSO) vessel, and installing Subsea, Umbilical, Riser, and Flowline (SURF) equipment. Sound footprints from representative sound sources, including vessels, a vertical seismic profile (VSP) source, and underwater impact pile driving equipment, were considered. The model results were used to estimate distances to marine mammal injury thresholds, based on best available science.

The underwater sound fields were modeled for water column sound speed profiles representative of April. This time corresponds with lowest surface temperatures, which lead to upward sound refraction and longer-distance sound propagation. The obtained results therefore ensure cautionary estimates of the distances to received sound level thresholds.

Six scenarios were modeled to simulate the following:

1. The operation of a Floating Production Storage and Offloading (FPSO) vessel,
2. The installation of the FPSO vessel, which includes the associated installation and support vessels,
3. The operation of a drill ship and a pipelaying vessel at one of the two drill centers, approximately 13 km north of the FPSO,
4. The operation of a VSP source in the vicinity of the drill centers,
5. Underwater impact pile driving of SURF equipment piles at one of the two drill centers, approximately 13 km north of the FPSO, and
6. Underwater impact pile driving of anchor mooring piles at the FPSO location.

The models produced estimates of the sound fields in M-weighted SEL_{24h} and peak sound pressure levels (PK). The sound fields account for source-specific sound emission characteristics (Section 4.1) and site-specific environmental parameters (Section 4.2). The estimated sound fields are applicable to other locations within the Project area, where site-specific environmental parameters are similar.

For scenarios 1 through 3, the distances to injury thresholds from vessels are small (<10 m). Distances to low- and mid-frequency cetacean injury thresholds for the VSP source were estimated for three sets of acoustic effects criteria. The distances vary from ≤35 m for mid-frequency cetaceans to ≤143 m for low-frequency cetaceans. Distances to the same thresholds for underwater impact pile driving operations are the longer than for the other scenarios. The distances vary from 100 to 762 m for mid-frequency cetaceans and from 1,025 to 1,375 m for low-frequency cetaceans. The sound levels at or above injury thresholds for impact pile driving were found close to the ocean bottom, at depths >1,000 m.

1. Introduction

JASCO Applied Sciences (JASCO) carried out a modeling study for Esso Exploration and Production Guyana Limited (EEPGL) to predict underwater sound levels associated with the Liza Phase 1 Development Project (hereinafter referred to as the Project) located within the Stabroek Block, approximately 190 km offshore central Guyana (Figure 1). The Project activities include installing and operating a Floating Production, Storage, and Offloading (FPSO) vessel, installing and operating Subsea Umbilical, Riser, and Flowline (SURF) equipment, as well as associated development drilling at two drill centers in the Liza field. Each drill center consists of an underwater injection (I) and a production (P) component, tied to the FPSO by the SURF equipment. Installing this Project infrastructure will require the use of multiple vessels, including drill ships, pipelaying vessels, tugs, barges, support, and supply vessels of various sizes. During production operations, the FPSO will be moored. Hydrocarbons produced from the wells will be offloaded onto tankers. This offloading operation may also require the use of tugs, while supply vessels will regularly dock alongside the FPSO.

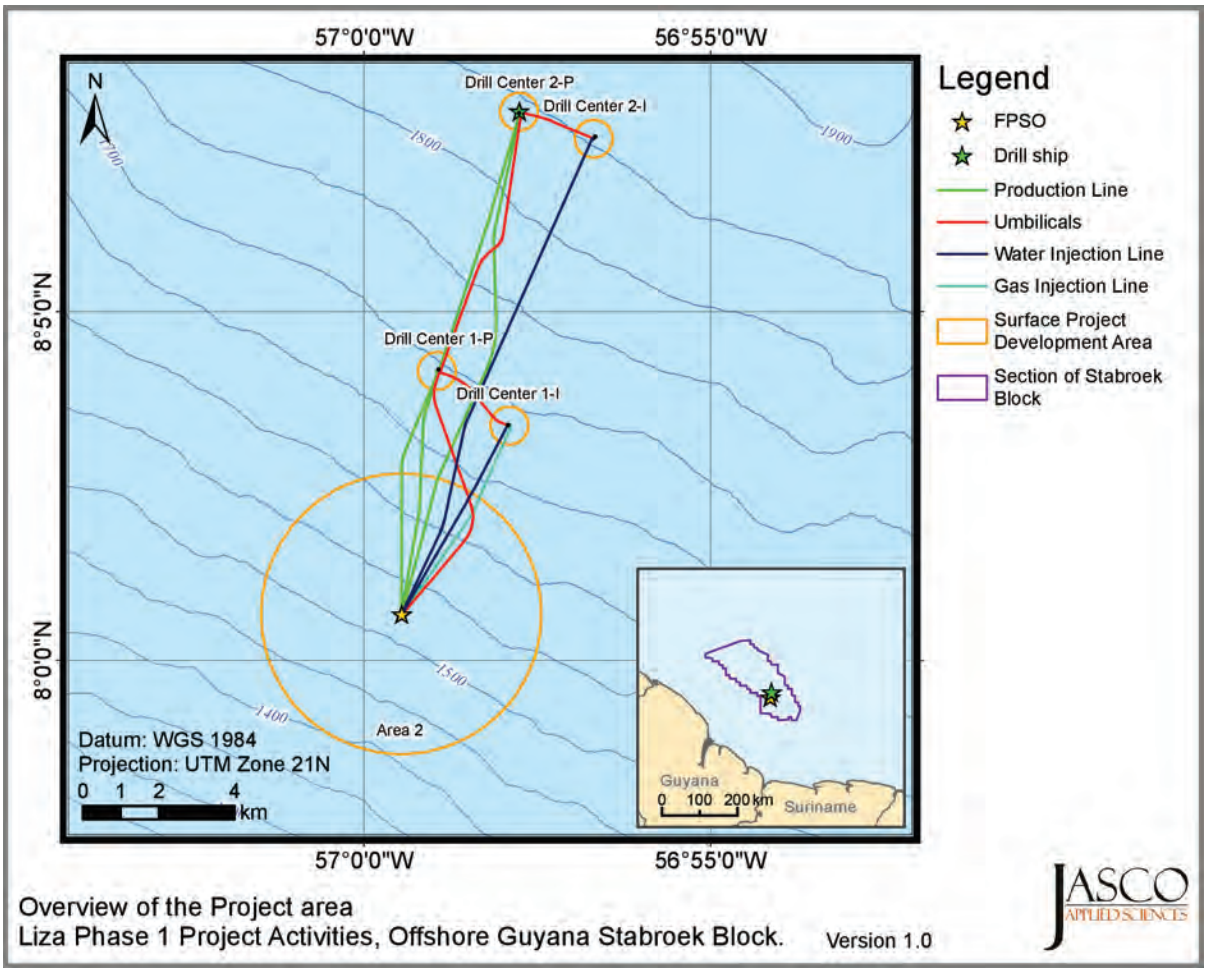


Figure 1. Overview of the Guyana Stabroek project area.

Six scenarios were considered in this modeling study, which include:

1. The operation of an FPSO vessel,
2. The installation of the FPSO vessel, which includes mooring the FPSO, and using several installation and service vessels, and
3. The installation of subsea flowlines and risers and operation of Drill Center 2-P, approximately 13 km north of the FPSO, which includes the operation of a drill ship, a pipelaying vessel, and multiple service vessels,
4. The operation of a VSP source in the vicinity of Drill Centers 2-P and 2-I,
5. The installation of piles for SURF equipment at Drill Center 2-P through underwater impact pile driving, and
6. The installation of anchor mooring piles at the FPSO location through underwater impact pile driving.

The specific vessels, the characteristics of the VSP source, as well as the specifications of the piles and driving hammer are at present unknown. Measurements from surrogate vessels, including the FPSO, drill ship, pipelaying vessel, tugs, and support vessels, were used to derive the acoustic characteristics of the vessels that will likely be used in the operations. The VSP source considered here is a six-element air gun array with a total volume of 1200 in^3. The source pressure signature of this array was modeled with JASCO's Airgun Array Source Model (AASM). This model accounts for individual element volume and position within the array. All modeled piles were 25 m in length, and 5 m in diameter. The modeled impact hammer model is the MENCK 500T, with underwater settings. It was assumed that it will take 5 hours to drive each pile, and that one pile will be driven per 24 hour period. The forcing function transferred from the hammer to the pile was modeled using the GRLWEAP model (GRLWEAP, Pile Dynamics 2010); the sound signature along the pile was modeled using JASCO's pile vibration and near-field sound radiation model (MacGillivray 2014).

Sound propagation was modeled with JASCO's Marine Operations Noise Model (MONM) and JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM). These models produced depth, range, and azimuth dependent sound fields associated with environmental parameters, including bathymetry, that are specific to the Stabroek Block area.

The sound footprint for each scenario was modeled to estimate distances to sound level thresholds based on injurious criteria prescribed by Southall et al. (2007) and Finneran (2015). The sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SEL) for 24 hours of operation.

Section 2 describes the acoustic effect criteria for this study. Definitions of the different metrics associated with the criteria are provided in Appendix A.1. Section 3 discusses the methodology for predicting the source levels and modeling the sound propagation. Section 4 describes the various input parameters pertinent to this study. Section 5 presents the results in two formats: tables of maximum and 95% distances to sound level thresholds and a sound field contour map showing the directivity of the various sound level threshold contours for the VSP source and impact pile driving operations. Section 6 presents an analysis of the results.

1.1. Modeled Scenarios

Various vessels were involved in the first three scenarios, including tugs, supply vessels, and support vessels. At the time of this study, the exact location and description of each vessel were unknown. The modeled scenarios represent an estimate of the general location of each vessel for a 24 hour period; the surrogate vessels provide estimates of the sound emission levels for the proposed vessel fleet. Table 1 and Figures 2–4 list the vessels, their operational state, and their location. Scenario 4 involves a VSP source operating near Drill Center 2-P (Table 1; Figure 4). Scenarios 5 and 6 represent the installation of SURF equipment and FPSO anchor mooring piles using an underwater impact pile driver (Table 1; Figure 5).

Table 1. List of vessels for each modeled scenario. FPSO: Floating Production Storage and Offloading; VSP: Vertical Seismic Profile.

Scenario	Vessel/Source type	Operational state	Location		UTM Coordinates	
			Latitude (°)	Longitude (°)	Easting (m)	Northing (m)
1	FPSO	Moored, not using main engines	8.010982	−56.990920	501000	885512
	Tanker	Idle, held in position by tugs	8.010955	−56.984305	501729	885509
	2 x tugs	Using dynamic positioning	8.010276, 8.011651	−56.987445, −56.987427	501383, 501385	885434, 885586
	Large tug	Using dynamic positioning	8.010955	−56.983479	501820	885509
	Supply vessel	Using dynamic positioning	8.011326	−56.991873	500895	885550
2	FPSO	Using main engine	8.010982	−56.990920	501000	885512
	2 x FPSO supply barges	Using dynamic positioning	8.000010, 8.010665	−56.991447, −56.991719	500942, 500912	884299, 885477
	2 x tugs	Using dynamic positioning	8.010213, 8.000769	−56.991447, −56.991447	500942, 500942	885427, 884383
	FPSO major work vessel	Using dynamic positioning	8.010629	−56.989732	501131	885473
	2 x supply vessels	Using dynamic positioning	8.011326, 7.993162	−56.991873, −56.983788	500895, 501786	885550, 883542
	3 x support vessels	Using dynamic positioning	8.011724, 7.989020, 8.010286	−56.989187, −56.996910, −56.989586	501191, 500340, 501147	885594, 883084, 885435
	Fast supply vessel	Using dynamic positioning	8.010673	−56.969304	503382	885478
	Light construction vessel	Using dynamic positioning	8.011299	−56.989777	501126	885547
3	Drill ship	Drilling and maintenance work	8.131187	−56.962605	504119	898801
	Large crane vessel	Using dynamic positioning	8.130906	−56.963123	504062	898770
	Light construction vessel	Using dynamic positioning	8.131431	−56.963277	504045	898828
	Multiple service vessel	Using dynamic positioning	8.134623	−56.958293	504594	899181
	Pipelaying vessel	Laying pipe	8.117347	−56.964095	503955	897271
	2 x barges	Towed by tugs	8.117428, 8.101734	−56.963841, −56.962799	503983, 504098	897280, 895545
	2 x tugs	Using dynamic positioning	8.117546, 8.102494	−56.963705, −56.962798	503998, 504098	897293, 895629
	2 x supply vessels	Using dynamic positioning	8.130734, 8.117799	−56.963059, −56.964268	504069, 503936	898751, 897321
	3 x support vessels	Using dynamic positioning	8.134479, 8.114625, 8.141861	−56.966644, −56.968507, −56.975277	503674, 503469, 502723	899165, 896970, 899981
	Field intervention vessel	Using dynamic positioning	8.141768	−56.949605	505551	899971
4	VSP source	Up to 40 pulses in 24 hours	8.128535	−56.953837	505085	898508
	VPS support vessel	Using dynamic positioning; deploying the VSP source	8.128535	−56.953837	505085	898508
5	Underwater impact pile driving	Driving SURF equipment piles at Drill Center 2-P	8.131187	−56.962605	504119	898801
6	Underwater impact pile driving	Driving FPSO anchor mooring piles at the FPSO	8.010982	−56.990920	501000	885512

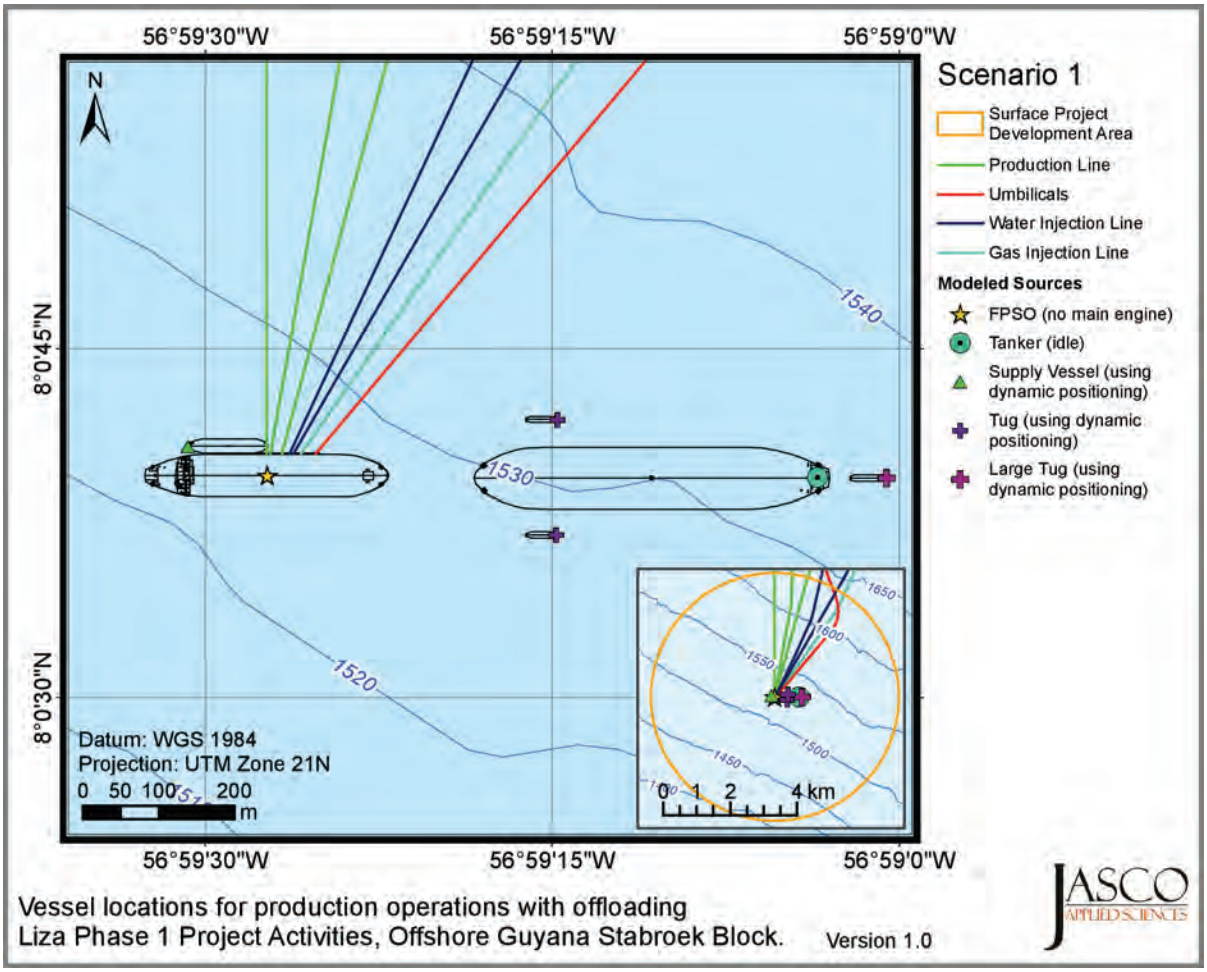


Figure 2. Scenario 1: Location of modeled vessels.

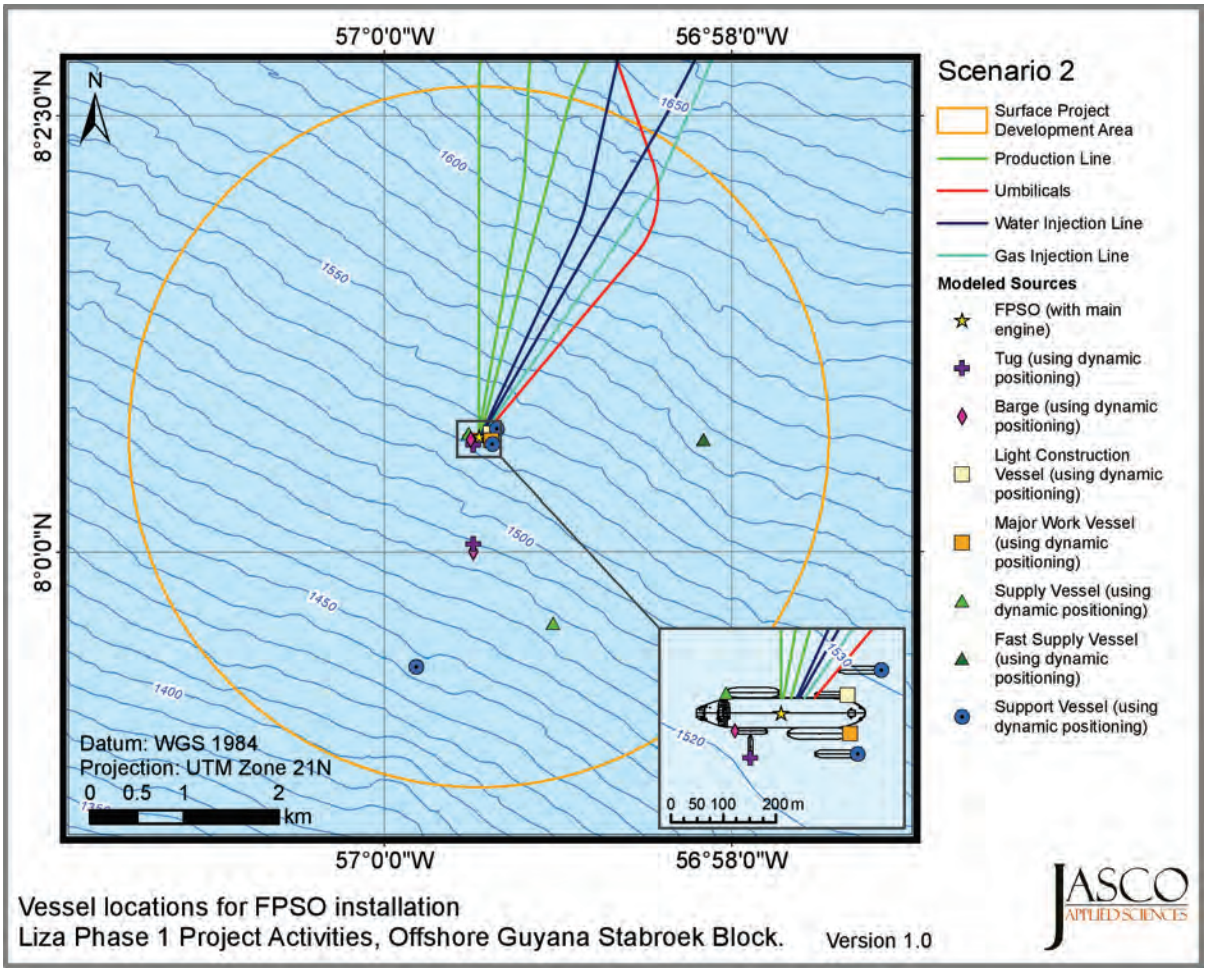


Figure 3. Scenario 2: Location of modeled vessels.

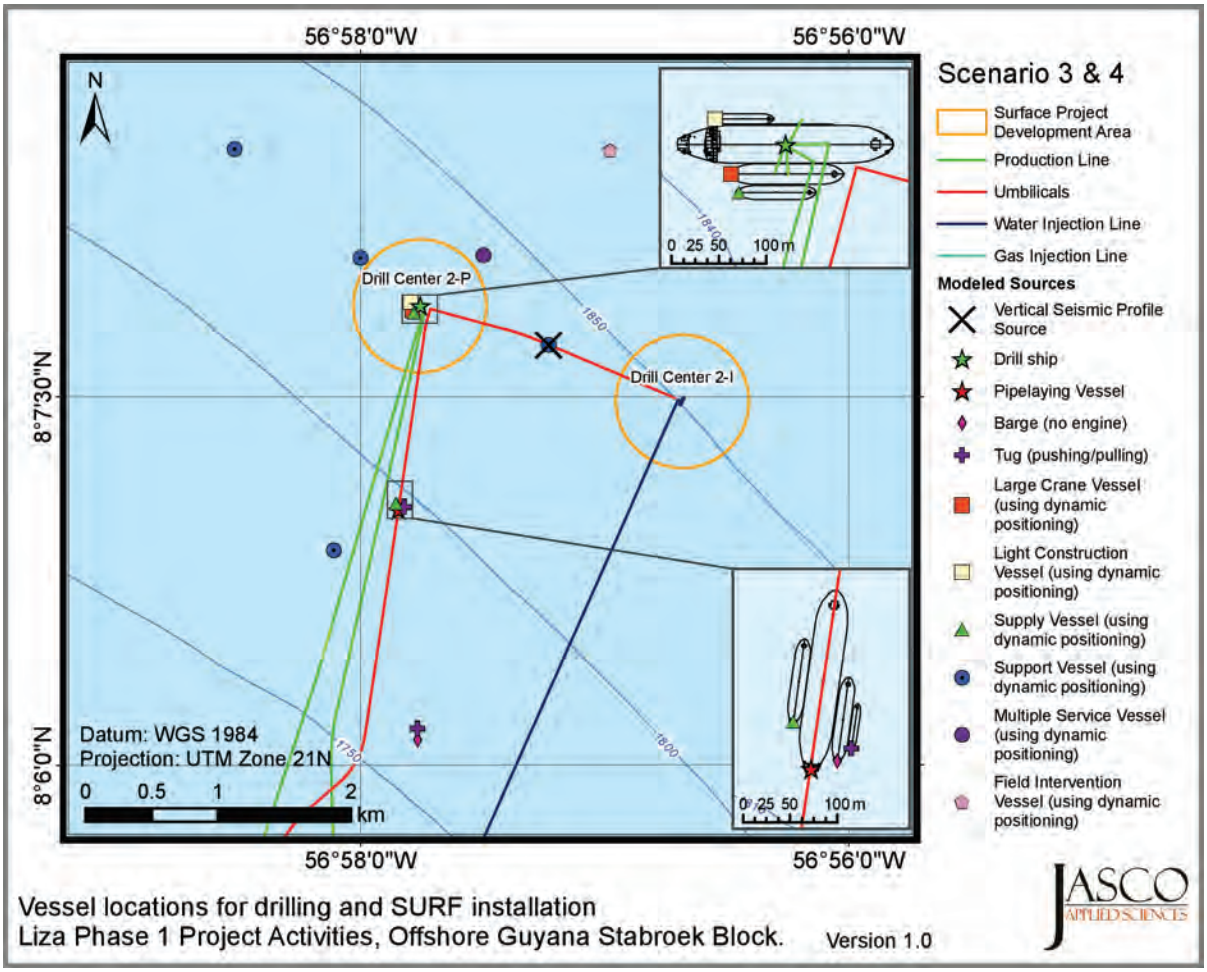


Figure 4. Scenarios 3 and 4: Location of modeled vessels and the VSP source at Drill Center 2.

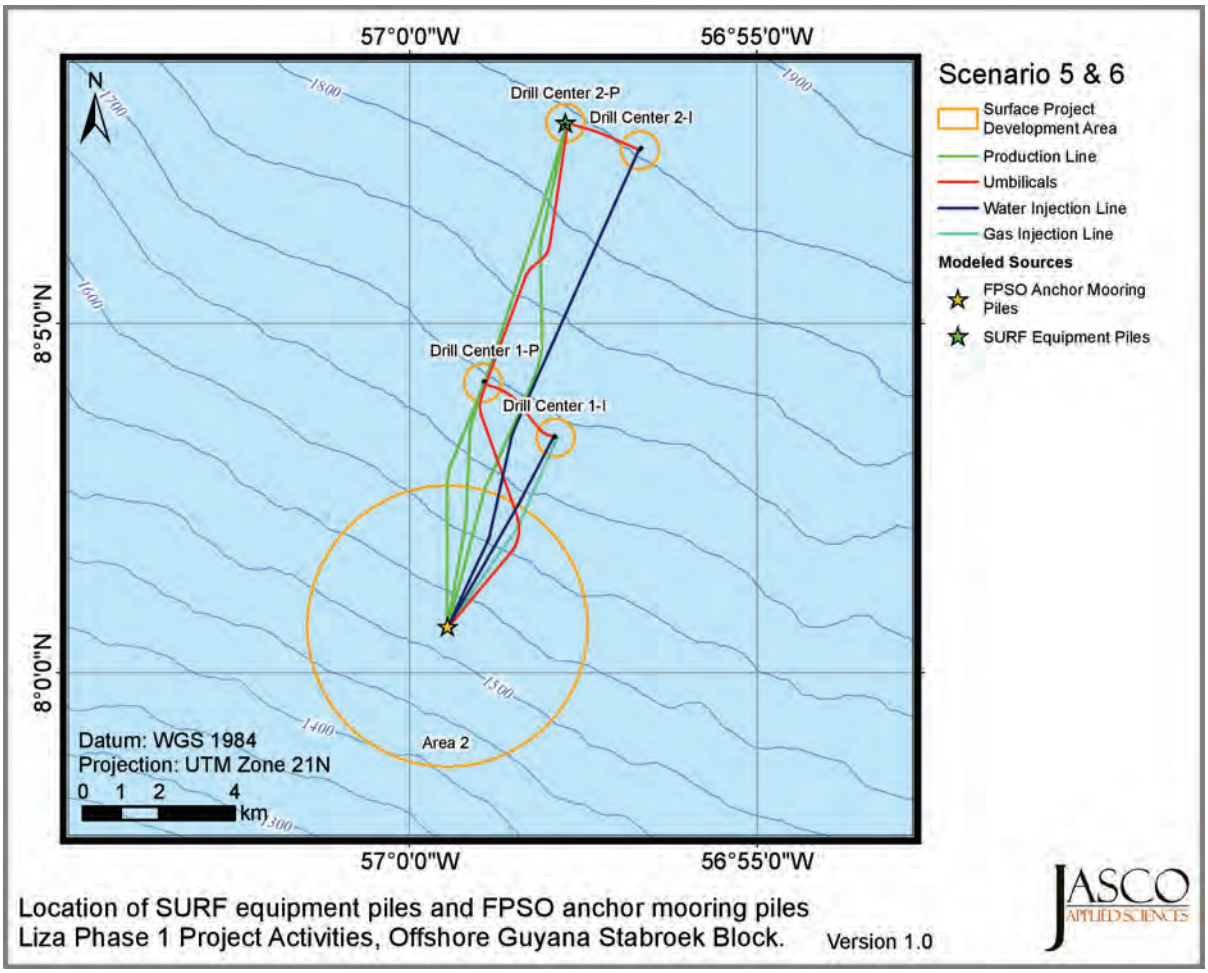


Figure 5. Scenarios 5 and 6: Location of modeled underwater impact pile driving operations at Drill Center 2-P and the FPSO (Area 2).

2. Acoustic Effects Criteria

Underwater sound can affect marine fauna in various ways. The question of which acoustic exposure levels might cause injury to marine mammals is still an active research. Since 2007, several expert groups have investigated SEL and peak pressure-based assessment approaches for injury using methods similar to those applied for humans, and a few key papers have been published on the topic. Those publications are reviewed, and the relative criteria discussed, in Appendix A.2. In the present section we propose specific thresholds used in other recent studies that are the most likely candidates for more widespread use; we caution readers, however, that assessment criteria are likely to evolve in the near future as research is progressing rapidly in this field.

Results of this modeling study are presented in terms M-weighted sound exposure level (SEL; $L_{E,24h}$) and peak pressure level (PK; L_{pk}) thresholds for injury to low- and mid-frequency cetaceans, based on two sets of criteria (Table 2): Southall et al. (2007) and Finneran (2015). These criteria have been chosen to include standard thresholds and thresholds suggested by the best available science, as reviewed and discussed in Appendix A.2. Low-frequency cetaceans, including baleen whales, and mid-frequency cetaceans, including dolphins and small whales, have been observed within or near the Project area. This study therefore focuses only on these marine mammal hearing groups.

Table 2. Marine mammal injury (Permanent Threshold Shift (PTS) onset) thresholds based on Southall et al. (2007), and Finneran (2015). PK and SPL in dB re 1 µPa; weighted SEL (24 hours) in dB re 1 µPa²·s.

Hearing group	Impulsive source				Non-impulsive source		
	Southall et al. (2007)		Finneran (2015)		Southall et al. (2007)		Finneran (2015)
	PK	Weighted SEL_{24h}	PK	Weighted SEL_{24h}	PK	Weighted SEL_{24h}	Weighted SEL_{24h}
Low-frequency cetaceans	230	198	230	192	230	215	207
Mid-frequency cetaceans	230	198	230	187	230	215	199

3. Methods

Underwater acoustic field for the studied vessels were modeled using JASCO's Marine Operations Noise Model (MONM), which is based on source levels derived from measurements of surrogate vessels.

Three complementary acoustic models were used to predict the underwater acoustic field for the studied seismic source. The pressure signatures and directional source levels of the VSP source were predicted with JASCO's Air gun Array Source Model (AASM). The acoustic fields around the array, in terms of M-weighted SEL_{24h}, were modeled with MONM. JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM) was used to determine peak pressure levels as a function of azimuth, depth, and range from the array.

The acoustic source signature for impact pile driving operations was modeled using JASCO's physical model of pile vibration and near-field sound radiation (MacGillivray 2014), in conjunction with the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010). The acoustic fields, in terms of M-weighted SEL_{24h} and peak pressure levels, were modeled with JASCO's FWRAM.

M-weighting was applied for two hearing groups to weight the importance of received sound levels according to their constituent frequencies.

3.1. Modeling Acoustic Source Levels

3.1.1. Vessels

Several types of vessels were modeled in this study, including an FPSO, a drill ship, a pipelaying vessel, tugs, barges, supply vessels, and support vessels. The vessels characteristics are presented in Section 4.1.1. Underwater sound that radiates from vessels is produced mainly by propeller and thruster cavitation (Ross 1976, §8.6), with a small fraction produced by sound transmitted through the hull, such as sound from engines, gearing, and other mechanical systems (Spence et al. 2007). Sound levels thus tend to be the highest when propulsion systems are used at high power. For example, during dynamic positioning in high currents or winds, or transiting at high speeds. A vessel's sound signature depends on the vessel's size, power output, and propulsion system characteristics (e.g., blade shape and size). Vessels produce broadband acoustic energy with most of the energy emitted below a few kilohertz. Sound from onboard machinery, particularly sound below 200 Hz, dominates the sound spectrum before cavitation begins—normally around 8 to 12 knots on many commercial vessels (Spence et al. 2007).

At the time of this study, the specific vessels engaged in installing and operating at the drill centers were unknown. Generalized source spectra were computed by comparing the expected specifications of the vessels to that of surrogate vessels for which source levels were available. Source levels for the surrogate were derived from measured received levels during various operational states. To account for the differences between the specification of the modeled and surrogate vessels, the spectra of the surrogates were corrected by the power ratings of the modeled and reference vessels:

$$S(f,P) = S_0(f) + 10\log\left(\frac{P}{P_0}\right) \quad (1)$$

where S_0 is the reference spectrum and P_0 is the reference power rating (Ross 1976, §8.6). When needed, surrogate spectra were extrapolated using −2 dB per decade at frequencies below 100 Hz and −1 dB per decade at frequencies above 1000 Hz (Ross 1976, §8.6).

3.1.2. Vertical Seismic Profile Source

The VSP source considered here is a six-element air gun array with a 1200 in^3 total volume. The source characteristics are presented in Section 4.1.2. The source levels and directivity of the VSP array were predicted with JASCO's Air gun Array Source Model (AASM; MacGillivray 2006a). This model is based on the physics of oscillation and radiation of air gun bubbles described by Ziolkowski (1970). The model solves the set of parallel differential equations that govern bubble oscillations. AASM also accounts for nonlinear pressure interactions between air guns, port throttling, bubble damping, and generator-injector (GI) gun behavior that are discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). AASM includes four empirical parameters that were tuned so model output matches observed air gun behavior. The model parameters fit to a large library of empirical data using a "simulated annealing" global optimization algorithm. These data are measurements of the signatures of Bolt 600/B guns ranging in volume from 5 to 185 in^3 (Racca and Scrimger 1986).

While air gun signatures are highly repeatable at low frequencies, which are used for seismic imaging, at higher frequencies their sound emissions have a large random component that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (560−25,000 Hz) sound emissions of individual air guns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each element in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each air gun
- Interactions between different elements in the array

These notional signatures are the pressure waveforms of the individual elements at a standard reference distance of 1 m; they account for the interactions with the other elements in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 1/3-octave-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered to be a directional point source in the far field.

A seismic array consists of many sources and the point-source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{nf} < \frac{l^2}{4\lambda} \tag{1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, an array length of l = 2 m yields a near-field range of 1.5 m at 2 kHz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modeling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the separation distances between array elements, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

3.1.3. Impact Pile Driving

A physical model of pile vibration and near-field sound radiation is used to calculate source levels of piles. The physical model employed in this study computes the underwater vibration and sound radiation of a pile by solving the theoretical equations of motion for axial and radial vibrations of a cylindrical shell. These equations of motion are solved subject to boundary conditions, which describe the forcing function of the hammer at the top of the pile and the soil resistance at the base of the pile (Figure 6). Damping of the pile vibration due to radiation loading is computed for Mach waves emanating from the pile wall. The equations of motion are discretised using the finite difference (FD) method and are solved on a discrete time and depth mesh.

In order to model the sound emissions of the piles, it was also necessary to model the force of the pile driving hammers. The force at the top of the pile was computed using the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010), which includes a large database of simulated hammers—both impact and vibratory—based on the manufacturer's specifications. The forcing functions from GRLWEAP were used as inputs to the FD model to compute the resulting pile vibrations.

The sound radiating from the pile itself is simulated using a vertical array of discrete point sources. The point sources are centered on the pile axis. Their amplitudes are derived using an inverse technique, such that their collective particle velocity—calculated using a near-field wave-number integration model—matches the particle velocity in the water at the pile wall. The sound field propagating away from the vertical source array is then calculated using a time-domain acoustic propagation model (e.g., FWRAM; Appendix A.5.3). MacGillivray (2014) describes the theory behind the physical model in more detail.

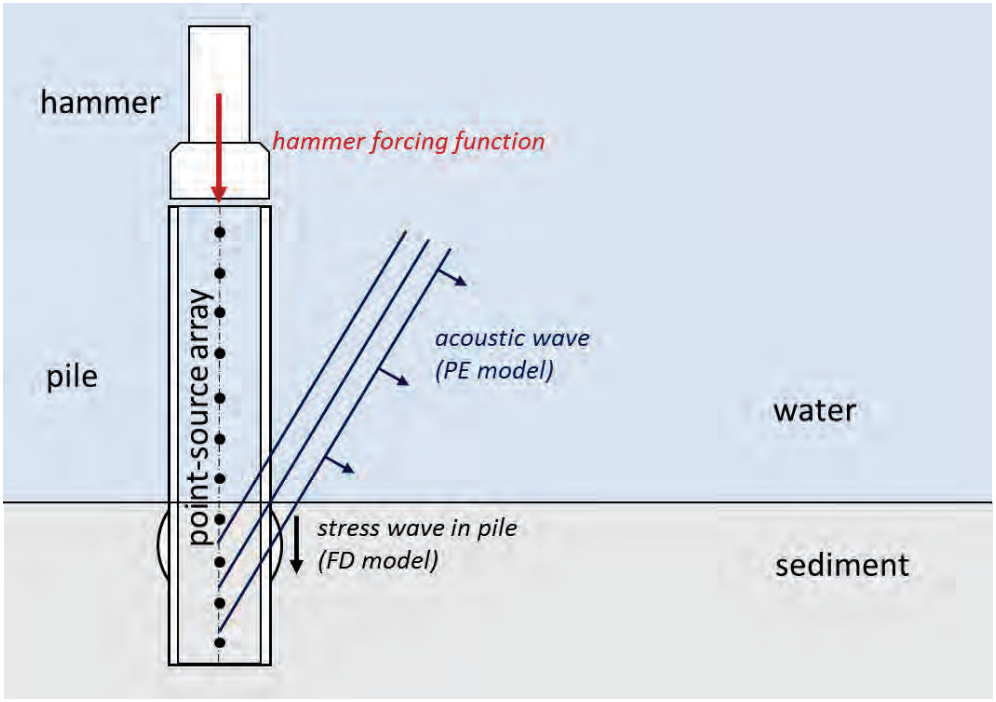


Figure 6. Physical model geometry for impact driving of a cylindrical pile (vertical cross-section). The hammer forcing function is used with the finite difference (FD) model to compute the stress wave vibration in the pile. A vertical array of point sources is used with the parabolic equation (PE) model to compute the acoustic waves that the pile wall radiates.

3.2. Modeling Sound Propagation

Underwater sound propagation (i.e., transmission loss) for the vessels and the VSP source exposure levels was predicted with JASCO's MONM (see Appendix A.5.2). The model computes received SEL (per-pulse SEL for impulsive sources) for directional sources located at a specified depth. It incorporates site-specific environmental properties including a bathymetric grid of the modeled area, in-water sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor. The model computes acoustic fields in three dimensions by modeling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source.

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, from 10 Hz to 32 kHz, are modeled to include the majority of acoustic energy emitted by the source. Sound propagation at frequencies from 5 to 32 kHz was modeled by modifying the transmission loss at 5 kHz with the frequency- and range-dependent absorption coefficient for sea water (François and Garrison 1982a). Although mostly insignificant at lower frequencies, absorption coefficients were also applied from 10 Hz to 5 kHz for consistency. The broadband underwater sound field, expressed in terms of M-weighted per-pulse SEL, was computed by filtering and summing the received 1/3-octave-band levels.

JASCO's FWRAM (see Appendix A.5.3) was used to determine peak pressure levels from the VSP source and per-pulse SEL from pile driving operations. FWRAM uses the same computational algorithm as MONM, but computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source such as an underwater pile (MacGillivray and Chapman 2012).

The parabolic equation (PE) approximation used in FWRAM (Appendix A.5.3) is valid for sound propagating within a vertical angle range of at least 45° above and below the horizontal plane at the source depth (the exact angle depends on the environment). In the case of underwater impact pile driving, where the pile extends only over a fraction of the water column, the received levels above the pile (propagating at a >45° angle from the horizontal plane) may be underestimated using this model. The main acoustic waves around the pile propagate, however, at an angle of ~17° from the horizontal plane (Reinhall and Dahl 2011). FWRAM therefore provides a valid estimate of the distances to injury thresholds, which occur well within the PE approximation angle.

This approach, combined with the pile driving source model, accurately estimates spectral levels within the 10–800 Hz band where most of the energy from impact pile driving is concentrated. An extrapolation method (Zykov et al. 2016) was used to extend the modeled levels in 1/3-octave-bands up to 25 kHz, by applying a −2 dB per 1/3-octave-band roll-off coefficient to the per-pulse SEL value starting at the 800 Hz band. The acoustic energy levels at these higher frequencies are required to correctly assess the acoustic fields against Finneran (2015) criteria. The broadband underwater sound field, expressed in terms of M-weighted per-pulse SEL, was computed by filtering and summing the received 1/3-octave-band levels.

The injury thresholds evaluated here account for the total acoustic energy a marine mammal is subjected to within a defined period (24 hours in the present case). In the present study, the M-weighted SEL_{24h} were obtained by assuming a stationary scenario. With this simplified approach the acoustic energy (SEL) for 1 sec (for non-impulsive sources) or a single pulse (for impulsive sources) at a particular location was replicated in situ to estimate the cumulative metric. For a given number (N) of source activity seconds or of acoustic pulse events over a 24-hour period, SEL_{24h} was thus computed using the basic formula:

$$SEL_{24h} = SEL + 10\log_{10}(N) \ . \qquad (2)$$

By assuming stationary sources, the method provides conservative estimates of the maximum extent of each sound level isopleth. This approach also yields notional values that are not strongly dependent on the environment or on the position of each source, which simplifies comparisons between different source types and acoustic effect criteria.

Although a more complex analysis would be outside the scope of this study, an important consideration that qualifies the cumulative received level estimates is that individuals of most species do not remain stationary throughout the exposure period. Their dose accumulation, therefore, depends on their movement and would likely be lower than for a stationary receiver. A second issue is that animals tend to recover from the sub-injurious effects of sound exposure over time; the paradigm of a strictly dosimetric accumulation is not therefore altogether correct, but the recovery period of most species is unknown.

3.3. Calculating Distances to Acoustic Effect Thresholds

The underwater sound fields predicted by the propagation models were sampled so that the received sound level at each location in the horizontal plane was taken to be the maximum value over all modeled depths for that location. Two distances from the source are reported for each sound level: 1) R_{max}, the maximum range at which the given sound level was encountered in the modeled maximum-over-depth sound field over all azimuths, and 2) $R_{95\%}$, the maximum range at which the given sound level was encountered after the 5% farthest such points were excluded (Figure 7). The $R_{95\%}$ is used because the maximum-over-depth sound field footprint is often non-circular and can include anomalous protrusions along a few azimuths. Regardless of the geometric shape of the maximum-over-depth footprint, $R_{95\%}$ is the predicted range encompassing at least 95% of the area (in the horizontal plane) that would be exposed to sound at or above that level. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the heterogeneity of the acoustic environment. The $R_{95\%}$ excludes ends of protruding areas or small isolated acoustic foci not representative of the nominal ensonification zone.

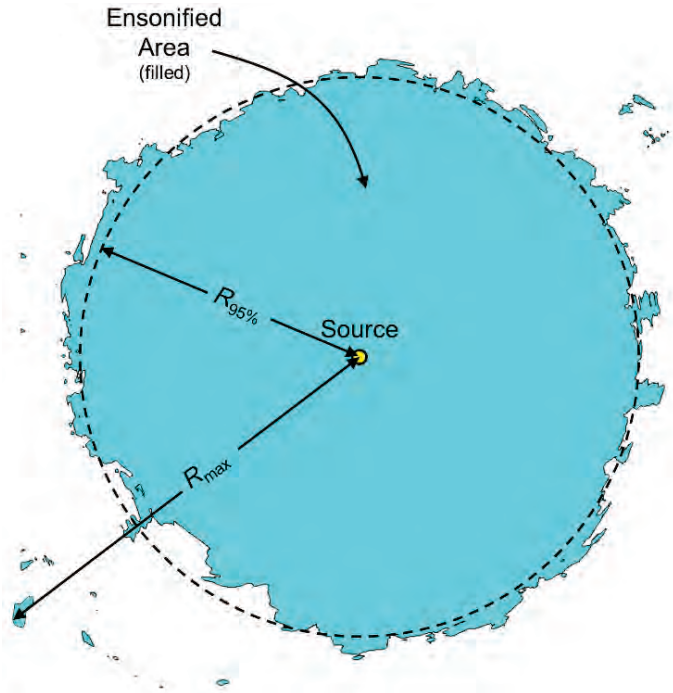


Figure 7. Example of an area ensonified to an arbitrary sound level showing R_{max} and $R_{95\%}$ radii.

4. Model Parameters

4.1. Acoustic Source Parameters

4.1.1. Vessels

A surrogate source vessel was chosen to represent each of the proposed vessels modeled in this study (Table 3). For vessels where the surrogate was significantly different in length, width, draft, or power, the surrogate's spectrum was adjusted based on the ratio of available power between the proposed and surrogate vessel (Section 3.1.1).

In Scenario 1 (Table 1; Figure 2), three tugs held the tanker in position (i.e., the tanker's main engine and propulsion system were idling or off). Thus, the sound levels from the tanker were neglected in the modeled scenario because they will be significantly lower (by at least 10 dB) than sounds from the tugs.

In Scenario 2 (Table 1; Figure 3), sound levels from the fast supply vessel, a small craft approximately 19 m long with a draft of less than 1 m, were also expected to be significantly lower (~150 dB re 1 µPa @ 1 m; Funk et al. 2008 §3.7) than sound levels from the adjacent vessels. This vessel was excluded from the modeled scenario.

The specific characteristics of the Floating Production Storage and Offloading (FPSO) that will be used in this project are unknown at present. The spectra used in Scenarios 1 and 2 were derived from the recordings of six FPSOs during various operational stages (Erbe et al. 2013). In Scenario 1, the FPSO was expected to be moored and operating; its spectrum was modeled using the 5th percentile 1/3-octave-band spectrum derived from all the FPSO source spectra recorded. In Scenario 2, tugs positioned the FPSO during installation and mooring. Such operations were expected to be noisier than in Scenario 1; the FPSO spectrum was modeled using the 95th percentile 1/3-octave-band spectrum derived from all the source spectra recorded.

Since the tugs in each scenario will be engaged in various activities (e.g., transiting at various speed, pulling and pushing vessels, handling cables and anchors), the spectra of the surrogate tug, recorded during transit at half and full speed and during anchor pulling, were averaged to produce a mean 1/3-octave-band spectrum.

The source depth for vessels other than the drill ship was based on the depth at which cavitation from the propulsion system was expected to occur. Gray and Greenley (1980) estimate that the center of the cavitation volume occurs below the propeller blade arc, by an amount equal to ~15% of the propeller diameter. The modeled source depth was estimated by:

$$Z_s = D - 0.85 \times \phi_{prop} \tag{3}$$

where Z_s is the source depth, D is the depth at the bottom of the propeller (often equal to the draft) of the proposed vessel, and $\varnothing_{\text{prop}}$ is the diameter of its propeller.

During drilling operations, sound will be generated at many locations along the drill shaft. For the purpose of this study, the sound was assumed to be concentrated at the top of the drill shaft; the source depth was equal to the operational draft of the drill ship (12 m).

Table 3. Specifications of proposed and surrogate vessels used to estimate source levels.

Vessel type	Proposed vessel								Surrogate vessel							
	Name	Length (m)	Breadth (m)	Draft (m)	Max. power (kW)	Bollard pull (t)	Main propulsion	Propeller diameter (m)	Name	Length (m)	Breadth (m)	Draft (m)	Max. power (kW)	Bollard pull (t)	Main propulsion	Reference
FPSO	Unknown	Unknown	Unknown	Unknown, assumed 10 and 16	Unknown	n/a	Unknown	Unknown, assumed 5.5	Average between	209–340	Unknown	10.8–16	n/a	n/a	n/a	Erbe et al. (2013)
FPSO major work vessel	*Normand Installer*	124	28	7.3	31360	n/a	4 x tunnel thrusters, 1 x retractable azimuth thruster, 2 x controllable pitch propellers in nozzles	4.5	DSV *Fu Lai*	107.1	19.4	Unknown	7400	56	4 x thrusters, 2 x controllable pitch propellers	MacGillivray (2006b)
FPSO supply barge Supply vessel Support vessel	*Hannah Chouest*	85	18	6	7200	n/a	Unknown	Unknown, assumed 3.2								
Light construction vessel Field intervention vessel	MEO *Ranger*	64	16	5.4	5000	n/a	2 x tunnel thrusters, 2 x Z-drive propeller	2.7								
Large crane vessel	*Normand Installer*	124	28	7.3	31360	n/a	4 x tunnel thrusters, 1 x retractable azimuth thruster, 2 x controllable pitch propellers in nozzles	4.5								
Multiple service vessel	*7 Pacific*	134	24	6.75	17300	n/a	3 x stern azimuth thrusters, 1 x retractable bow azimuth thruster, 2 x bow tunnel thrusters	3.2								
Tug	Unknown	Unknown	Unknown	Unknown, assumed 5.5	Unknown	80	Azimuth stern drive	Unknown, assumed 3.2	*Britoil 51*	45	12	5.5	6600	90	2 x fixed pitch nozzeled propellers	Hannay et al. (2004)
Tug (large)	Unknown	Unknown	Unknown	Unknown, assumed 5.4	Unknown	120	Azimuth stern drive	Unknown, assumed 3.2	*Britoil 61*	51	13	5.4	10500	130	2 x controllable pitch nozzeled propellers	Adjusted from *Britoil 51* based on power
Drill ship	*Stenna Carron*	228	42	12	Unknown	n/a	6 x thrusters	n/a	*Stena Forth*	228	41	12	1750	n/a	6 x thrusters	Kyhn et al. (2009)
Pipelaying vessel	*7 Borealis*	182	46	8.5–11.35	45622	n/a	4 x azimuth thrusters, 1 x tunnel thruster	3	*Castoro*	191	35	10	Unknown	n/a	2 x variable pitch propellers, 1 x bow thruster	MacGillivray (2006b)

4.1.2. Vertical Seismic Profile Source

The Schlumberger High-performance Magnum six-gun array (1200 in³ total volume) was modeled as a surrogate VSP source in Scenario 4. The array consists of two vertically-triangular air gun clusters with in-line separations of 2 m. The first cluster has three 150 in³ elements with 0.9 m separation, the second cluster has three 250 in³ elements with a 1.1 m separation. In both clusters, the center air gun is shallower. The elements are fired simultaneously at 2000 psi air pressure. The array was modeled at a 4.5 m depth (the center of the clusters). It is estimated that the VSP source will produce 20–40 pulses within 6–12 hours of operation. Figure 8 illustrates the element distribution in the horizontal (*x*-*y*) plane, and Table 4 shows the array specifications.

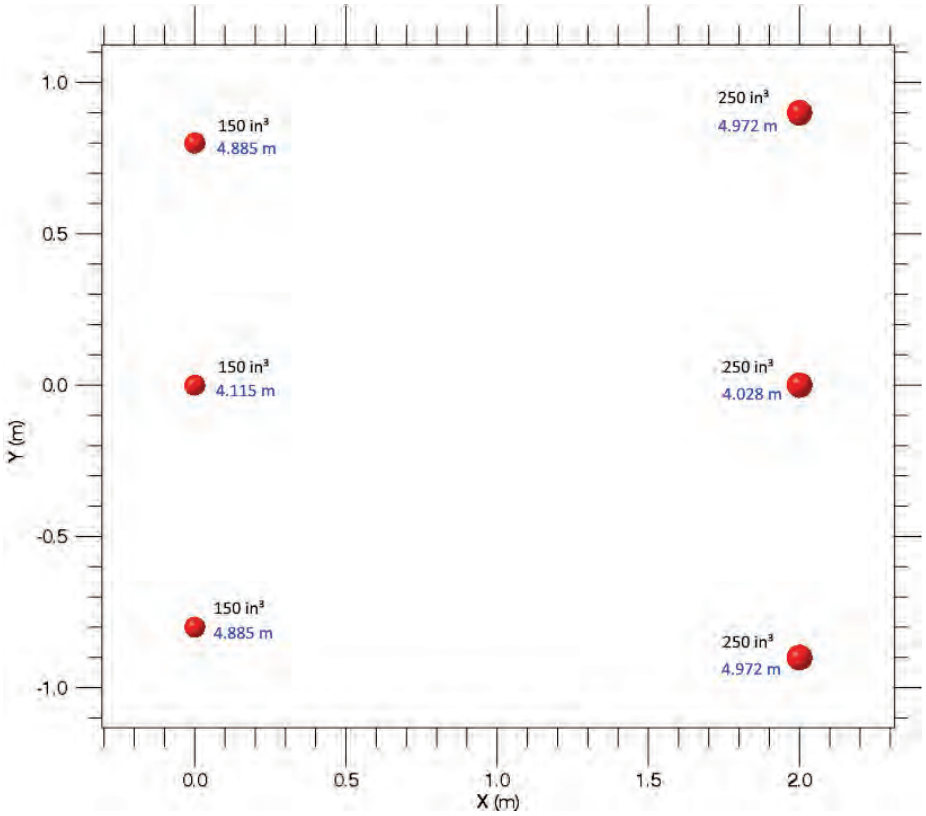


Figure 8. Layout of the High-performance Magnum six-gun array (1200 in³ total volume, 4.5 m depth), composed of 6 elements. Black labels indicate element volume in cubic inches; blue labels indicate the depth of the element relative to the sea surface.

Table 4. Relative positions of the elements within the 1200 in^3 array.

Element	*x* (m)	*y* (m)	*z* (m)	Volume (in^3)
1	0.0	0.000	4.115	150
2	0.0	−0.445	4.885	150
3	0.0	0.445	4.885	150
4	−2.0	0.000	4.028	250
5	−2.0	−0.545	4.972	250
6	−2.0	−0.545	4.972	250

4.1.3. Impact Pile Driving

Impact pile driving of cylindrical steel piles was modeled at two locations (Scenarios 5 and 6; Table 1). At both locations, the water depth was much deeper (1524.4 m and 1842.7 m) than the length of the pile (25 m long; 5 m in diameter). The MENCK 500T underwater hammer was used as the impact pile driver. A generic pile helmet, with a weight 1/5 that of the hammer (Parola 1970), was assumed with the default parameters of the hammer in the GRLWEAP 2010 wave equation model.

Information on the penetration rate per blow was unknown at the time of this study. The maximum number of strikes per minute (38) for the modeled hammer was assumed over a driving period of 5 hours. One driving period was assumed to occur every 24 hours.

4.2. Environmental Parameters

4.2.1. Bathymetry

Bathymetry data, covering an area of approximately 23 × 21 km centered on the modeled sites, was provided by EEPGL. For the long-range modeling (up to 100 km from the FPSO and the drill ship), this grid was extended using data from SRTM15+ (v1.0; Becker et al. 2009, Sandwell et al. 2014) global bathymetry grid, with a resolution of 30 arc-seconds (~460 × 460 m at the studied latitude), to produce a 150 × 150 km region. The data were re-gridded, by minimum curvature gridding, onto a Universal Transverse Mercator (UTM) Zone 21 coordinate projection with a regular grid spacing of 100 × 100 m.

4.2.2. Geoacoustics

The geoacoustic properties of surficial seabed layers depend on the sediment type. As the porosity decreases, the compressional sound speed, sediment bulk density, and compressional attenuation increase. For each modeled location, MONM assumes a single geoacoustic profile of the seafloor for the entire modeled area. The acoustic properties required by MONM are:

- Sediment bulk density,
- Compressional-wave (or P-wave) speed,
- P-wave attenuation in decibels per wavelength,
- Shear-wave (or S-wave) speed, and
- S-wave attenuation, also in decibels per wavelength.

Along the Guyana coast, suspended Amazonian sediments and fluvial mud from various Guyana rivers are transported eastward with the Guiana Current. This large volume of sediment deposition results in a thick (estimated up to 30 m; Rucker 1967) and fairly uniform layer of fine-grained sediment (Maxon

Consulting Inc. 2014). This surficial sediment layer, also characterized by a low concentration of organic carbon (Maxon Consulting Inc. 2014), overlays a mixture of sand and clay ~30–100 m thick (Rucker 1967).

The estimated geoacoustic profile (Table 5) was based on empirical formulas presented by Hamilton (1980). Without information from recent boreholes, a generic geoacoustic profile for silt-clay sediments was used with a 1.3 m/s per meters below the seafloor (mbsf) sound-speed gradient. The density and P-wave attenuation coefficients were taken from Hamilton (1980).

Table 5. Geoacoustic properties of the sub-bottom sediments as a function of depth, in meters below the seafloor (mbsf). Within each depth range, each parameter varies linearly within the stated range.

Depth (mbsf)	Material	Density (g/cm³)	P-wave speed (m/s)	P-wave attenuation **(dB/λ)**	S-wave speed (m/s)	S-wave attenuation **(dB/λ)**
0–30	Silt-clay	1.45–1.49	1500–1539	0.17–0.18	200	3.0
30–100	Sand-clay	1.83–2.00	1623–1700	1.21–2.00		
100–500	Sand-clay	2.00	1700–2100	2.00		
>500	Sand-clay	2.00	2100	2.00		

4.2.3. Ocean Sound Speed Profile

The ocean sound speed profiles for the modeled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981):

$$\begin{aligned} c(z,T,S,\phi) &= 1449.05 + 45.7t - 5.21t^2 - 0.23t^3 \\ &\quad + \left(1.333 - 0.126t + 0.009t^2\right)(S-35) + \Delta \\ \Delta &= 16.3Z + 0.18Z^2, \quad Z = \frac{z}{1000}\left[1 - 0.0026\cos(2\phi)\right], \quad t = \frac{T}{10} \end{aligned} \tag{4}$$

where z is water depth (m), T is temperature (°C), S is salinity (psu), and ϕ is latitude (radians).

Mean monthly sound speed profiles were derived from the GDEM profiles at the FPSO and drill ship locations. There are no significant variations in sound speed with geographical location. Monthly variations in sound speed are also minimal, although the profile in April tends to be mostly upward refracting in the top 100 m (Figure 9). This month is therefore expected to promote longest range propagation and was used for all modeled scenarios.

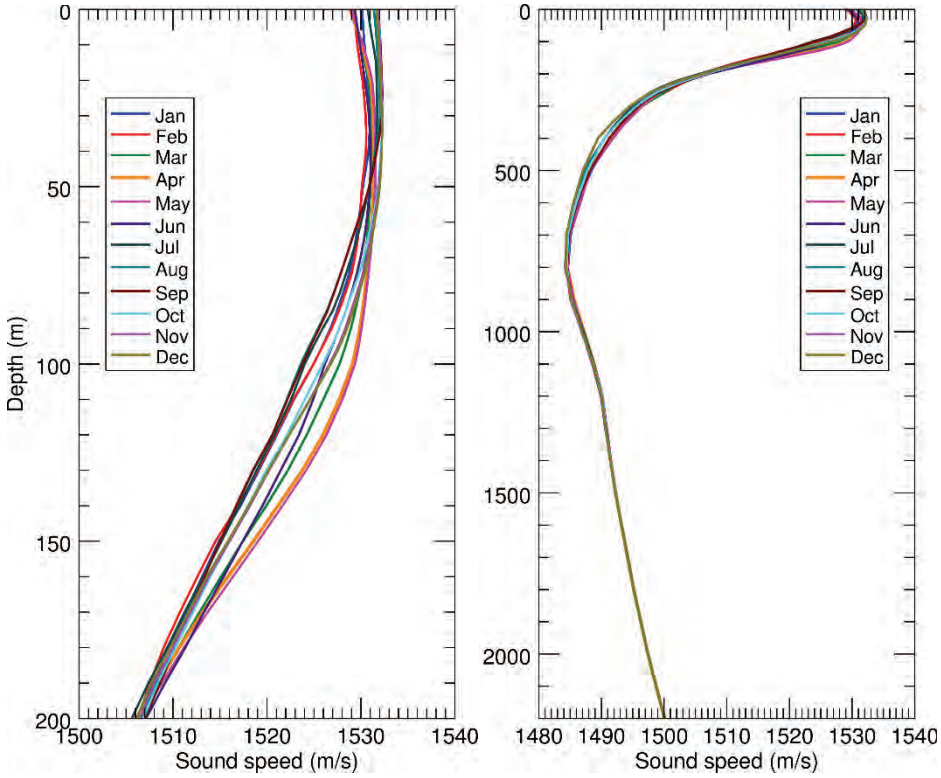


Figure 9. Mean monthly sound speed profiles (left: top 200 m; right: entire water column) at the FPSO location (08° 00' 39.53" N, 056° 59' 27.31" W) derived from data obtained from *GDEM V 3.0* (Teague et al. 1990, Carnes 2009).

4.3. Sound Propagation Modeling Zones

For the purposes of assessing sound levels with MONM, the sound field was modeled up to distances of 2 and 20 km from the FPSO (Scenarios 1 and 2) and the drill ship (Scenario 3), with a horizontal separation of 5 and 20 m between receiver points along the modeled radials. The horizontal angular separation between radials was 2.5°, for a total of N = 144 radial planes. Receiver depths were chosen to span the entire water column over the modeled areas, from 1 to 5000 m, with step sizes increasing with depth.

FWRAM modeled synthetic pulses of the VSP source up to 20 km, along four radials (0, 90, 180, and 270° from the tow direction) to compute peak pressure levels. The horizontal range step was set at 20 m. The tow direction was 293°. The same parameters were used to model sound from pile driving operations, the range step was however adjusted to 2 m up to 200 m from the source, and 25 m thereafter.

5. Results

5.1. Source Levels

5.1.1. Vessels

Figures 10–14 show the estimated 1/3-octave-band source levels for the modeled vessels. The broadband (10 Hz to 32 kHz) source levels vary from 173.4 dB re 1 µPa for the light construction and field intervention vessel to 196.1 dB re 1 µPa for the large tug. Although source levels may vary substantially during different operations, these modeled spectra represent a conservative average over a 24 hour period.

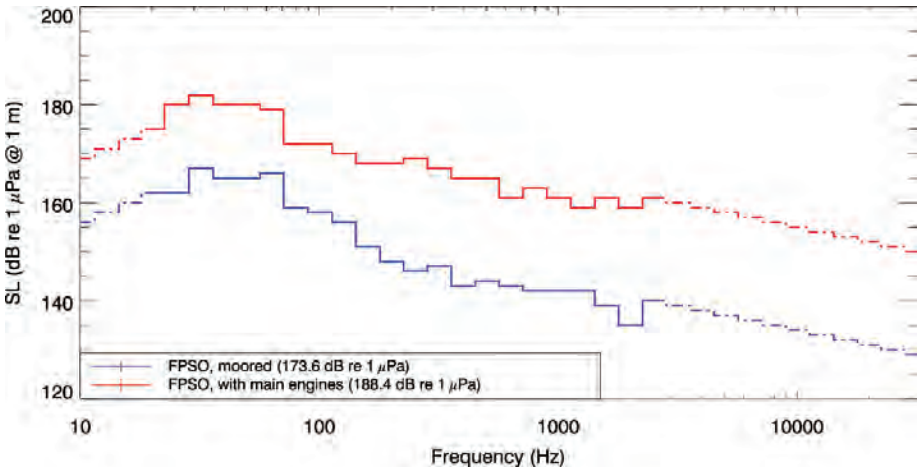


Figure 10. Estimated source level spectra for the FPSO. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

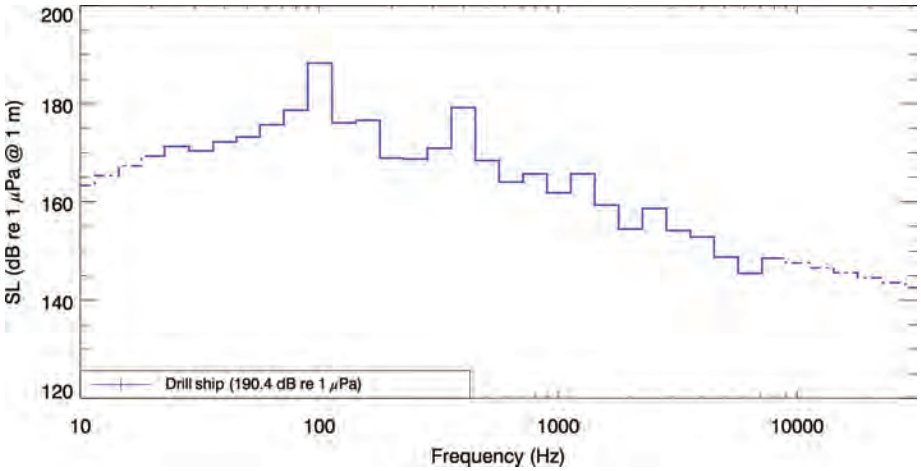


Figure 11. Estimated source level spectrum for the drill ship. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

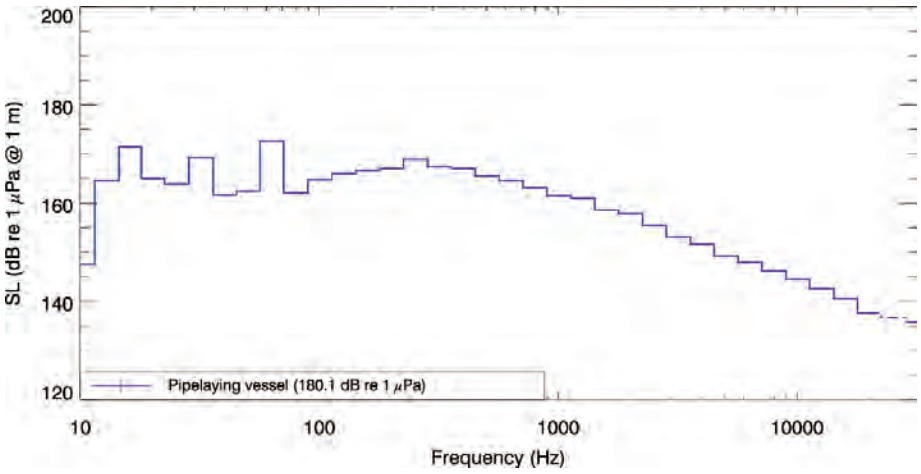


Figure 12. Estimated source level spectrum for the pipelaying vessel. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

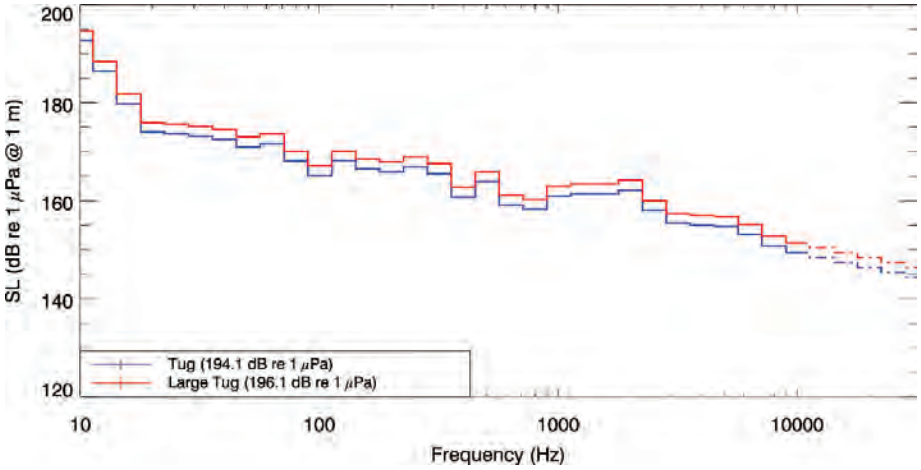


Figure 13. Estimated source level spectra for the tugs. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

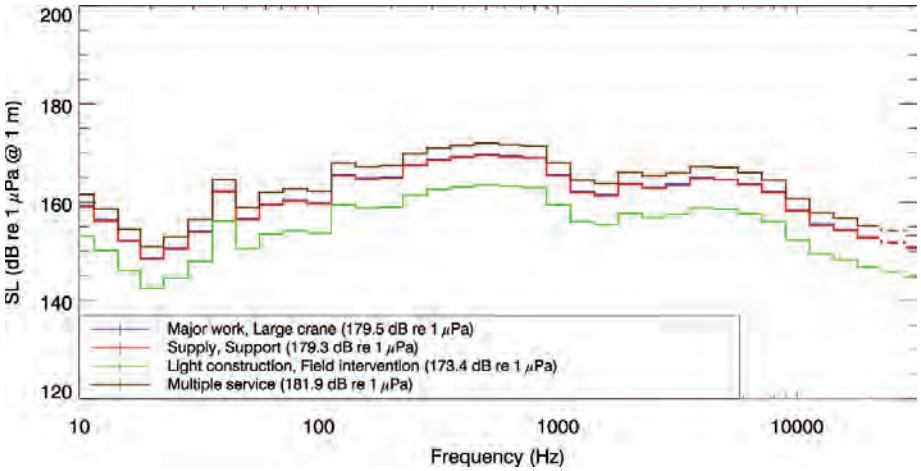


Figure 14. Estimated source level spectra for the various support vessels. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

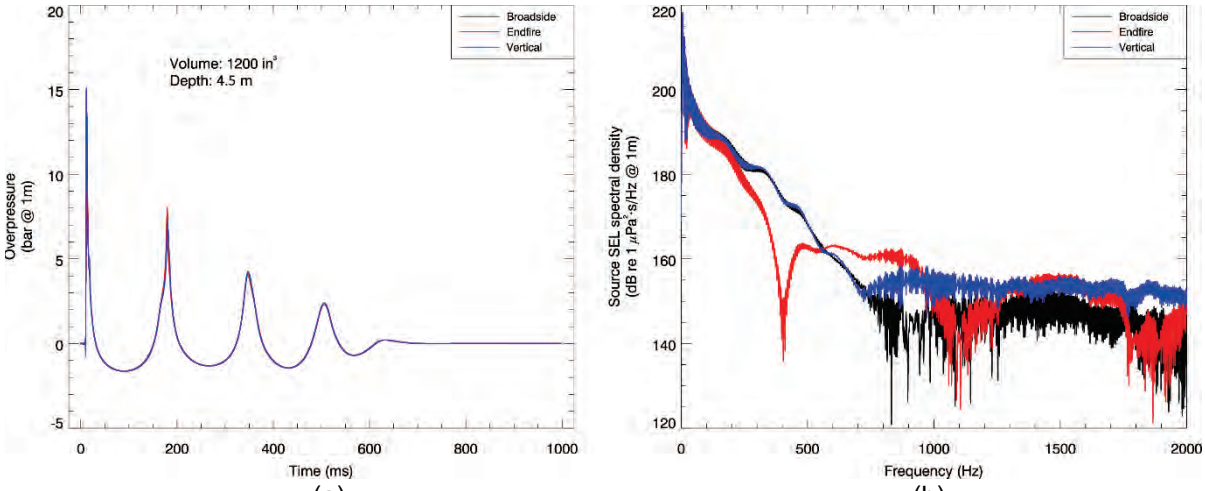
5.1.2. Vertical Seismic Profile Source

The pressure signatures of the individual array elements and the composite 1/3-octave-band source levels of the array, as functions of azimuthal angle (in the horizontal plane), were modeled with AASM (Section 3.1.2). While effects of surface reflected signals on bubble oscillations and inter-bubble interactions are accounted for in the notional pressure signatures of each element by AASM, the surface-reflected signal (i.e., surface ghost) is not shown in the far-field source signature plots below. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

Figure 15 shows the horizontal overpressure signatures (broadside–perpendicular to the tow direction, and endfire–parallel to the tow direction), the vertical overpressure signature, and corresponding power spectrum levels for the 1200 in^3 array at a 4.5 m tow depth. The signatures consist of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy is produced at frequencies below 600 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among elements in the array, and depend on the volumes and relative locations of the element.

Table 6 shows the broadband SPL and unweighted per-pulse SEL source levels.

Horizontal 1/3-octave-band source levels are shown as a function of band center frequency and azimuth (Figure 16). As discussed in Section 3.1.1, directivity in the sound field is most noticeable at frequencies from ~316 to 2000 Hz.



(a) (b)

Figure 15. Predicted source level details for the 1200 in^3 array. (a) The overpressure signature and (b) the power spectrum in the broadside (perpendicular to tow direction), endfire (directly aft of the array), and downward (vertical) directions.

Table 6. Source level specifications in the horizontal plane for the 1200 in^3 array, for a 4.5 m tow depth.

Direction	Peak pressure level (dB re 1 **µPa @ 1** m)	SPL (dB re 1 **µPa @** 1 m)	Unweighted per-pulse SEL (dB re 1 **µPa**^{2}·s **@** 1 m)	
			10–2000 Hz	2000–25000 Hz
Broadside (no surface ghost)	243.5	225.7	219.4	172.8
Endfire (no surface ghost)	242.6	225.6	219.3	176.9
Vertical (no surface ghost)	243.6	225.7	219.4	176.4
Vertical (with surface ghost)	243.6	224.3	219.8	179.4

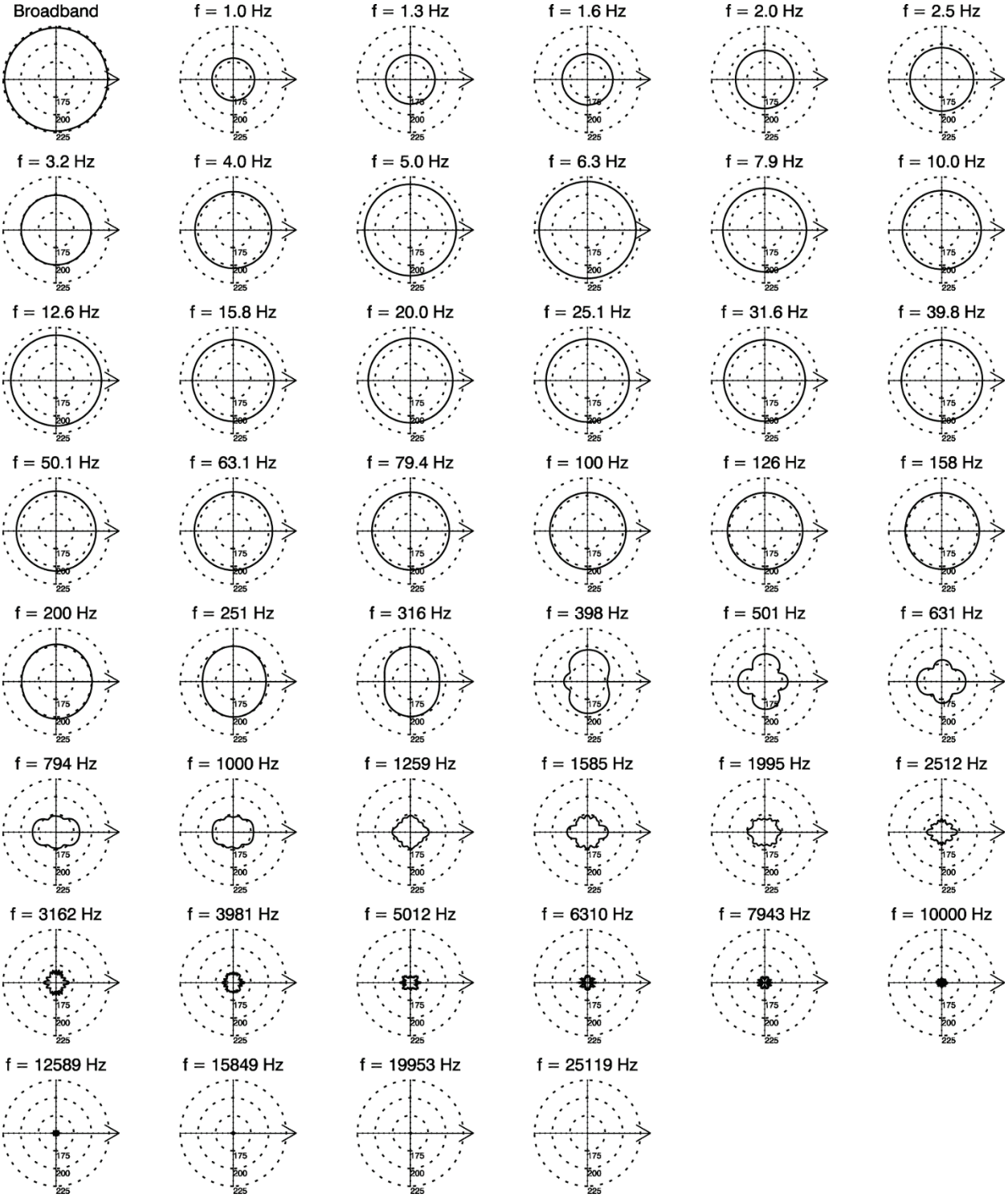


Figure 16. Directionality of the predicted horizontal source levels for the 1200 in^3 array, 10–25,000 Hz.Source levels (in dB re 1 µPa^2·s) are shown as a function of azimuth for the center frequencies of the 1/3-octave-bands modeled; frequencies are shown above the plots. Tow direction is to the right and tow depth is 4.5 m.

5.1.3. Impact Pile Driving

The forcing function at the top of the pile (Figure 17) was modeled using the GRLWEAP 2010 wave equation model. The forcing function consists of a strong primary peak, related to the initial contact of the ram and helmet, followed by a series of pulses associated with the ram-helmet oscillations. JASCO's pile driving source model estimated equivalent source signatures every 2 m along the pile. Figure 18 presents the signature of the monopoles at the top, center, and bottom of the pile. The first peak of these signatures represents the initial pile deformation traveling down the pile; its amplitude decreases and arrival time increases with depth along the pile.

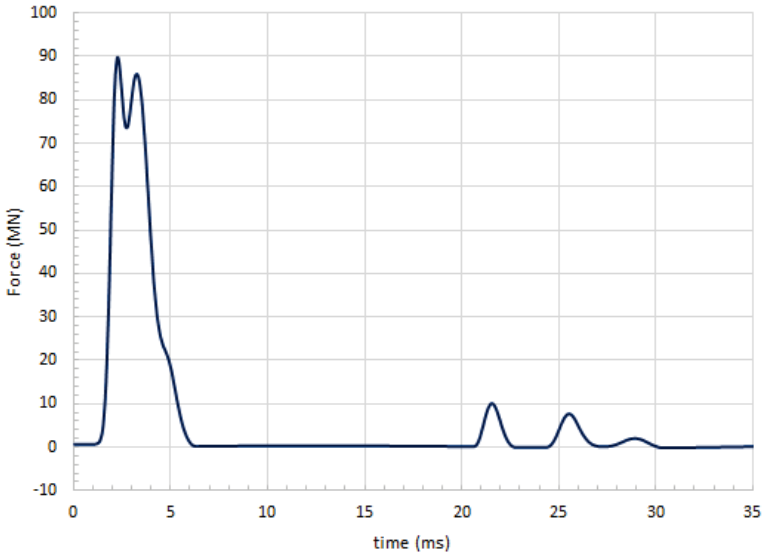


Figure 17. Force at the top of a pile during impact driving of a 25-m long, 5-m wide cylindrical steel pile with the MENCK 500T (underwater) hammer.

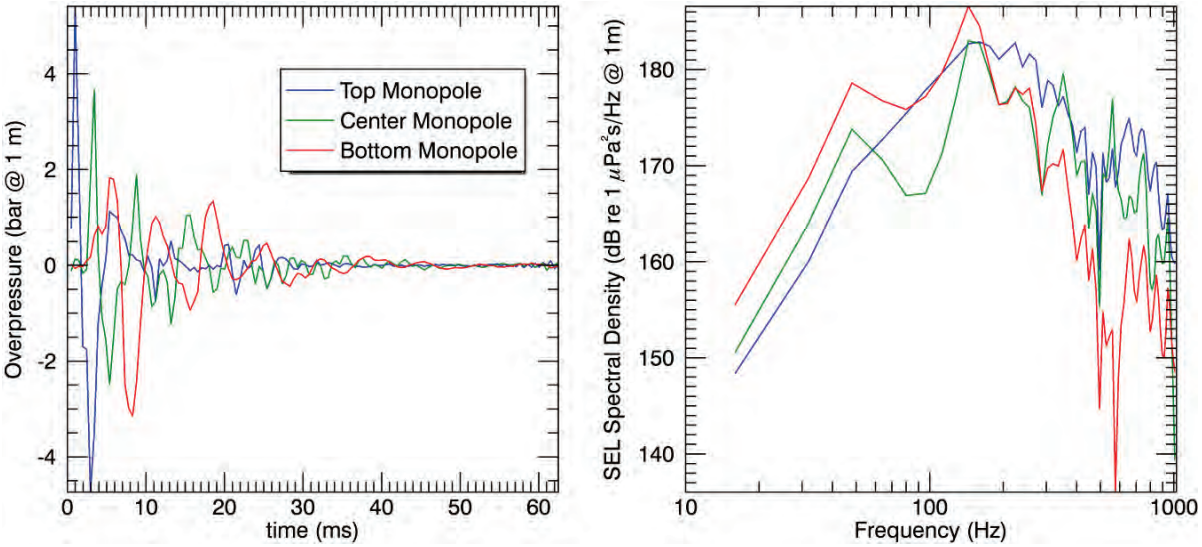


Figure 18. Predicted overpressure signature of three monopoles along the modeled pile: top (in water), center (in water), and bottom (in substrate).

5.2. Sound Fields

5.2.1. Vessels

This section includes the distances to marine mammal injury thresholds resulting from the presence of vessels (Table 7). For the purpose of estimating M-weighted SEL_{24h} in this study, all vessels were assumed stationary, operating over 90% of a 24 hour period. Peak pressure level thresholds for injury criteria were not reached; distances to peak pressure levels are not presented below.

The tabulated values represent the maximum R_{max} and $R_{95\%}$ from any vessels present in a scenario.

Table 7. Scenarios 1–3: Distances (m) to marine mammal injury for non-impulsive sources.

Hearing group	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)
Scenario 1						
Low-frequency cetaceans	215	6	6	207	< 5	< 5
Mid-frequency cetaceans	215	< 5	< 5	199	< 5	< 5
Scenario 2						
Low-frequency cetaceans	215	< 5	< 5	207	< 5	< 5
Mid-frequency cetaceans	215	-	-	199	-	-
Scenario 3						
Low-frequency cetaceans	215	9	9	207	6	6
Mid-frequency cetaceans	215	< 5	< 5	199	-	-

5.2.2. Vertical Seismic Profile Source

This section presents the distances to marine mammal injury thresholds for the VSP source in Scenario 4. To estimate distances to marine mammal injury thresholds in M-weighted SEL_{24h}, one operational period was modeled (i.e., it was assumed that the VSP source produces 40 pulses in 24 hours). Distances to peak pressure level thresholds are either not reached or less than distances to M-weighted SEL_{24h} thresholds for injury criteria (Table 8); distances to peak pressure levels are not presented below. In Figure 19, area ensonified at or above injury thresholds are compared; the range to the Mid-frequency cetacean injury threshold based on Finneran (2015) was below the minimum resolvable range.

Table 8. Scenario 4: Distances (m) to marine mammal injury thresholds for the VSP source.

Hearing group	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	73	68	192	39	36
Mid-frequency cetaceans	198	35	32	187	-	-

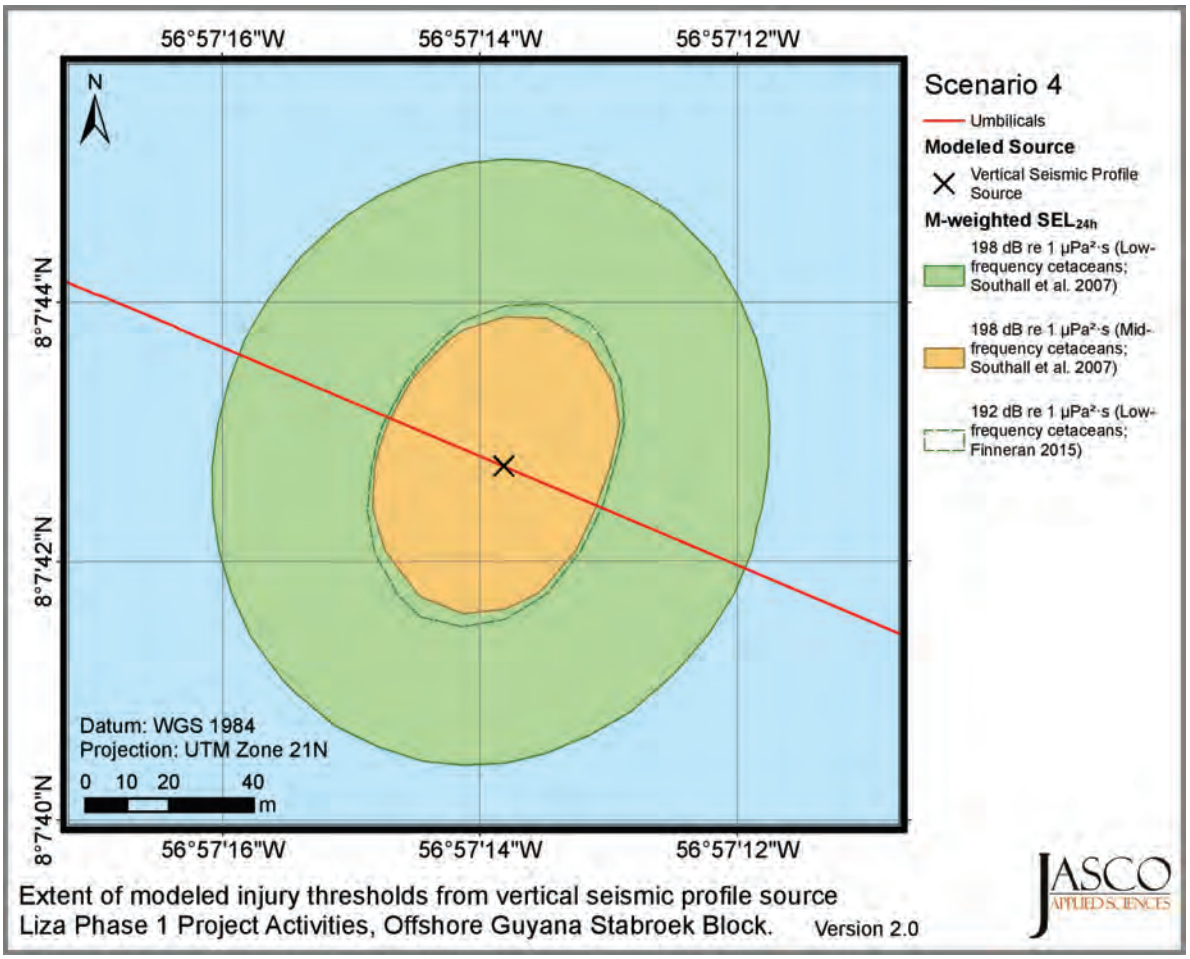


Figure 19. Scenario 4: Sound level contour map showing the extend of the maximum-over-depth M-weighted SEL_{24h} from the VSP source for marine mammal injury thresholds based on Southall et al. (2007) and Finneran (2015).

5.2.3. Impact Pile Driving

This section presents the distances to marine mammal injury thresholds for the underwater pile driving operations in Scenarios 5 and 6. To estimate distances to marine mammal injury thresholds in M-weighted SEL_{24h}, we assumed that one pile was driven for 5 hours, at a rate of 38 strikes per minute, every 24 hours. Distances to peak pressure level thresholds were either not reached or were less than distances to M-weighted SEL_{24h} thresholds for injury criteria; distances to peak pressure levels are not presented.

Tables 9–10, and Figures 20–23, present the distances to marine mammal injury thresholds at Drill Center 2-P and the FPSO, respectively. Figures 21–22 and 24–25 present vertical slices of the corresponding M-weighted SEL_{24h} fields, east of the piles. The parabolic equation (PE) approximation used in FWRAM (Section 3.2) is estimated to be valid for sound propagating up to 45° from the horizontal plane at the source depth. This angle is indicated by the black dash line in each slice.

Table 9. Scenario 5: Distances (m) to marine mammal injury thresholds for the underwater pile driving operations at Drill Center 2-P.

Hearing group	Southall et al. (2007)		Finneran (2015)	
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)
Low-frequency cetaceans	198	1,300	192	1,025
Mid-frequency cetaceans	198	762	187	136

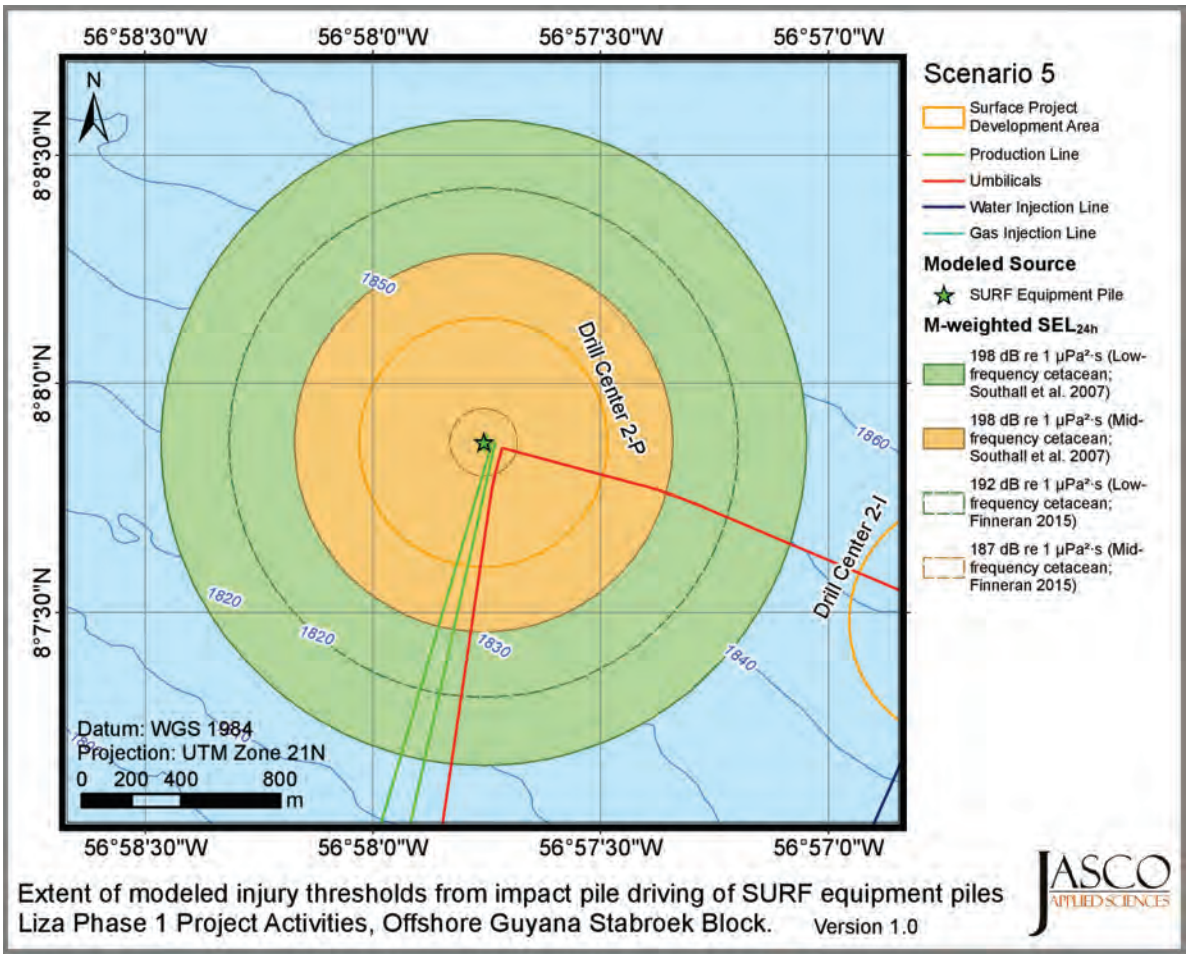


Figure 20. Scenario 5: Sound level contour map showing the extend of the maximum-over-depth M-weighted SEL_{24h} from impact pile driving for marine mammal injury thresholds based on Southall et al. (2007) and Finneran (2015).

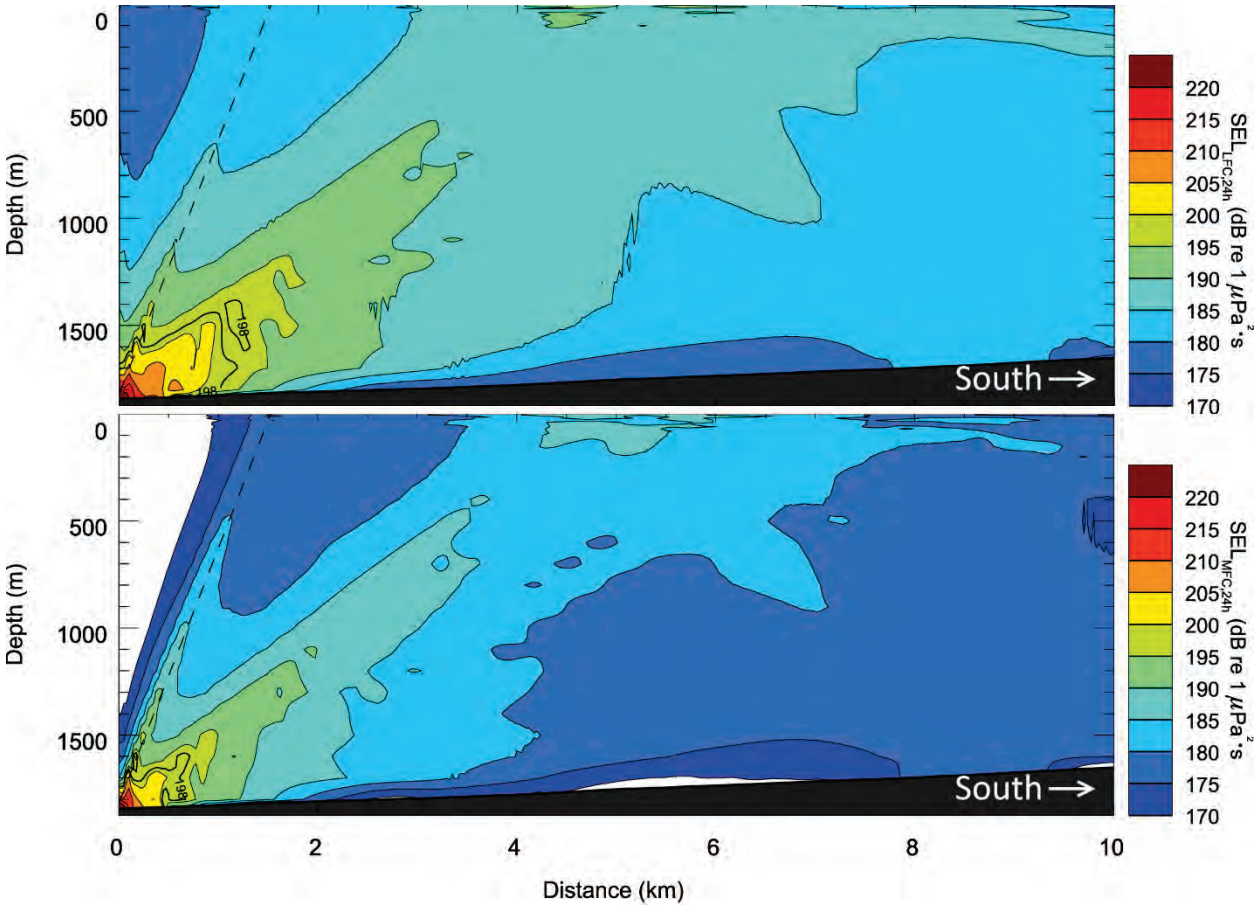


Figure 21. Scenario 5: Estimated M-weighted SEL_{24h} based on Southall et al. (2007), propagating south of the pile at Drill Center 2-P. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

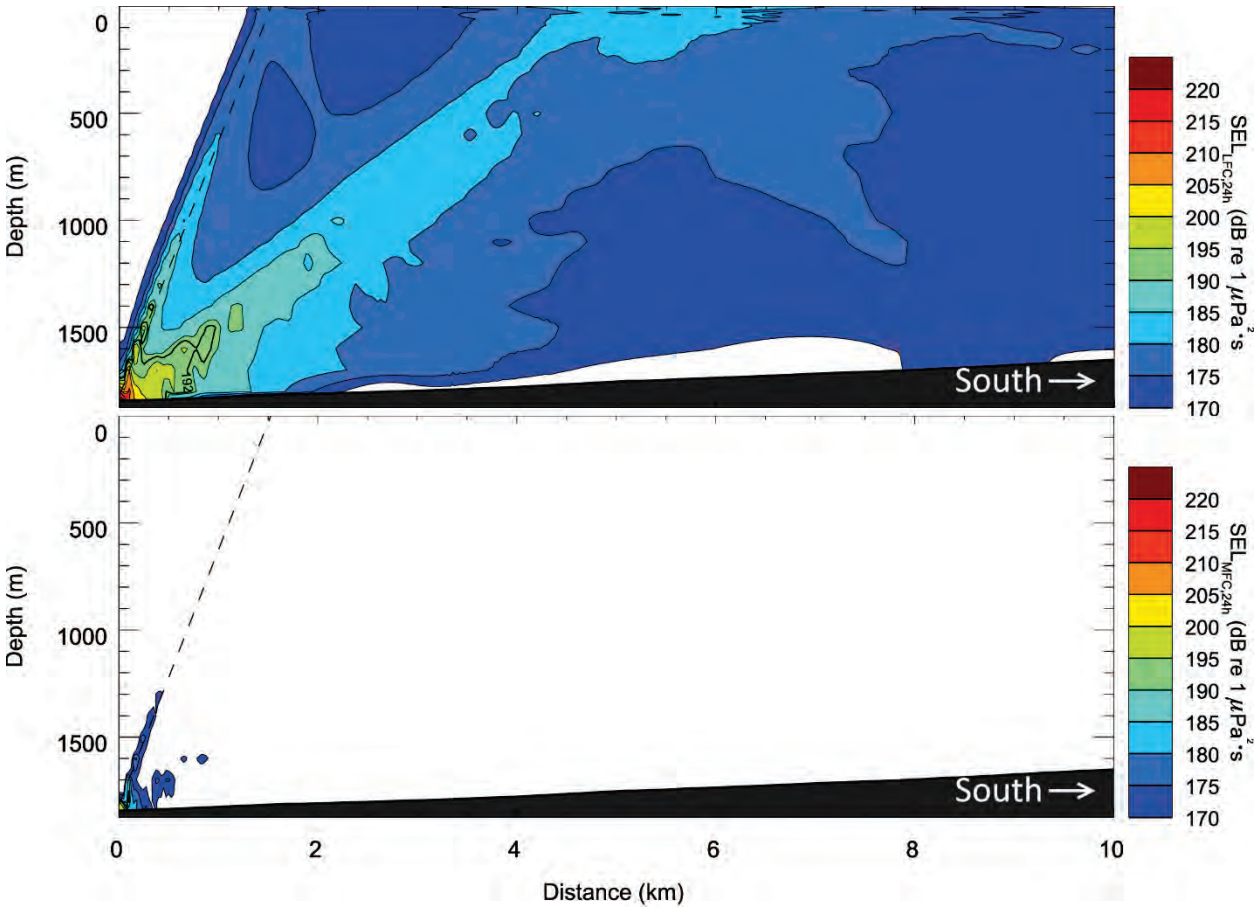


Figure 22. Scenario 5: Estimated M-weighted SEL_{24h} based on Finneran (2015), propagating south of the pile at Drill Center 2-P. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

Table 10. Scenario 6: Distances (m) to marine mammal injury thresholds for the underwater pile driving operations at the FPSO location.

Hearing group	Southall et al. (2007)		Finneran (2015)	
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)
Low-frequency cetaceans	198	1,375	192	1,075
Mid-frequency cetaceans	198	725	187	100

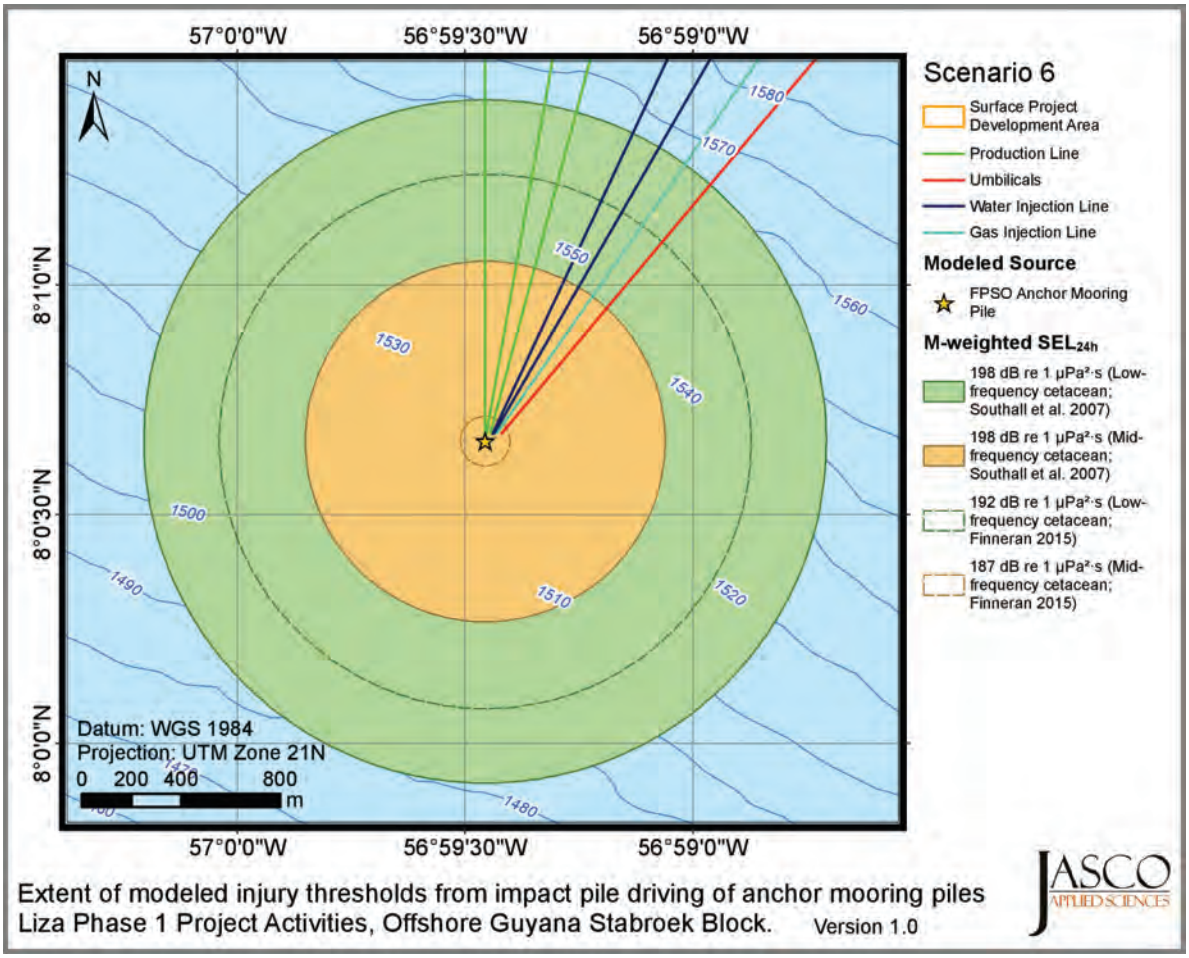


Figure 23. Scenario 6: Sound level contour map showing the extend of the maximum-over-depth M-weighted SEL_{24h} from impact pile driving for marine mammal injury thresholds based on Southall et al. (2007) and Finneran (2015).

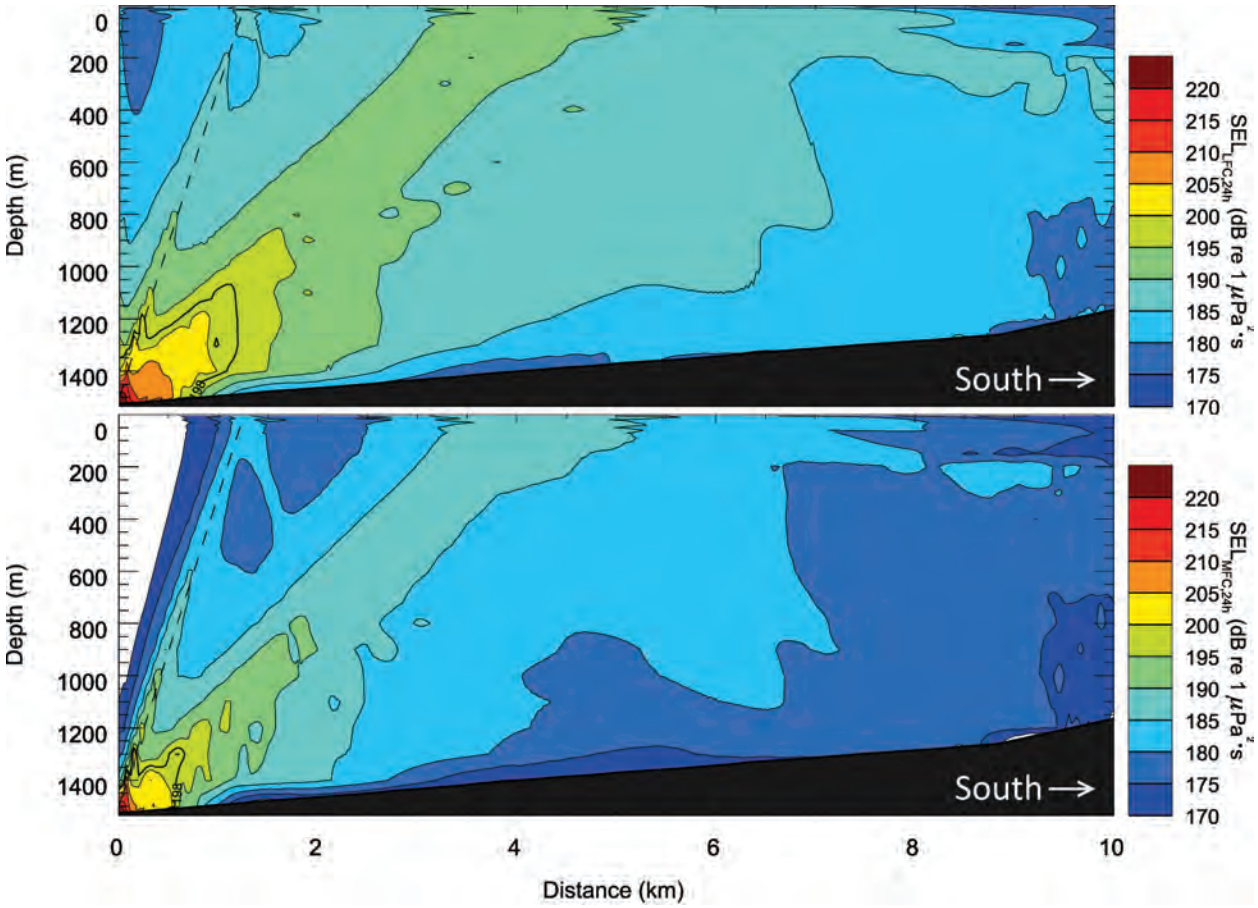


Figure 24. Scenario 6: Estimated M-weighted SEL_{24h} based on Southall et al. (2007), propagating south of the FPSO anchor mooring piles. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

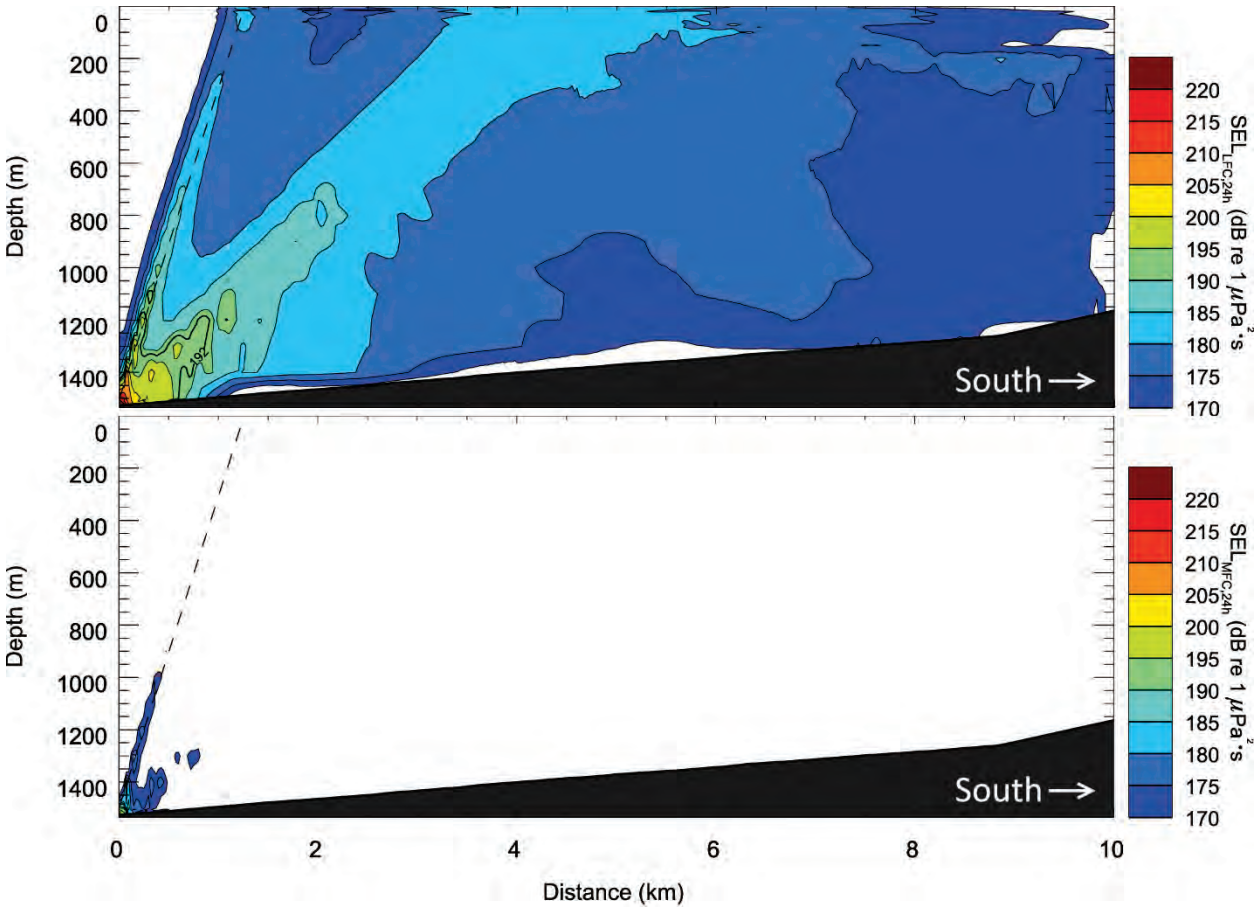


Figure 25. Scenario 6: Estimated M-weighted SEL_{24h} based on Finneran (2015), propagating south of the FPSO anchor mooring piles. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

6. Discussion

The estimated broadband source levels of vessels varied from 173.4 dB re 1 µPa at 1 m for the light construction and field intervention vessels, to 196.1 dB re 1 µPa at 1m for the large tug. Although source levels may vary substantially during operations, the modeled source level spectra of the vessels represent conservative averages over a 24 hour period.

For scenarios 1 through 3, the distances to injury thresholds from vessels were small: <10 m for all species, thus essentially insignificant relative to the size of the vessels. The distances to injury thresholds were similar for Southall et al. (2007) and Finneran (2015) criteria (Table 7). These results assume that the vessels were stationary for 24 hours and the animal was present within the stated distance for the entire accumulation period (24 hours).

The broadband (10–25,000 Hz) per-pulse SEL source level of the VSP source was 219–220 dB re 1 µPa^2·s @ 1 m in all directions (Table 6). Distances (R_{max}) to injury thresholds for mid-frequency cetaceans were 35 m based on Southall et al. (2007) and below the minimum resolvable range based on Finneran (2015); for low-frequency cetaceans they were 73 and 39 m, respectively (Table 8). For this source, the injury thresholds based on Finneran (2015) were generally lower than for Southall et al. (2007) due to the steeper roll-off at low frequencies of the weighting functions for the former. Because most of the energy from the VSP source lies below 600 Hz (Figure 15), Finneran's weighting yields a greater discount than Southall et al. (2007) (see Appendix A.4).

Distances to injury thresholds were longer for impact pile driving than for other operations. Across both modelled sites, for mid-frequency cetaceans the maximum ranges were 762 m based on Southall et al. (2007) and 136 m based on Finneran (2015); for low-frequency cetaceans they were 1,375 m and 1,075 m, respectively (Tables 9–10). The differences in ranges between the two sites were minor. The sound levels at or above injury thresholds were found close to the ocean bottom, at depths >1,000 m. Low-frequency cetacean species present in the area are not expected to dive to those depths and, therefore, should never be exposed to injurious sound levels from pile driving activities. A few species within the mid-frequency hearing group, such as some dolphins, may feed at depths greater than 1,000 m and could therefore be affected by pile driving sound. The amount of time these animals spend below 1,000 m is, however, limited due to their need to resurface to breathe, which reduces the probability of injury.

Glossary

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands make up one octave. One-third-octave-bands become wider with increasing frequency. See also octave.

90%-energy time window
The time interval over which the cumulative energy rises from 5% to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% root-mean-square sound pressure level (90% SPL)
The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

Air gun
A device that has a chamber of compressed air, which is “fired” (quickly released) to produce a pulse of acoustic energy.

A-weighting
Frequency-selective weighting for human hearing in air that is derived from the inverse of the idealized 40-phon equal loudness hearing function across frequencies.

absorption
The conversion of acoustic energy into heat, which is captured by insulation.

ambient noise
All-encompassing sound at a given place, usually a composite of sound from many sources near and far (ANSI S1.1-1994 R2004), e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

auditory weighting function (frequency-weighting function)
Auditory weighting functions account for marine mammal hearing sensitivity. They are applied to sound measurements to emphasize frequencies that an animal hears well and de-emphasize frequencies they hear less well or not at all (Southall et al. 2007, Finneran and Jenkins 2012, NOAA 2013).

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

background noise
Total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal (ANSI S1.1-1994 R2004). Ambient noise detected, measured, or recorded with a signal is part of the background noise.

bandwidth
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic sources, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI/ASA S1.13-2005 R2010).

bar
Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to 10^6 Pa or 10^{11} µPa.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

broadside direction
Perpendicular to the travel direction of a source. Compare with endfire direction.

cavitation
A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of sound.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

continuous sound
A sound whose sound pressure level remains above ambient sound during the observation period (ANSI/ASA S1.13-2005 R2010). A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

endfire direction
Parallel to the travel direction of a source. See also broadside direction.

ensonified
Exposed to sound.

equal-loudness contour
A curve or curves that show, as a function of frequency, the sound pressure level required to cause a given loudness for a listener having normal hearing, listening to a specified kind of sound in a specified manner (ANSI S1.1-1994 R2004).

far-field
The zone where, to an observer, sound originating from an array of sources (or a spatially-distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

fast-average sound pressure level
The time-averaged sound pressure levels calculated over the duration of a pulse (e.g., 90%-energy time window), using the leaky time integrator from Plomp and Bouman (1959) and a time constant of 125 ms. Used only for pulsed sounds.

fast Fourier transform (FFT)
A computationally efficiently algorithm for computing the discrete Fourier transform.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

geoacoustic
Relating to the acoustic properties of the seabed.

hearing group
Grouping of marine mammal species with similar hearing ranges. Commonly defined hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

hearing threshold
The sound pressure level that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency cetacean
The functional hearing group that represents odontocetes specialized for using high frequencies.

intermittent sound
A level of sound that abruptly drops to the background noise level several times during the observation period.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, seismic sources and impact pile driving.

low-frequency cetacean
The functional hearing group that represents mysticetes (baleen whales).

mid-frequency cetacean
The functional hearing group that represents some odontocetes (dolphins, toothed whales, beaked whales, and bottlenose whales).

M-weighting
The process of band-pass filtering loud sounds to reduce the importance of inaudible or less-audible frequencies for broad classes of marine mammals. “Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds” (Southall et al. 2007).

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and the gray whale (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level)

that impulsive signals have (ANSI/ASA S3.20-1995 R2008). For example, marine vessels, aircraft, machinery, construction, and vibratory pile driving (NIOSH 1998, NOAA 2015).

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete
The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The toothed whales' skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid
A common term used to describe members of the Otariidae, eared seals, commonly called sea lions and fur seals. Otariids are adapted to a semi-aquatic life; they use their large fore flippers for propulsion. Their ears distinguish them from phocids. Otariids are one of the three main groups in the superfamily Pinnipedia; the other two groups are phocids and walrus.

parabolic equation method
A computationally-efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

peak sound pressure level (peak SPL)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak sound pressure level. Unit: decibel (dB).

percentile level, exceedance
The sound level exceeded *n* % of the time during a measurement.

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive acoustic exposure. PTS is considered auditory injury.

phocid
A common term used to describe all members of the family Phocidae. These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves. Phocids are one of the three main groups in the superfamily Pinnipedia; the other two groups are otariids and walrus.

pinniped
A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

power spectrum density
The acoustic signal power per unit frequency as measured at a single frequency. Unit: $\mu Pa^2/Hz$, or $\mu Pa^2 \cdot s$.

power spectral density level
The decibel level ($10\log_{10}$) of the power spectrum density, usually presented in 1 Hz bins. Unit: dB re 1 $\mu Pa^2/Hz$.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

pressure, hydrostatic
The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

received level
The sound level measured at a receiver.

Root-mean-square sound pressure level (SPL)
See sound pressure level.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

signature
Pressure signal generated by a source.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$. SEL is expressed over the summation period (e.g., per-pulse SEL [for seismic sources], single-strike SEL [for pile drivers], 24-hour SEL).

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 µPa:

$$\mathrm{SPL} = 10\log_{10}\left(p^2 / p_0^2\right) = 20\log_{10}\left(p / p_0\right)$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level. See also 90% sound pressure level and fast-average sound pressure level.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound pressure level measured 1 meter from a theoretical point source that radiates the same total sound power as the actual source. Unit: dB re 1 µPa @ 1 m.

spectrum
An acoustic signal represented in terms of its power (or energy) distribution compared with frequency.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive acoustic exposure.

transmission loss (TL)
The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also called propagation loss.

wavelength
Distance over which a wave completes one oscillation cycle. Unit: meter (m). Symbol: λ.

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If applied, the frequency weighting of an acoustic event should be specified, as in the case of M-weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.1.1. 1/3-Octave Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analyzing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into 1/3-octave-bands, which are one-third of an octave wide; each octave represents a doubling in sound frequency. The center frequency of the ith 1/3-octave-band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{i/10} , \tag{A-5}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith 1/3-octave-band are defined as:

$$f_{lo} = 10^{-1/20} f_c(i) \quad \text{and} \quad f_{hi} = 10^{1/20} f_c(i) . \tag{A-6}$$

The 1/3-octave-bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modeling spans from band 10 ($f_c(10)$ = 10 Hz) to band 45 ($f_c(45)$ = 32 kHz).

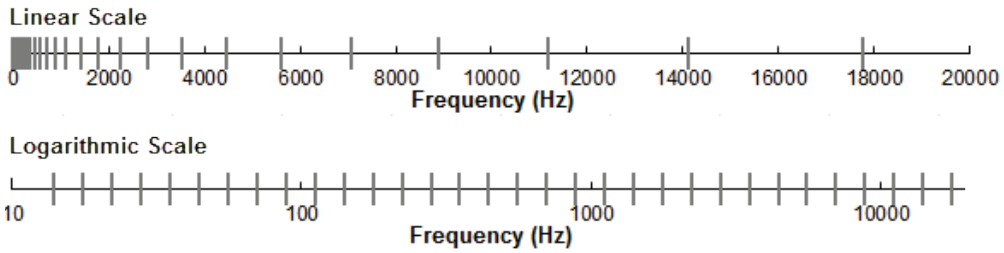

Figure A-1. One-third-octave-bands shown on a linear frequency scale and on a logarithmic scale.

The sound pressure level in the ith 1/3-octave-band $\left(L_b^{(i)}\right)$ is computed from the power spectrum $S(f)$ between f_{lo} and f_{hi}:

$$L_b^{(i)} = 10 \log_{10} \left(\int_{f_{lo}}^{f_{hi}} S(f) df \right) . \tag{A-7}$$

Summing the sound pressure level of all the 1/3-octave-bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_i 10^{L_b^{(i)}/10} . \tag{A-8}$$

Figure A-2 shows an example of how the 1/3-octave-band sound pressure levels compare to the power spectrum of an ambient noise signal. Because the 1/3-octave-bands are wider with increasing frequency, the 1/3-octave-band SPL is higher than the power spectrum, especially at higher frequencies. Acoustic

A.2.2. Vessel Sounds

Underwater sound that radiates from vessels is produced mainly by propeller and thruster cavitation, with a smaller fraction of sound produced by sound transmitted through the hull, such as by engines, gearing, and other mechanical systems. Sound levels tend to be the highest when thrusters are used to position the vessel and when the vessel is transiting at high speeds. A vessel's sound signature depends on the vessel's size, power output, propulsion system (e.g., conventional propellers vs. Voith Schneider propulsion), and the design characteristics of the given system (e.g., blade shape and size). A vessel produces broadband acoustic energy with most of the energy emitted below a few kilohertz. Sound from onboard machinery, particularly sound below 200 Hz, dominates the sound spectrum before cavitation begins—normally around 8–12 knots on many commercial vessels (Spence et al. 2007). Sound from vessels typically raises the background sound level by tenfold or more (Arveson and Vendittis 2000).

A.2.3. Vertical Seismic Profile Sources

Seismic air guns generate pulsed acoustic energy by releasing a highly compressed air bubble into the water that expands and then collapses. These sources produce frequencies from several hertz to a few kilohertz, with larger element volumes producing lower frequencies and higher sound levels.

During a vertical seismic profiling, a stationary source array is deployed from either a drill ship or a closely stationed auxiliary vessel. A single element produces an approximately omnidirectional sound field, emitting acoustic energy equally in all directions. For all seismic surveys, source array layouts and firing delays are configured to achieve higher sound energy emission levels in the vertical direction where the pulses from all elements add in-phase. Lower levels of sound energy are emitted in other directions. Source arrays might show significant directionality in the horizontal direction due to the phase delay between pulses because the elements are horizontally separated.

A.2.4. Impact Pile Driving

Impact pile driving consists of infixing piles of various shapes and materials into the ground by striking the top end of the pile with a ram. In its simplest form, pile driving is achieved by a free-falling ram directly striking the pile. After the strike, the ram is raised and the action repeated until a sufficient portion of the pile penetrates the ground. Additional equipment can be used for higher efficiency or to accomplish activities such as driving fully submerged piles. For example, free-falling pile drivers have generally been replaced by more sophisticated mechanisms that control downward and upward movement of the ram. Cushion materials can be installed between the ram and the drive head. Aside from redistributing some of the energy from the hammer impact and protecting the contact surfaces from damage, the cushion also allows some control on the maximum amplitude and duration of the force applied to the pile.

After each strike, the initial radial deformation at the top of the pile wall caused by impact compression rapidly travels downward along the pile, generating in the process a pressure wave in the water column. Because of the properties of the material, the deformation travels down the pile faster than the speed of sound in water, resulting in a radiating pressure wave that resemble a Mach cone with a cone angle of ~17° (Reinhall and Dahl 2011).

A.3. Acoustic Effect Criteria

A.3.1. Marine Mammals

It has been long recognized that marine mammals can be adversely affected by underwater anthropogenic sound. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater sound sources and the possibility that impulsive sources could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater sound sources (NMFS 1998, ONR 1998, HESS 1998, Nedwell and Turnpenny 1998, Ellison and Stein 1999).

The U.S. National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) considered recommendations from these workshops and adopted a set of interim thresholds for assessing injury and disturbance due to both impulsive and non-impulsive, or continuous sound, types of acoustic sources (e.g., NOAA 1998). We refer to these thresholds as the NMFS SPL criteria. Regulatory agencies in many countries have applied these criteria since the early 2000s, but recent advances in assessment approaches are starting to replace them.

The NMFS SPL criteria for acoustic exposure injury to marine mammals were set according to recommendations for cautionary estimates of sound levels leading to onset of permanent hearing threshold shift (PTS). These criteria prescribe injury thresholds of 190 dB re 1 µPa SPL for pinnipeds and 180 dB re 1 µPa SPL for cetaceans (NMFS 2013). A corresponding injury threshold was not defined for non-impulsive sounds at that time. NMFS indicates that the SPL criteria should be used for all sources including sonars and explosives (NMFS 2013). These injury thresholds are applied to individual acoustic pulses and do not consider the overall duration of the sound or its acoustic frequency distribution.

Criteria that do not take into account exposure duration or acoustic spectra are generally insufficient for assessing hearing injury. Human workplace noise assessments consider the SPL as well as the duration of exposure and sound spectral characteristics. For example, the International Institute of Noise Control Engineering (I-INCE) and the Occupational Safety and Health Administration (OSHA) suggests thresholds in C-weighted peak pressure level and A-weighted time-average sound level (dB(A)[1] L_{eq}). They also suggest exchange rates that increase the allowable thresholds for each halving or doubling of exposure time. This approach assumes that hearing damage depends on the relative loudness perceived by the human ear. It also assumes that the ear might partially recover from past exposures, particularly if there are periods of quiet nested within the overall exposure.

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new acoustic exposure criteria (NMFS 2013). Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and cumulative SEL_{24h} thresholds, where the subscripted *24h* refers to the 24 hour accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: Low-, Mid- and High-Frequency Cetaceans (LFC, MFC, and HFC respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.4.1). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it infers a 3 dB exchange rate).

[1] The "A" refers to a specific frequency-dependent filter shaped according to a human equal loudness contour.

where *G*(f) is the weighting function amplitude (in dB) at the frequency *f* (in Hz), and *a* and *b* are the estimated lower and upper hearing limits, respectively, which control the roll-off and passband of the weighting function. The parameters *a* and *b* are defined uniquely for each hearing group (Table A-1). The auditory weighting functions recommended by Southall et al. (2007) are shown in Figure A-3.

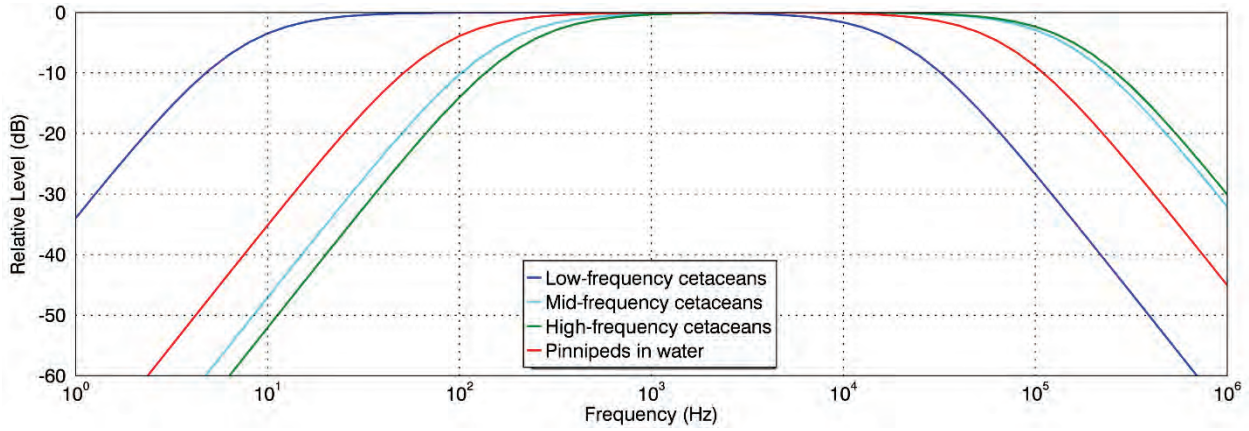

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups as recommended by Southall et al. (2007).

Table A-1. Parameters for the auditory weighting functions recommended by Southall et al. (2007).

Hearing group	Southall et al. (2007)	
	a (Hz)	*b* (Hz)
Low-frequency cetaceans (LFC)	7	22,000
Mid-frequency cetaceans (MFC)	150	160,000
High-frequency cetaceans (HFC)	200	180,000
Pinnipeds in water (Pw)	75	75,000

A.4.2. Finneran 2015

In 2015, a U.S. Navy Technical Report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^{2}\right]^{a}\left[1+(f/f_{hi})^{2}\right]^{b}}\right)\right], \quad \text{(A-10)}$$

Although the inclusion of some species changed (e.g., the addition of hourglass (*Lagenorhynchus cruciger*) and Peale's (*Lagenorhynchus australis*) dolphins to the high-frequency functional hearing group), the five recommended functional hearing groups remained those presented in the Finneran and Jenkins (2012). Table A-2 lists the frequency-weighting parameters for each hearing group; Figure A-4 shows the resulting frequency-weighting curves.

Table A-2. Parameters for the auditory weighting functions recommended by Finneran (2015).

Hearing group	*a*	*b*	f_{lo} (Hz)	f_{hi} (kHz)	*K* (dB)
Low-frequency cetaceans	1.5	2	380	13,000	0.43
Mid-frequency cetaceans	1.6	2	7,400	110,000	1.02
High-frequency cetaceans	1.7	2	16,000	150,000	1.63
Phocid pinnipeds in water	2.0	2	770	27,000	0.49
Otariid pinnipeds in water	0.8	2	1,300	37,000	0.38

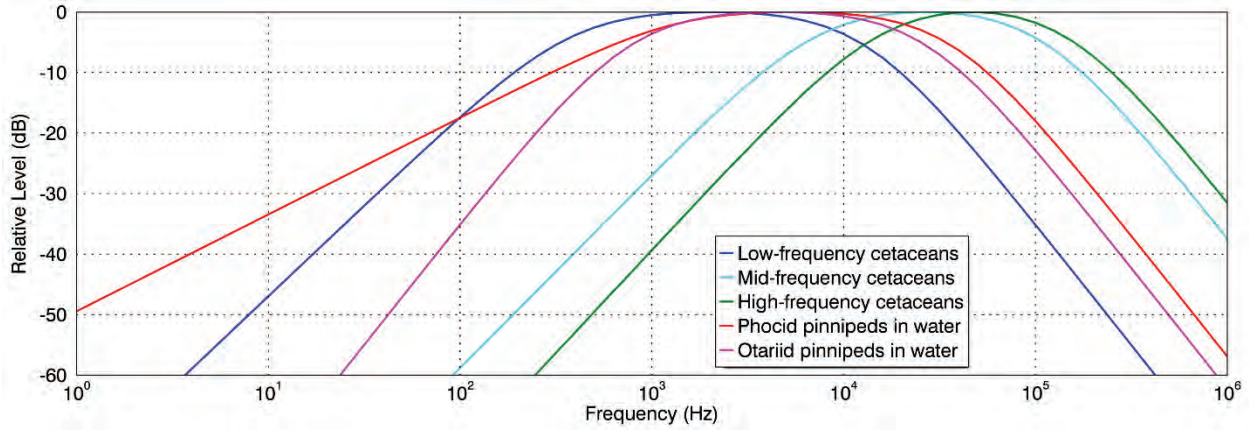

Figure A-4. Auditory weighting functions for functional marine mammal hearing groups as recommended by Finneran (2015).

A.5. Sound Propagation Models

A.5.1. Transmission Loss

The propagation of sound through the environment was modeled by predicting the acoustic transmission loss—a measure, in decibels, of the decrease in sound level between a source and a receiver some distance away. Geometric spreading of acoustic waves is the predominant way by which transmission loss occurs. Transmission loss also happens when the sound is absorbed and scattered by the seawater, and absorbed scattered, and reflected at the water surface and within the seabed. Transmission loss depends on the acoustic properties of the ocean and seabed; its value changes with frequency.

If the acoustic source level (SL), expressed in dB re 1 µPa @ 1 m, and transmission loss (TL), in units of dB, at a given frequency are known, then the received level (RL) at a receiver location can be calculated in dB re 1 µPa @ 1 m by:

$$\mathrm{RL} = \mathrm{SL} - \mathrm{TL} \, . \qquad \text{(A-11)}$$

A.5.2. Acoustic Propagation with MONM

Underwater sound propagation (i.e., transmission loss) at frequencies of 10 Hz to 2 kHz was predicted with JASCO's Marine Operations Noise Model (MONM). MONM computes received per-pulse SEL for directional impulsive sources, and SEL over 1 s for non-impulsive sources, at a specified source depth.

MONM computes acoustic propagation via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent

Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modeled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

MONM computes acoustic fields in three dimensions by modeling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure A-5).

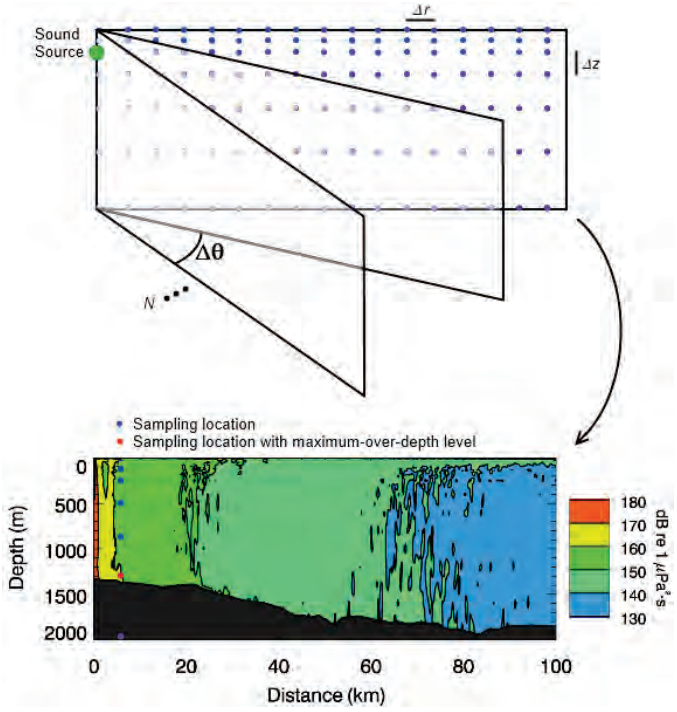

Figure A-5. The N×2-D and maximum-over-depth modeling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modeled to include the majority of acoustic energy emitted by the source. At each center frequency, the transmission loss is modeled within each of the N vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received SEL are then computed by summing the received 1/3-octave-band levels.

The frequency-dependent transmission loss computed by MONM may be corrected to account for the attenuation of acoustic energy by molecular absorption in seawater. The volumetric sound absorption is quantified by an attenuation coefficient, expressed in units of decibels per kilometer (dB/km). The absorption coefficient depends on the temperature, salinity, and pressure of the water as well as the sound frequency. In general, the absorption coefficient increases with the square of frequency. The absorption of acoustic wave energy has a noticeable effect (>0.05 dB/km) at frequencies above 1 kHz. For example, at 10 kHz the absorption loss over 10 km distance can exceed 10 dB. This coefficient for seawater can be computed according to the formulae of François and Garrison (1982b, b), which

consider the contributions of pure seawater, magnesium sulfate, and boric acid. The formula applies to all oceanic conditions and frequencies from 200 Hz to 1 MHz. For this project, absorption coefficients were computed and applied for all modeled frequencies. Because of the computational expense associated with parabolic equation modeling at frequencies at or above several kHz and the relative importance of absorption at such frequencies, the transmission loss in each frequency band between 6 and 32 kHz was approximated from the transmission loss computed at 5 kHz by applying the correct frequency-dependent absorption coefficient in each band.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as color contours around the source.

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Martin et al. 2015).

An inherent variability in measured sound levels is caused by temporal variability in the environment and the variability in the signature of repeated acoustic impulses (sample sound source verification results is presented in Figure A-6). While MONM's predictions correspond to the averaged received levels, cautionary estimates of the threshold radii are obtained by shifting the best fit line (solid line, Figure A-6) upward so that the trend line encompasses 90% of all the data (dashed line, Figure A-6).

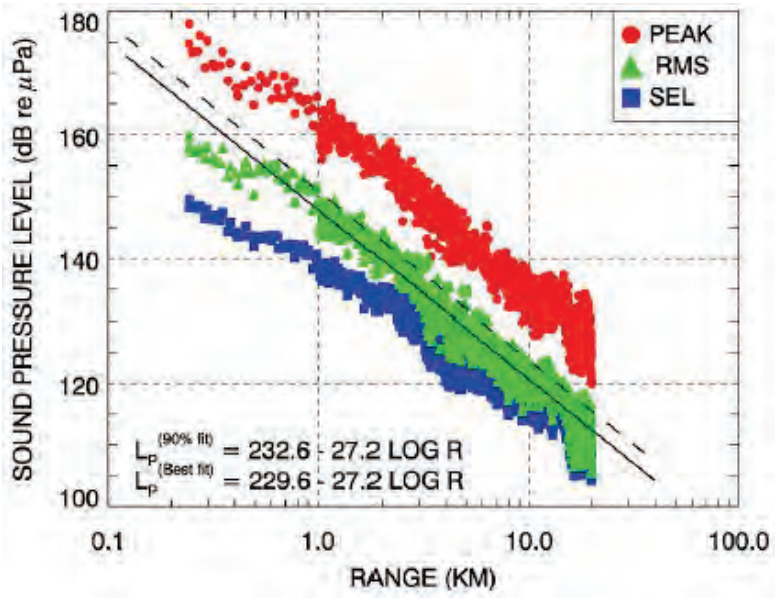

Figure A-6. Peak and SPL and per-pulse SEL versus range from a 20 in^3 air gun array. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

Sound source verification results show that this 90th percentile best-fit is, on average, 3 dB higher than the original best fit line for sources in water depths greater than 20 m (Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010). Consequently, a safety factor of 3 dB is

customarily added to the predicted received levels to provide cautionary results reflecting the inherent variability of sound levels in the modeled area.

The transmission loss computed by MONM can be further corrected to account for the attenuation of acoustic energy by molecular absorption in seawater. The volumetric sound absorption is quantified by an attenuation coefficient, expressed in units of decibels per kilometer (dB/km). The absorption coefficient depends on the temperature, salinity, and pressure of the water as well as the sound frequency. In general, the absorption coefficient increases with the square of frequency. The absorption of acoustic wave energy has a noticeable effect (>0.05 dB/km) at frequencies above 1 kHz. At 10 kHz, the absorption loss over a 10 km distance can exceed 10 dB. This coefficient for seawater can be computed according to the formulae of François and Garrison (1982b, 1982a), which consider the contribution of pure seawater, magnesium sulfate, and boric acid. The formulae apply to all oceanic conditions and frequencies from 200 Hz to 1 MHz.

A.5.3. Acoustic Propagation with FWRAM

For impulsive sounds, time-domain representations of the pressure waves generated in the water are required to calculate peak pressure level or to accuratly model sound propagating away from a vertical source array. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seabed geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Synthetic pressure waveforms were modeled over the frequency range 10–2048 Hz, inside a 1 s window. The synthetic pressure waveforms were post-processed, after applying a travel time correction, to calculate PK and SEL metrics versus range and depth from the sources.

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APPENDIX I

Recent Environmental Baseline Survey Reports

Resubmitted without changes

March 2022

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Environmental Baseline Survey and Habitat Assessment Report: Continental Slope AUV Survey, Hammerhead Development, Offshore Guyana

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Environmental Baseline Survey and Habitat Assessment Report

Continental Slope AUV Survey
Hammerhead Development, Offshore Guyana

Date of Report: 17 October 2019
Date of Field Work: 22 April to 27 May 2019

Fugro Document No.: 1903-1507-V8-EBS

Esso Exploration and Production Guyana Limited

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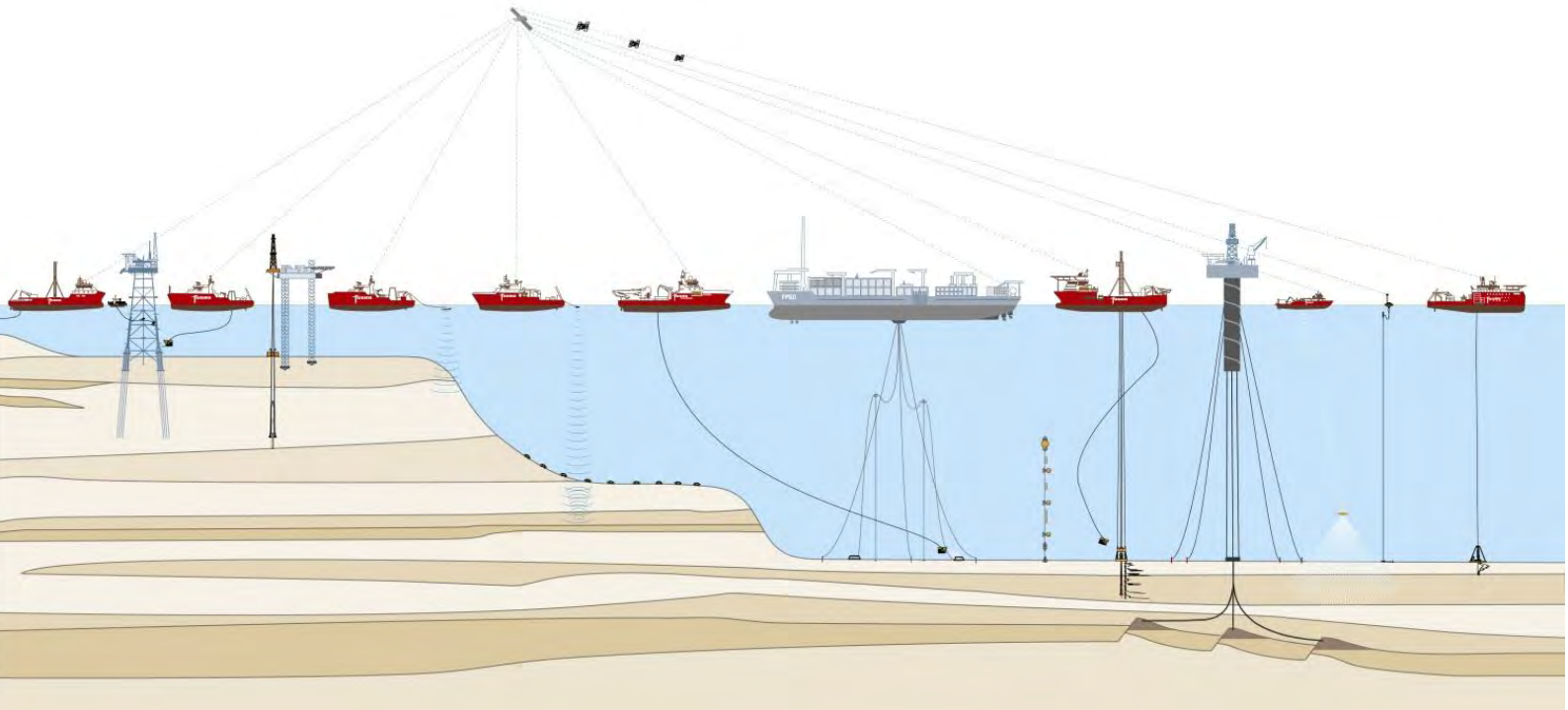

Environmental Baseline Survey and Habitat Assessment Report

Continental Slope AUV Survey
Hammerhead Development, Offshore Guyana

Date of Report: 17 October 2019
Date of Field Work: 22 April to 27 May 2019

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Final

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Attention: Mr Patrick Lee

Environmental Baseline Survey and Habitat Assessment Report
Continental Slope AUV Survey
Hammerhead Development, Offshore Guyana

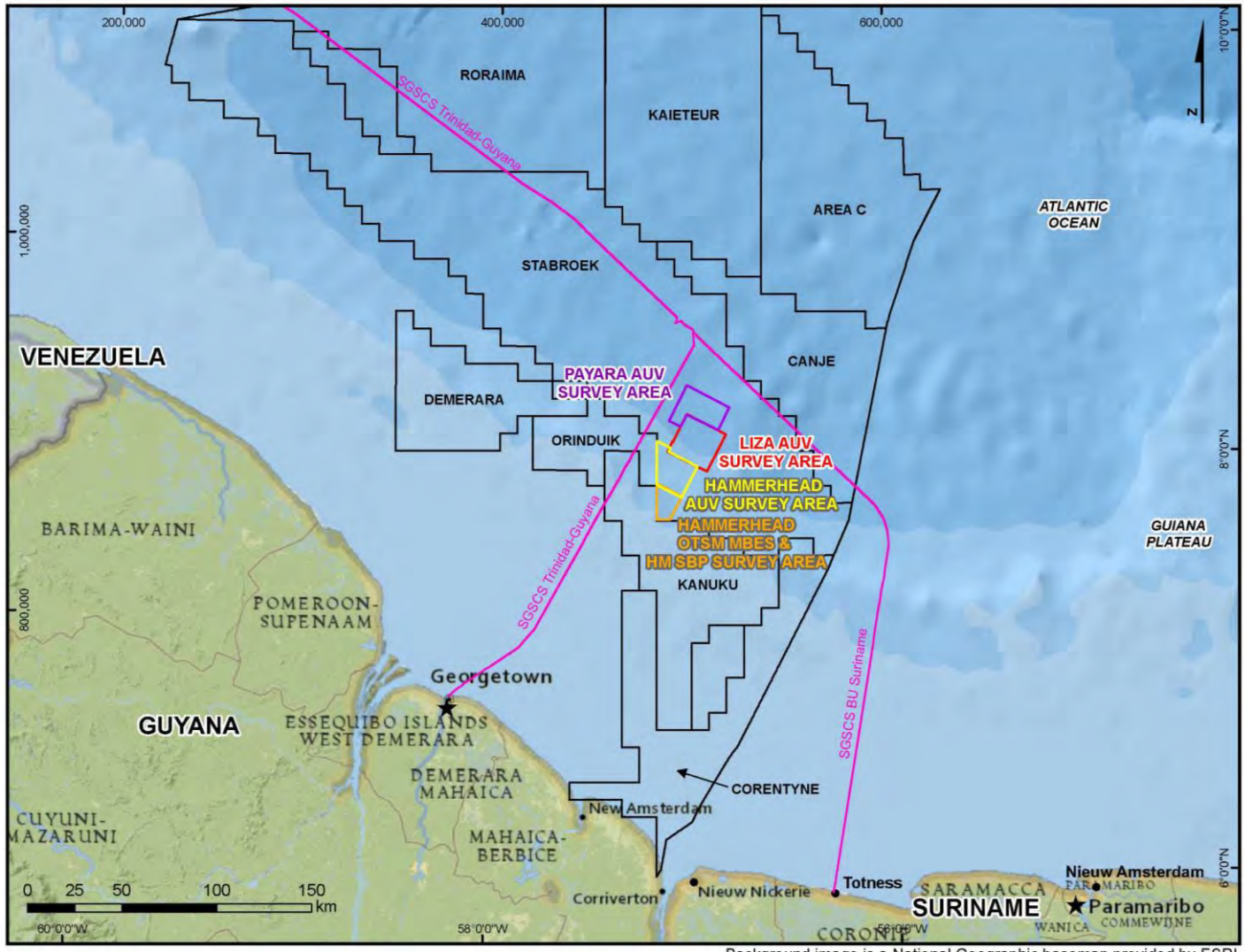
As a subcontractor to Fugro Canada Corp., Fugro GB Marine Limited has the pleasure of submitting the Final Environmental Baseline Survey and Habitat Assessment Report for the integrated site investigation programme within the Hammerhead Development Field, offshore Guyana. This report presents a summary of the survey operations and the results from the environmental survey. This report is based on AUV data collected between 17 March and 18 April 2019 by FUSAMI aboard the R/V Fugro Brasilis.

This work was carried out as authorised by Master Marine Survey Order A4001077, dated 8 November 2018 and under Master Marine Survey Agreement A1998840 and Marine Survey Sub agreement A2002836, both dated 14 February 2006 (contract reference Schedule H – Onshore Reporting, item 8.3). This report was prepared in general accordance with the Esso Exploration and Production Guyana Limited (EEPGL) project work scope, in accordance with Fugro proposal PL18-036 dated 8 June 2018, and as otherwise agreed with the EEPGL representative, Patrick Lee.

We hope that you find this report to your satisfaction; should you have any queries, please do not hesitate to contact us.

Yours faithfully
Fugro GB Marine Limited

David Watson
Project Manager
Distribution: One electronic copy to **Mr Patrick Lee**



Background image is a National Geographic basemap provided by ESRI.
Coordinate Grid: WGS 1984 UTM Zone 21N, meters

GENERAL LOCATION MAP

FRONTISPIECE

EXECUTIVE SUMMARY

Introduction

On the instruction of Esso Exploration and Production Guyana Limited (EEPGL), Fugro performed an integrated site investigation programme within the Hammerhead development, offshore Guyana. Geophysical operations, comprising automated underwater vehicle (AUV), multibeam echosounder (MBES), side scan sonar (SSS), and sub-bottom profiler (SBP) data collection were undertaken during the first phase of survey operations. The second phase of the site investigation comprised over the side mounted (OTSM), MBES and hull-mounted sub-bottom profiler (SBP) data collection upslope of the AUV survey area, geotechnical sampling and an environmental baseline survey (EBS).

Survey Strategy

Seabed video and still photographic data collection was performed at 15 locations to establish and identify the seabed habitats and epifaunal species within the survey area. Sediment box core sampling was performed at eight locations to establish the physico-chemical and biological properties of the sediment. Water quality was assessed through in situ collection of water column profiles and acquisition of water samples at eight locations.

Sediment Characterisation

Using the Wentworth (1922) sediment description, four stations were classified as ‘fine silt’, three stations were classified as ‘very fine silt’ and the remaining station classified as ‘medium silt’. The majority of the sediments were classed as very poorly sorted with one station classified as poorly sorted. All stations had a sediment composition consisting of mainly sand and fines content.

Sediment Hydrocarbons

The gas chromatographic profiles obtained from sediments collected from within the Hammerhead survey area were typical of background sediments, displaying weathered low level petroleum and biogenic hydrocarbons and an associated unresolved complex mixture (UCM) commonly found in marine sediments.

The total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations were low across the survey area. The United States Environmental Protection Agency’s 16 priority PAH pollutants (US EPA 16 PAH) were below their respective effects range low (ERL) values at all stations (Buchman, 2008).

Sediment Trace/Heavy Metals

The concentrations of metals (aqua regia digest) displayed low variability for all metal concentrations across the sediments (RSD ≤ 21 %). Metal concentrations were below their respective ERL values at all stations, with the exception of arsenic and nickel. Arsenic concentrations exceeded the National Oceanic and Atmospheric Administration (NOAA) ERL (8.2 µg/g, Buchman, 2008) at six stations, whilst nickel concentrations exceeded the NOAA ERL (20.9 µg/g, Buchman, 2008) at seven stations. No arsenic or nickel concentrations exceeded their respective NOOA ERM (70.0 µg/g and 51.6 µg/g, respectively, Buchman, 2008).

Water Profiles

Water profiles showed a stratified water column, with a defined thermocline, halocline, pH boundary and oxygen boundary down to ca. 400 m, after which values remained relatively constant. Turbidity remained constant throughout the profile.

Water Nutrients and Total Suspended Solids (TSS)

Nitrogen compounds, total organic carbon (TOC) and TSS values across the Hammerhead water samples showed no evidence of stratification.

Water Hydrocarbons

Total hydrocarbon content (THC) concentrations across the survey area were below the MRV for the majority of stations with the exception of station EBSHHW_05 (Bottom) and station EBSHHW_07 (Mid and Bottom). Unresolved complex mixture (UCM) concentrations were below the minimum reporting value (MRV) of 10 µg/L for all stations with the exception of station EBSHHW05 (Bottom). Total 2 to 6 ring PAH concentrations displayed moderate variability (RSD 36 %) between samples. Total US EPA 16 PAH concentrations and naphthalene and phenanthrene/anthracene and dibenzothiophene (NPD) displayed moderate variability (RSD 65 % and 37 % respectively). Percentage NPD displayed low variability (RSD 11 %). The mean total US EPA 16 PAH concentration (3.9 ng/L) within the Hammerhead development was lower than the mean values observed at the Payara development (4.0 ng/L, Fugro, 2019a) and the Liza field survey (9.5 ng/L, Fugro, 2016).

Water Trace/Heavy Metals

Heavy and trace metal concentrations were low in most water samples, being close to or below their respective MRVs in the majority of samples across the Hammerhead development. No metals concentrations exceeded the US EPA criterion continuous concentration (CCC) or criterion maximum concentration (CMC) values (US EPA, 2018). Consequently, the metals concentrations within the water samples are unlikely to negatively impact the benthic or pelagic biota. No trends were observed between metals concentrations and depth in the Hammerhead water samples.

Seabed Habitats

Analysis of the photographic data identified two broad biotope complexes in accordance with the ‘Biotopes/Ecosystems Nomenclature, Habitats of South America’ (Institute of Terrestrial Ecology, 1996) with ‘Sublittoral soft seabeds (11.22) observed at all drop-down video stations and ‘Deep-sea floor” (11.21) observed at all transects.

EUNIS (2012) biotopes were also assigned to offer further habitat description: ‘Sublittoral soft seabeds’ (11.22) were assigned the EUNIS (2012) ‘Sublittoral mud’ (A5.3) habitat. The EUNIS (2012) classification allowed the ‘Deep-sea floor” (11.21) (Institute of Terrestrial Ecology, 1996) description to be further split in to: Muddy Sand’ (A6.4), describing areas with gravelly, muddy sand sediments where epifaunal diversity and abundance was low; and ‘deep-sea rock and artificial hard substrata’ (A6.1) describing areas of elevated, exposed bedrock where the epifaunal community comprised predominantly of sessile taxa. No potentially sensitive habitats or species were identified in the current survey.

Macrofauna

The faunal community within the survey area was moderately diverse with a large number of taxa occurring in relatively low abundances. Arthropods and annelids and were the most numerous taxa recorded, similar to the community recorded at the Payara development (Fugro, 2019a) and Liza field in 2016 (Fugro, 2016).

Univariate analysis indicated that diversity was high across the survey area. Multivariate analysis demonstrated moderate to high variability across the survey area, potentially due to the relatively high number of taxa and the low number of individuals observed. Multivariate statistics highlighted that differences in the macrofaunal community

were largely reflective of elevated abundance of several taxa within shallower stations, and the presence or absence of taxa associated with different depth ranges or depth related parameters (e.g. sediment characteristics).

No meaningful correlations were observed between the macrofaunal community and the physico-chemical parameters sampled across the Hammerhead development survey area.

DOCUMENT ARRANGEMENT

Volume 1 AUV, EBS, and Geotechnical Sampling Operations Report
Volume 2 Digital Deliverables and Data Transmittal Report
Volume 3 Shallow Sampling Program - Geotechnical and Geohazards Field Report
Volume 4 Shallow Sampling Program - Environmental Baseline Field Report
Volume 5a Onboard Geophysical Field Report Continental Slope AUV Survey
Volume 5b Onboard Geophysical Field Report Outer Continental Shelf and Shelf Break Over-The-Side-Mounted MBES & Hull-Mounted SBP Survey
Volume 6 Shallow Sampling Program - Geotechnical Laboratory Data and Interpretation of Soil Properties
Volume 7 Geological Testing Interpretation Report
Volume 8 Environmental Baseline Survey and Habitat Assessment Report
Volume 9a Geophysical Results and Interpretation Report Continental Slope AUV Survey
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ABBREVIATIONS

1-λ	Simpson's diversity index
AUV	Autonomous underwater vehicle
BC	Box corer
BIO	Biodiversity DNA sample
BSL	Below sea level
CCC	Criterion continuous concentration
CLUSTER	Hierarchical agglomerative clustering
CMC	Criterion maximum concentration
CPI	Carbon preference index
CTD	Conductivity temperature depth
CV-AFS	Cold vapour-atomic fluorescence spectroscopy
Dam.	Damaged
DCM	Dichloromethane
DO	Dissolved oxygen
DTI	Department of Trade and Industry
EBS	Environmental baseline survey
EEPGL	Esso Exploration and Production Guyana Limited
EOL	End of line
ERL	Effects range low
ERM	Effects range median
EUNIS	European Nature Information System
FA/FB	Fauna sample/replicate A or B
FID	Flame ionisation detection
FTU	Formazin turbidity units
FGBML	Fugro GB Marine Limited
GC	Gas chromatography
GC-FID	Gas chromatography–flame ionisation detection
GC-MS	Gas chromatography-mass spectrometry
H'Log_2	Shannon-Wiener index
Hb	Brillouin's diversity index
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma-optical emission spectrometry
IDA	Industrial denatured alcohol
IHM	Inhouse method
J	Pielou's evenness
Juv.	Juveniles
MBES	Multibeam echo sounder
MRV	Minimum reporting value
NA	Not applicable
nC_{12-36}	n-alkane range
NDIR	Non-dispersive infrared detector
nMDS	Non-metric multidimensional scaling
NOAA	National Oceanic and Atmospheric Administration
NMBAQC	National Marine Biological Analytical Quality Control scheme
NPD	Naphthalene, phenanthrene/anthracene and dibenzothiophene
OTSM	Over the side mounted
PAH	Polycyclic aromatic hydrocarbon
PC	Physico-chemical sediment sample

Ph	Phytane
Pr	Pristane
PSU	Practical salinity unit
Pr/Ph	Ratio of pristane to phytane
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle size analysis
PSD	Particle size distribution
RSD	Relative standard deviation
RV	Research vessel
SBP	Sub-bottom profiler
SD	Standard deviation
SIMPROF	Similarity profiling
SOL	Start of line
SSS	Side scan sonar
TKN	Total Kjeldhal nitrogen
THC	Total hydrocarbon content
TOC	Total organic carbon
TSS	Total suspended solids
UCM	Unresolved complex mixture
UKAS	United Kingdom Accreditation Service
USBL	Ultra short baseline
US EPA	United States Environmental Protection Agency
US EPA 16	United States Environmental Protection Agency's 16 priority PAH pollutants
US NEL	United States Naval Electronics Laboratory
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984
WP	Water profile
WS	Water sample

1. INTRODUCTION

1.1 Background

On the instruction of Esso Exploration and Production Guyana Limited (EEPGL), Fugro performed an integrated site investigation programme in support of the Hammerhead development, offshore Guyana. Automated underwater vehicle (AUV), multibeam echosounder (MBES), side scan sonar (SSS), and sub-bottom profiler (SBP) data collection were undertaken during the first phase of survey operations. The second phase of the site investigation comprised over the side mounted (OTSM), multibeam echosounder (MBES) and hull-mounted SBP data collection upslope of the AUV survey area, geotechnical sampling and an environmental baseline survey (EBS).

The survey was conducted onboard RV Fugro Brasilis during the survey period 22 April to 25 May 2019.

Appendix A outlines the guidelines for use of this report.

1.2 Scope of Work

The surveys were undertaken to establish the water column and sediment conditions encountered at the Hammerhead development. The environmental survey was carried out to assess the biological and physico-chemical properties of the water column and seabed, to acquire sufficient environmental data to describe all habitats recorded within the survey area and to identify and delineate the extent of any potentially sensitive habitats or species. Following the acquisition of the shelf and shelf break geophysical data, camera transects were selected to investigate areas of elevated rough hard substrate which had reduced or near zero signal penetration on the SBP data.

1.3 Coordinate Reference System

All coordinates detailed in this report are referenced to WGS84 (World Geodetic System 1984) datum, Universal Transverse Mercator (UTM) Projection Zone 21 N.

Table 1.1 provides the detailed geodetic and projection parameters.

Table 1.1: Project Geodetic Parameters

Global Positioning System Geodetic Parameters*	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Reciprocal flattening:	1/f = 298.257 223 563
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator (UTM)
UTM Zone:	21 N
Central Meridian:	57° 00’ 00.0” West
Latitude of Origin:	00° 00′ 00″ North
False Easting:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	Metre
Notes: * = Fugro Starfix navigation software always uses WGS84 geodetic parameters as a primary datum for any geodetic calculations	

1.4 Regional Standards and Comparable Studies

Regional comparison data was compiled from previous surveys conducted near the study area. The Payara field EBS (Fugro, 2019a) and the Liza field EBS (Fugro, 2016) were conducted at similar water depths to the samples collected in the current survey. The Liza field (Fugro, 2016) metals data are not directly comparable to other regional data due to the application of differing analytical methods and are included for information only.

In the absence of regional standards specific to Guyana for physico-chemical data, internationally recognised environmental standards have been adopted. For results in sediments recorded above the minimum reporting value, comparison has been made to the National Oceanic and Atmospheric Administration (NOAA) effects range low (ERL) and effects range median (ERM) reference values (Buchman, 2008) where applicable. ERLs represent the low point (10th percentile) and ERMs represent the 50th percentile on a continuum of chemical concentrations over which adverse biological effects have been observed (O' Connor, 2004). Water data were compared to the United States Environmental Protection Agency (US EPA) criterion continuous concentration (CCC) and criterion maximum concentration (CMC) values (US EPA, 2018), where available. Detrimental effects are rarely observed in biota when concentrations are below these values.

2. ENVIRONMENTAL SURVEY METHODS

2.1 Survey Strategy

The objectives of the EBS were to provide data to establish the baseline physico-chemical and biological characteristics of the seabed and water column environment, by undertaking water column and seabed sampling. Seabed photographic data were also collected to identify the habitats and epifaunal communities present within the survey area.

The EBS sampling stations were pre-determined by the client. Following the acquisition of the shelf and shelf break geophysical data, camera transects were selected to investigate areas of elevated rough hard substrate which had reduced or near zero signal penetration on the SBP data.

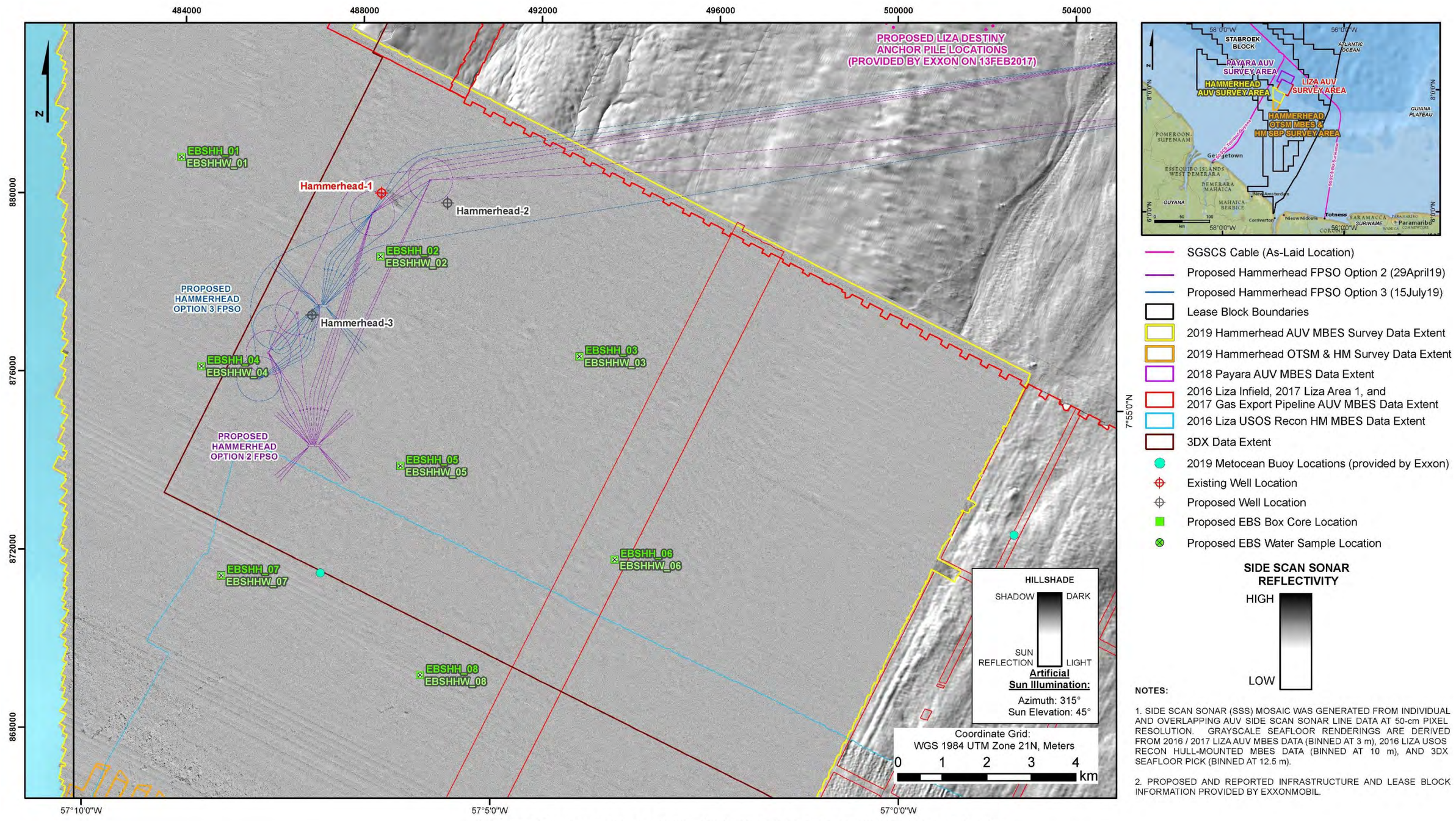
Table 2.1 provides the coordinates, data to be acquired and rationale for each location. The orientation of the camera transects was subject to change to accommodate vessel manoeuvrability at the time of survey operations. Figure 2.1 spatially displays the proposed environmental survey locations overlaid on a SSS mosaic. Figure 2.2 spatially displays the proposed environmental camera transects on bathymetry data, whilst Figure 2.3 spatially displays the proposed drop down camera transects on bathymetry data.

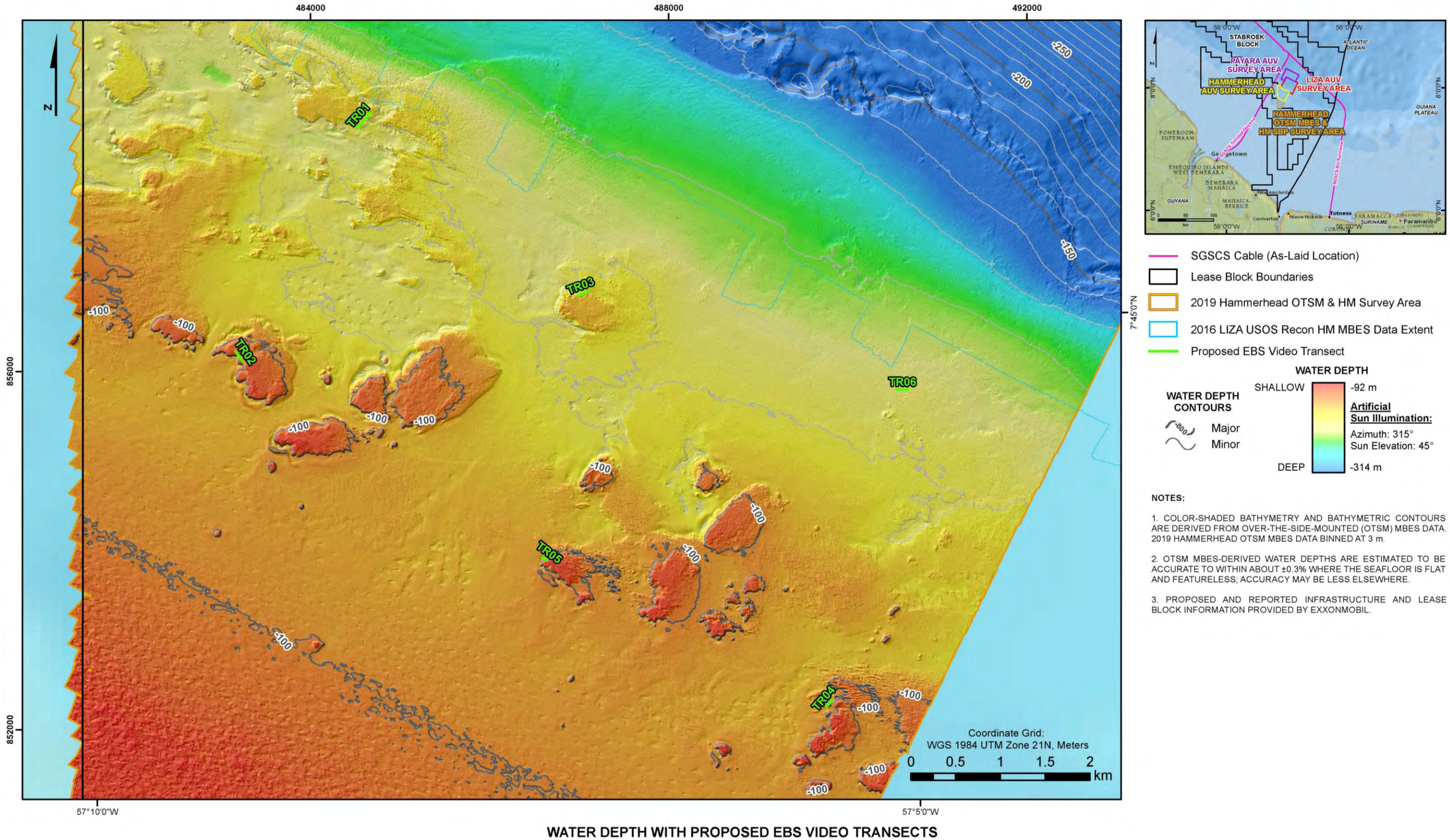
Table 2.1: Proposed Environmental Survey Sampling Stations, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N					
Station		**Easting [m]**	**Northing [m]**	**Rationale**	**Sample/Data Acquisition**
Camera Transects					
TR01	SOL	484 524	858 728	2 m high rugged undulations	Video and stills
	EOL	484 667	858 890		
TR02	SOL	483 162	856 229	Raised seabed (5 m in height), possible reef	Video and stills
	EOL	483 243	856 113		
TR03	SOL	487 107	856 901	Uneven seabed in the centre of the site	Video and stills
	EOL	486 987	856 855		
TR04	SOL	489 761	852 259	A 5 m high and 30 m wide seabed elevation in the west of site	Video and stills
	EOL	489 824	852 332		
TR05	SOL	486 588	853 927	Scouring next to an elevated seabed	Video and stills
	EOL	486 637	853 891		
TR06	SOL	490 673	853 927	Client requested. Possible active seep	Video and stills
	EOL	490 545	855 798		
Drop-down camera					
EBSHHDD_01		483 891	880 797	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_02		488 361	878 559	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_03		492 832	876 320	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_04		484 335	876 101	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_05		488 805	873 863	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_06		493 622	871 761	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_07		484 780	871 405	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_08		489 250	869 167	Client predetermined for site spatial coverage	Video and stills
GEOPC010DD		487 688	873 556	Client requested, pockmark investigation	Video and stills

Geodetic Parameters: WGS84 UTM Zone 21 N				
Station	**Easting [m]**	**Northing [m]**	**Rationale**	**Sample/Data Acquisition**
Sediment Sampling				
EBSHH_01	483 891	880 797	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_02	488 361	878 559	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_03	492 832	876 320	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_04	484 335	876 101	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_05	488 805	873 863	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_06	493 622	871 761	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_07	484 780	871 405	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_08	489 250	869 167	Client predetermined for site spatial coverage	PC, FA, FB, BIO
Water Sampling				
EBSHHW_01	483 891	880 797	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_02	488 361	878 559	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_03	492 832	876 320	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_04	484 335	876 101	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_05	488 805	873 863	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_06	493 622	871 761	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_07	484 780	871 405	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_08	489 250	869 167	Client predetermined for site spatial coverage	WS, WP, BIO

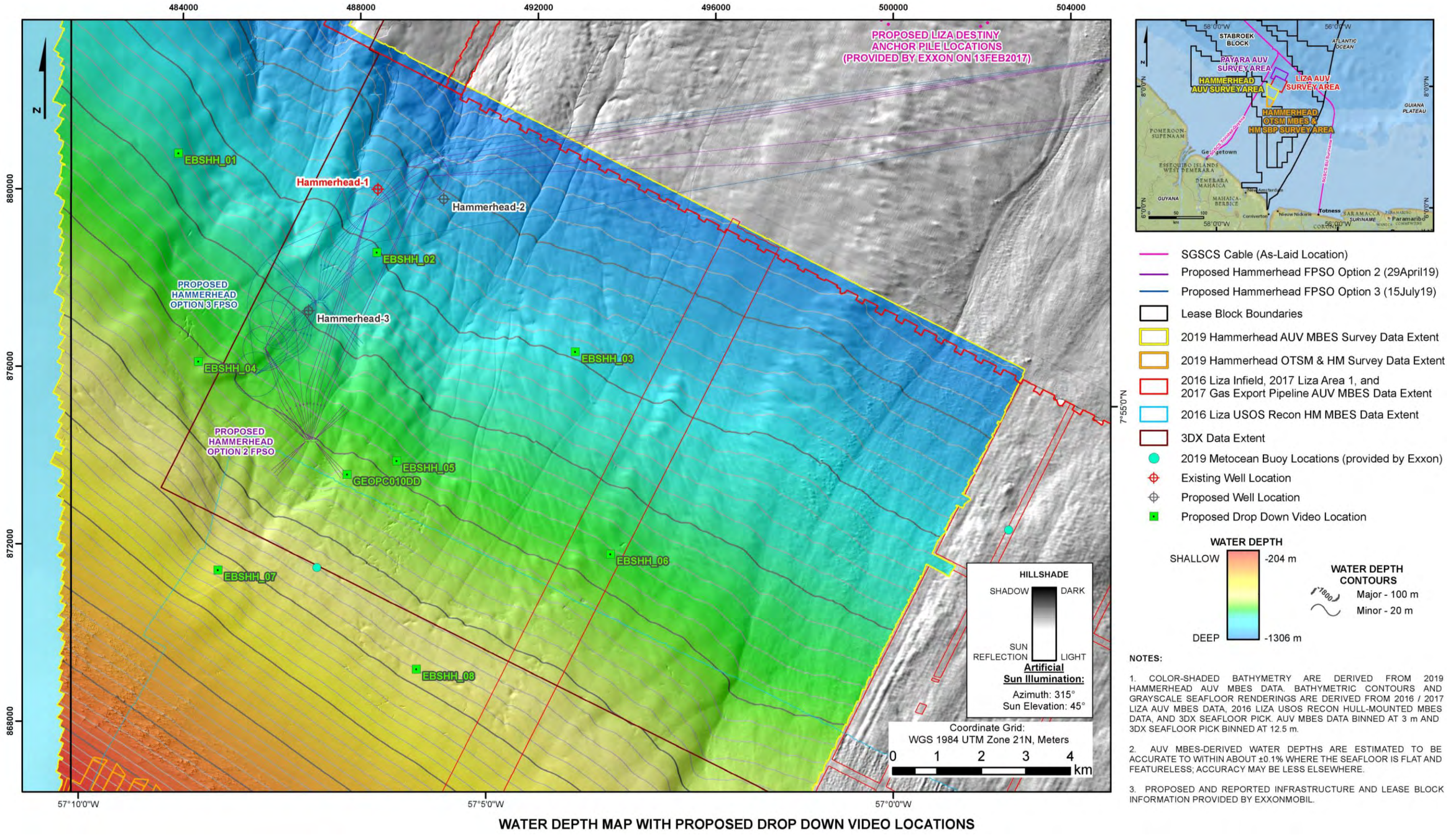
Notes:
PC = Physico-chemical sediment sample
FA/FB = Faunal sample A or B
WS = Physico-chemical water sample
WP = Water profile
BIO = Biodiversity DNA sample (to include BIOA1, BIOA2, BIOB1, BIOB2, BIOC1 and BIOC2)


484000
488000
492000
496000
500000
504000
880000
876000
872000
868000
N
PROPOSED LIZA DESTINY ANCHOR PILE LOCATIONS (PROVIDED BY EXXON ON 13FEB2017)
EBSHH_01
EBSHHW_01
Hammerhead-1
Hammerhead-2
EBSHH_02
EBSHHW_02
PROPOSED HAMMERHEAD OPTION 3 FPSO
Hammerhead-3
EBSHH_04
EBSHHW_04
EBSHH_03
EBSHHW_03
PROPOSED HAMMERHEAD OPTION 2 FPSO
EBSHH_05
EBSHHW_05
EBSHH_06
EBSHHW_06
EBSHH_07
EBSHHW_07
EBSHH_08
EBSHHW_08
HILLSHADE
SHADOW
DARK
SUN REFLECTION
LIGHT
Artificial Sun Illumination:
Azimuth: 315°
Sun Elevation: 45°
Coordinate Grid:
WGS 1984 UTM Zone 21N, Meters
0 1 2 3 4 km
7°55'0"N
57°10'0"W
57°5'0"W
57°0'0"W
58°0'0"W
56°0'0"W
8°0'0"N
6°0'0"N
STABROEK BLOCK
ATLANTIC OCEAN
PAYARA AUV SURVEY AREA
HAMMERHEAD AUV SURVEY AREA
LIZA AUV SURVEY AREA
HAMMERHEAD OTSM MBES & HM SBP SURVEY AREA
GUIANA PLATEAU
POMEROON-SUPENAAM
Georgetown
ESSEQUIBO ISLANDS-WEST DEMERARA
DEMERARA-MAHAICA
MAHAICA-BERBICE
New Amsterdam
GUYANA
Corriverton
Nieuw Nickerie
Totness
SURINAME
Paramaribo
SARAMACCA
CORANTIJN
SGSCS Trinidad-Guyana
SGSCS Tobago-Trinidad
SGSCS Barbados-Guyana
SGSCS Barbados-Trinidad
SGSCS Barbados-Tobago
SGSCS Barbados-Suriname
SGSCS Barbados-Venezuela
SGSCS Barbados-Grenada
SGSCS Barbados-St. Vincent
SGSCS Barbados-St. Lucia
SGSCS Barbados-Martinique
SGSCS Barbados-Dominica
SGSCS Barbados-Guadeloupe
SGSCS Barbados-Antigua
SGSCS Barbados-St. Kitts
SGSCS Barbados-Nevis
SGSCS Barbados-Montserrat
SGSCS Barbados-Anguilla
SGSCS Barbados-St. Martin
SGSCS Barbados-St. Barthelemy
SGSCS Barbados-Saba
SGSCS Barbados-St. Eustatius
SGSCS Barbados-St. Maarten
SGSCS Barbados-Aruba
SGSCS Barbados-Curacao
SGSCS Barbados-Bonaire



WATER DEPTH WITH PROPOSED EBS VIDEO TRANSECTS

Figure 2.2: Proposed environmental camera transects overlaid on bathymetry, Hammerhead development



WATER DEPTH MAP WITH PROPOSED DROP DOWN VIDEO LOCATIONS

Figure 2.3: Proposed environmental drop down camera transects overlaid on bathymetry, Hammerhead development

2.2 Survey Methods

Seabed photography was acquired using a Sonar Equipment Services deep-sea camera system mounted within a purpose built camera frame complete with one high resolution video camera, one stills camera, a separate strobe and four light emitting diode lights.

Seabed video footage was displayed on a computer monitor and recorded directly onto a hard drive. A video overlay was used to overlay a navigation string from an attached ultra short baseline (USBL) beacon, including the time, date, depth and location (easting and northing). The survey location and station number were also displayed (manually updated). The stills camera imagery was visible on a second window of the computer. Footage was viewed in real time via a co-axial cable, assisting in the control of the camera in the water. Two lasers were set up 9 cm apart to provide image scaling.

Seabed grab samples were primarily collected for analysis of physico-chemical and biological sediment characterisation; however, observations of the grab sample contents have been used to supplement the seabed video/photographic data in describing the benthic habitat where appropriate. Seabed samples were acquired using a United States Naval Electronics Laboratory (US NEL) 0.25 m^2 box corer equipped with a USBL beacon, within the agreed 50 m sampling accuracy.

Water profiles were acquired from sea surface to near seabed during deployment and recovery of a Valeport 606+ deepwater conductivity temperature depth (CTD) profiler, set up to record depth, salinity, conductivity, dissolved oxygen (DO), pH, turbidity and temperature. At each station, the initial drop had a clump weight, beacon, CTD and two 5 litre Niskin water samplers attached to the lifting wire at intervals coinciding with the sampling depths. The CTD profiles were acquired simultaneously with the collection of near-seabed (bottom) water samples. Mid-depth and near-surface samples were then acquired in two subsequent deployments of the Niskin sampler only.

Further detail can be found within the Hammerhead development field report (Fugro, 2019b).

2.3 Analytical Strategy

The following list briefly describes the suites of analyses carried out. Further description of the methods used for the analyses are detailed in Appendix B.

- Sediment particle size distribution (PSD) analysis and characterisation including total organic carbon (TOC) (Section 4);
- Sediment total hydrocarbon content (THC) by gas chromatography–flame ionisation detection (GC-FID; Sections 5.2.1 and 5.2.2);
- Sediment 2 to 6 ring aromatic hydrocarbons, including the United States Environmental Protection Agency's (US EPA) 16 priority pollutants, by gas chromatography-mass spectrometry (GC-MS; Section 5.2.3);
- Sediment metals predominantly by an aqua regia acid digest and subsequent instrumental analysis. Arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc were analysed by inductively coupled plasma-mass spectrometry (ICP-MS). Aluminium, barium and iron were analysed by inductively coupled plasma-optical emission spectrometry (ICP-OES). Mercury was analysed by cold vapour-atomic fluorescence spectroscopy (CV-AFS) (Section 6);

- Water sample data were analysed for total suspended solids (TSS), TOC, nitrogen compounds, hydrocarbons and metals content (Section 7);
- Habitats were classified using the 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (Institute of Terrestrial Ecology, 1996); (Section 8)
- Macrofauna were identified and enumerated from two sample replicates at each station, 0.5 mm sieve (Section 9).

3. FIELD OPERATIONS

3.1 Seabed Sampling

Box corer sampling was successfully conducted at all the proposed eight environmental sediment stations. Table 3.1 summarises the samples acquired. Figure 3.1 spatially displays the locations of all completed seabed sampling locations overlaid on a SSS mosaic. Complete suites of samples (two macrofauna, one biodiversity DNA analysis sample and one physico-chemical sample) were acquired at all stations.

Table 3.1: Completed Environmental Survey Sampling Stations, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N				
Station	**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Sample Acquisition**
EBSHH_01	483 901.7	880 800.3	1039*	FA, FB, BIO
	483 880.6	880 796.5	1037*	PC
EBSHH_02	488 359.2	878 553.6	1098	PC, FA, FB, BIO
EBSHH_03	492 842.9	876 316.2	1110	PC, FA, FB, BIO
EBSHH_04	484 335.6	876 094.4	888	PC, FA, FB, BIO
EBSHH_05	488 811.0	873 870.1	926	PC, FA, FB, BIO
EBSHH_06	493 624.9	871 760.4	938	PC, FA, FB, BIO
EBSHH_07	484 789.1	871 407.7	673	PC, FA, FB, BIO
EBSHH_08	489 254.6	869 170.5	722	PC, FA, FB, BIO

Notes:
BSL = Below sea level
FA/FB = Faunal sample A or B
BIO = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample
* = Mean depth value considered for further statistical analysis

3.2 Seabed Video/Photography

Photographic stills and video data were successfully acquired at all nine proposed drop-down camera stations and at the six proposed camera transects (Table 3.2).

Figure 3.2 spatially displays the locations of all the completed camera transects, whilst Figure 3.3 spatially displays all completed drop down camera transects on bathymetry data. Stations EBSHH_03 and EBSHH_06 were repeated due to technical issues. Acquisition of video and photographic data was successful on the second attempt at station EBSHHDD_05 due to marginal sea conditions affecting vessel manoeuvrability on the first attempt. Poor sea conditions prevented acquisition of good quality stills at station EBSHHDD_01, this station was repeated and on the fourth attempt, stills images were accepted by the onboard client representative.

Table 3.2: Completed Environmental Survey Camera Transects, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N						
Transect		**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
TR01_part1	SOL	483 267.6	856 086.6	111	42	7 min 47 sec 10 stills
	EOL	484 500.2	858 711.5	109		
TR01_part2	SOL	484 534.7	858 748.6	103	200	20 min 39 sec 41 stills
	EOL	484 669.0	858 896.4	103		
TR02_part1	SOL	483 136.9	856 254.5	95	148	16 min 48 sec 33 stills
	EOL	483 230.1	856 139.4	96		
TR02_part2	SOL	483 232.7	856 135.9	94	60	8 min 3 sec 13 stills
	EOL	483 267.6	856 086.6	96		
TR03	SOL	486 939.4	856 840.3	104	183	21 min 19 sec 38 stills
	EOL	487 108.9	856 909.6	105		
TR04	SOL	489 648.0	852 133.1	100	266	29 min 59 sec 63 stills
	EOL	489 821.7	852 334.2	99		
TR05_part1	SOL	486 551.3	853 954.9	99	50	6 min 56 sec 12 stills
	EOL	486 592.7	853 927.6	101		
TR05_part2	SOL	486 600.0	853 923.6	100	62	8 min 58 sec 22 stills
	EOL	486 648.6	853 885.2	95		
TR06_part1	SOL	490 481.3	855 793.1	112	101	12 min 17 sec 22 stills
	EOL	490 582.6	855 798.4	109		
TR06_part2	SOL	490 594.7	855 799.2	110	83	14 min 58 sec 23 stills
	EOL	490 677.0	855 792.8	111		
Drop-down Camera						
EBSHHDD_01	SOL	483 850.9	880 790.1	1031	75	13 min 44 sec 14 stills
	EOL	483 925.7	880 796.7	1031		
EBSHHDD_01a	SOL	483 854.2	880 795.2	1033	66	12 min 17 sec 19 stills
	EOL	483 919.2	880 805.9	1034		
EBSHHDD_01b	SOL	483 843.4	880 804.1	1034	45	10 min 47 sec 8 stills
	EOL	483 887.9	880 801.7	1035		
EBSHHDD_01c	SOL	483 849.5	880 792.5	1034	85	19 min, 16 sec 26 stills
	EOL	483 934.5	880 799.0	1036		
EBSHHDD_02	SOL	488 296.6	878 534.7	1094	104	17 min 49 sec 21 stills
	EOL	488 392.2	878 576.4	1097		
EBSHHDD_03	SOL	492 803.0	876 326.8	1107	61	7 min 43 sec 10 stills
	EOL	492 863.4	876 332.1	1107		
EBSHHDD_03a	SOL	492 781.4	876 327.3	1106	77	15 min 3 sec 30 stills
	EOL	492 857.4	876 317.2	1108		
EBSHHDD_04	SOL	484 267.2	876 107.1	880	93	15 min 21 sec 26 stills
	EOL	484 360.0	876 103.3	883		
EBSHHDD_05	SOL	488 753.3	873 859.9	921	71	14 min 49 sec 13 stills
	EOL	488 821.0	873 882.7	922		
EBSHHDD_05a	SOL	488 761.6	873 859.7	917	70	10 min 57 sec 17 stills
	EOL	488 832.0	873 857.8	922		
EBSHHDD_06	SOL	493 608.0	871 754.2	933	21	13 min 27 sec 19 stills
	EOL	493 628.0	871 759.5	933		

Geodetic Parameters: WGS84 UTM Zone 21 N						
Transect		**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
EBSHHDD_06a	SOL	493 622.7	871 738.0	935	106	20 min, 56 sec 21 stills
	EOL	493 611.4	871 843.3	932		
EBSHHDD_07	SOL	484 722.1	871 373.5	663	96	15 min 42 sec 25 stills
	EOL	484 808.6	871 414.7	663		
EBSHHDD_08	SOL	489 191.7	869 161.8	716	112	27 min 10 sec 39 stills
	EOL	489 301.6	869 181.5	724		
GEOPC010DD	SOL	487 652.4	873 544.8	879	66	14 min 0 sec 15 stills
	EOL	487 711.2	873 574.6	881		
Notes: BSL = Below sea level SOL = Start of line EOL = End of line						

3.3 Water Sampling and Profiling

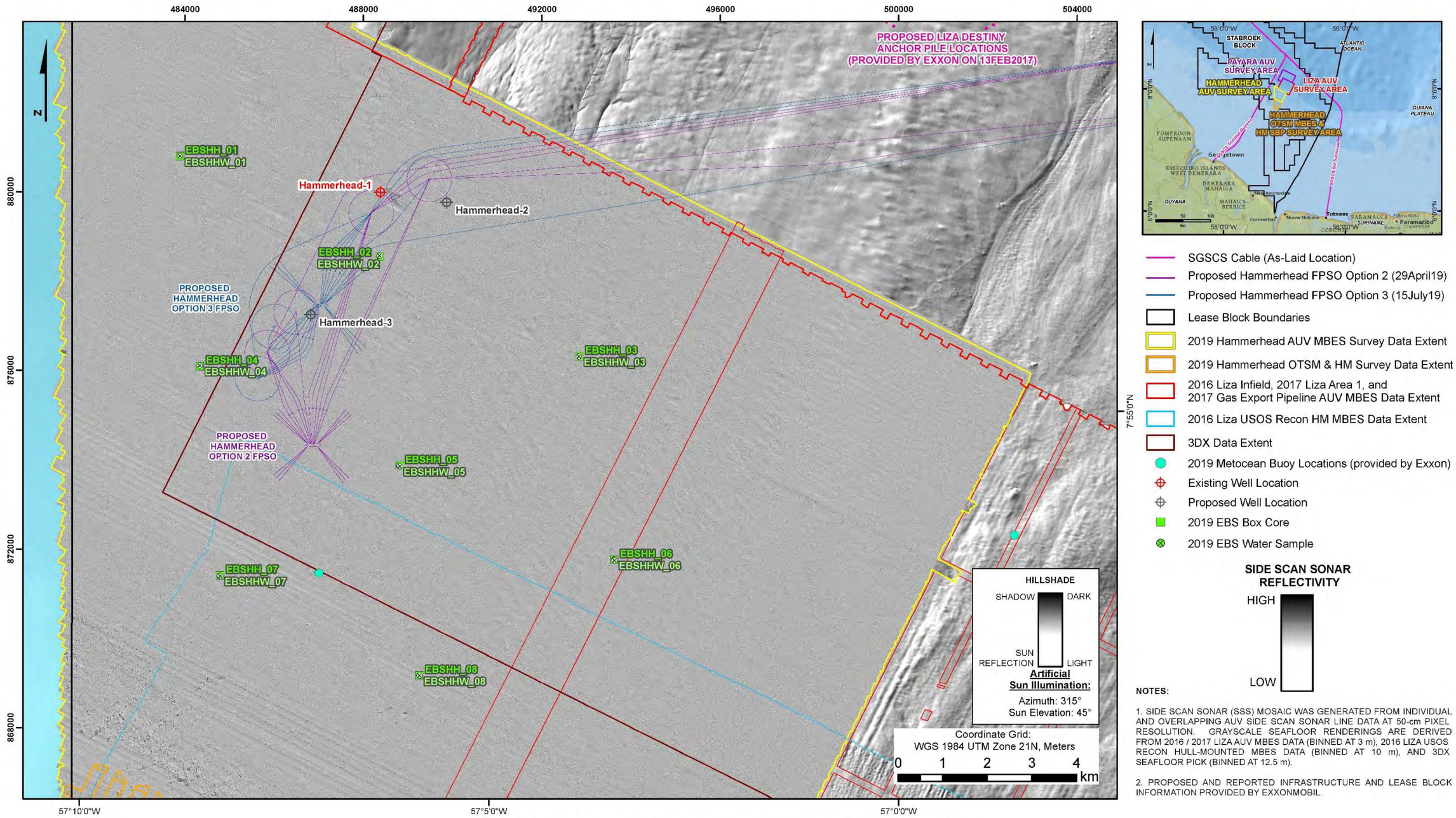
A complete suite of water samples was successfully collected at all eight water stations. Two water profiles were collected at all stations except stations EBSHHW_04, EBSHHW_07 and EBSHHW_08. At station EBSHHW_04 the Valeport CTD failed during the first deployment. At station EBSHHW_07 one profile was accepted by the onboard client representative. At station EBSHHW_08 the Valeport CTD failed during the second deployment. Table 3.3 provides details of sample and water profile data acquisition. Figure 3.1 spatially displays the locations of all completed water sampling locations overlaid on a SSS mosaic (along side previously mentioned environmental sampling stations). Water profiles are displayed in Appendix F.

Table 3.3: Completed Environmental Water Sampling Stations, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N						
Station	**Easting [m]**	**Northing [m]**	**Sample Depth [m BSL]**			**Sample/Data Acquisition**
			Surface	**Mid**	**Bottom**	
EBSHHW_01	483 889.8	880 797.8	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_01	483 890.6	880 799.7	5	-	-	BIOC1, BIOC2
EBSHHW_01	483 895.6	880 798.9	-	202	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_01	483 895.9	880 799.0	-	202	-	BIOC1, BIOC2
EBSHHW_01	483 877.2	880 811.0	-	-	1027	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW_01	483 888.0	880 797.3	-	-	1030	BIOC1, BIOC2, WP
EBSHHW_02	488 356.8	878 557.8	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_02	488 356.4	878 560.4	5	-	-	BIOC1, BIOC2
EBSHHW_02	488 359.3	878 562.1	-	205	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_02	488 358.7	878 561.2	-	198	-	BIOC1, BIOC2
EBSHHW_02	488 357.6	878 569.3	-	-	1090	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW_02	488 359.9	878 565.3	-	-	1090	BIOC1, BIOC2, WP
EBSHHW_03	492 832.5	876 320.2	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_03	492 831.7	876 321.6	5	-	-	BIOC1, BIOC2
EBSHHW_03	492 833.5	876 319.9	-	200	-	BIOA1, BIOA2, BIOB1, BIOB2, WS

Geodetic Parameters: WGS84 UTM Zone 21 N						
Station	Easting [m]	Northing [m]	Sample Depth [m BSL]			Sample/Data Acquisition
			Surface	Mid	Bottom	
EBSHHW_03	492 834.1	876 319.4	-	203	-	BIOC1, BIOC2
EBSHHW_03	492 838.1	876 298.4	-	-	1100	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW_03	492 829.9	876 310.3	-	-	1101	BIOC1, BIOC2, WP
EBSHHW_04	484 336.4	876 108.0	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_04	484 335.0	876 107.3	5	-	-	BIOC1, BIOC2
EBSHHW_04	484 334.2	876 106.9	-	237	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_04	484 340.9	876 104.6	-	239	-	BIOC1, BIOC2
EBSHHW_04	484 336.8	876 100.8	-	-	880	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_04	484 332.0	876 108.9	-	-	895	BIOC1, BIOC2, WP
EBSHHW_05	488 797.4	873 860.8	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_05	488 797.5	873 862.0	5	-	-	BIOC1, BIOC2
EBSHHW_05	488 799.8	873 869.1	-	204	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_05	488 802.4	873 862.1	-	203	-	BIOC1, BIOC2
EBSHHW_05	488 820.3	873 846.7	-	-	918	WP
EBSHHW_05	488 814.9	873 854.3	-	-	916	WP
EBSHHW_05	488 806.8	873 865.4	-	-	918	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_05	488 815.9	873 852.7	-	-	918	BIOC1, BIOC2
EBSHHW_06	493 623.3	871 765.8	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_06	493 623.6	871 767.1	5	-	-	BIOC1, BIOC2
EBSHHW_06	493 626.6	871 769.1	-	199	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_06	493 626.7	871 762.8	-	201	-	BIOC1, BIOC2
EBSHHW_06	493 645.0	871 752.0	-	-	931	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW_06	493 629.8	871 745.7	-	-	933	BIOA1, BIOA2, BIOB1, BIOB2, WP
EBSHHW_07	484 779.9	871 406.7	5	-	-	BIOC1, BIOC2
EBSHHW_07	484 779.1	871 394.9	5	-	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_07	484 780.5	871 401.0	-	198	-	BIOC1, BIOC2
EBSHHW_07	484 778.1	871 401.9	-	200	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_07	484 797.9	871 391.3	-	-	662	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW_07	484 794.3	871 392.2	-	-	663	BIOC1, BIOC2
EBSHHW_08	489 251.3	869 172.1	5	-	-	BIOA1, BIOA2, WS
EBSHHW_08	489 252.2	869 171.6	5	-	-	BIOB1, BIOB2
EBSHHW_08	489 252.1	869 170.3	5	-	-	BIOC1, BIOC2
EBSHHW_08	489 255.1	869 174.8	-	203	-	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW_08	489 261.6	869 164.2	-	201	-	BIOC1, BIOC2
EBSHHW_08	489 264.4	869 157.1	-	-	711	BIOA1, BIOA2, WS, WP
EBSHHW_08	489 257.7	869 163.3	-	-	716	BIOB1, BIOB2
EBSHHW_08	489 262.3	869 162.4	-	-	717	BIOC1, BIOC2

Notes:
BSL = Below sea level
WS = Physico-chemical water sample
WP = Water profile
BIO = Biodiversity DNA sample



SIDE SCAN SONAR MOSAIC WITH ACTUAL EBS SAMPLING LOCATIONS

Figure 3.1: Completed environmental survey locations over side scan sonar (SSS), Hammerhead development

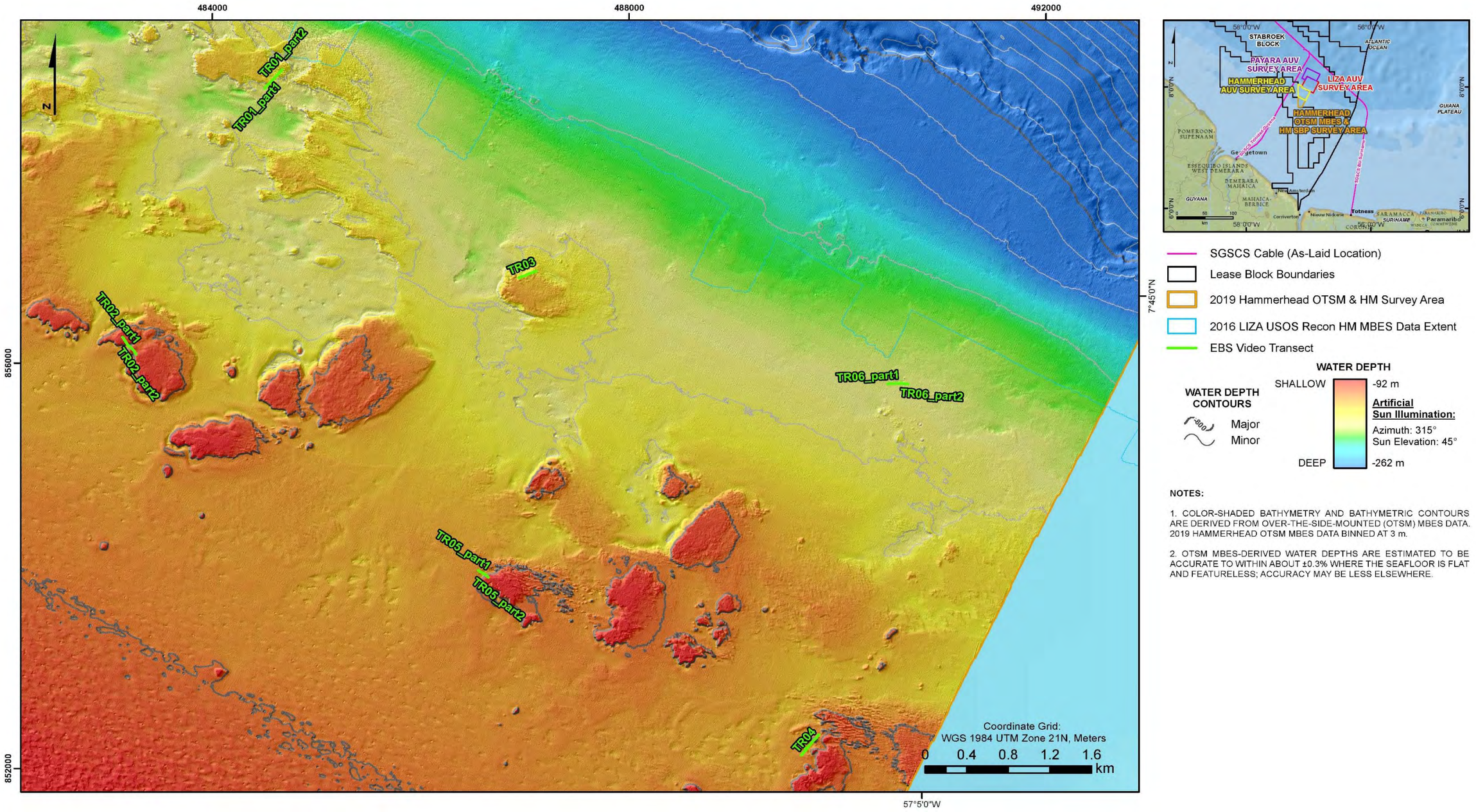


Figure 3.2: Completed environmental camera transects overlaid on bathymetry, Hammerhead development

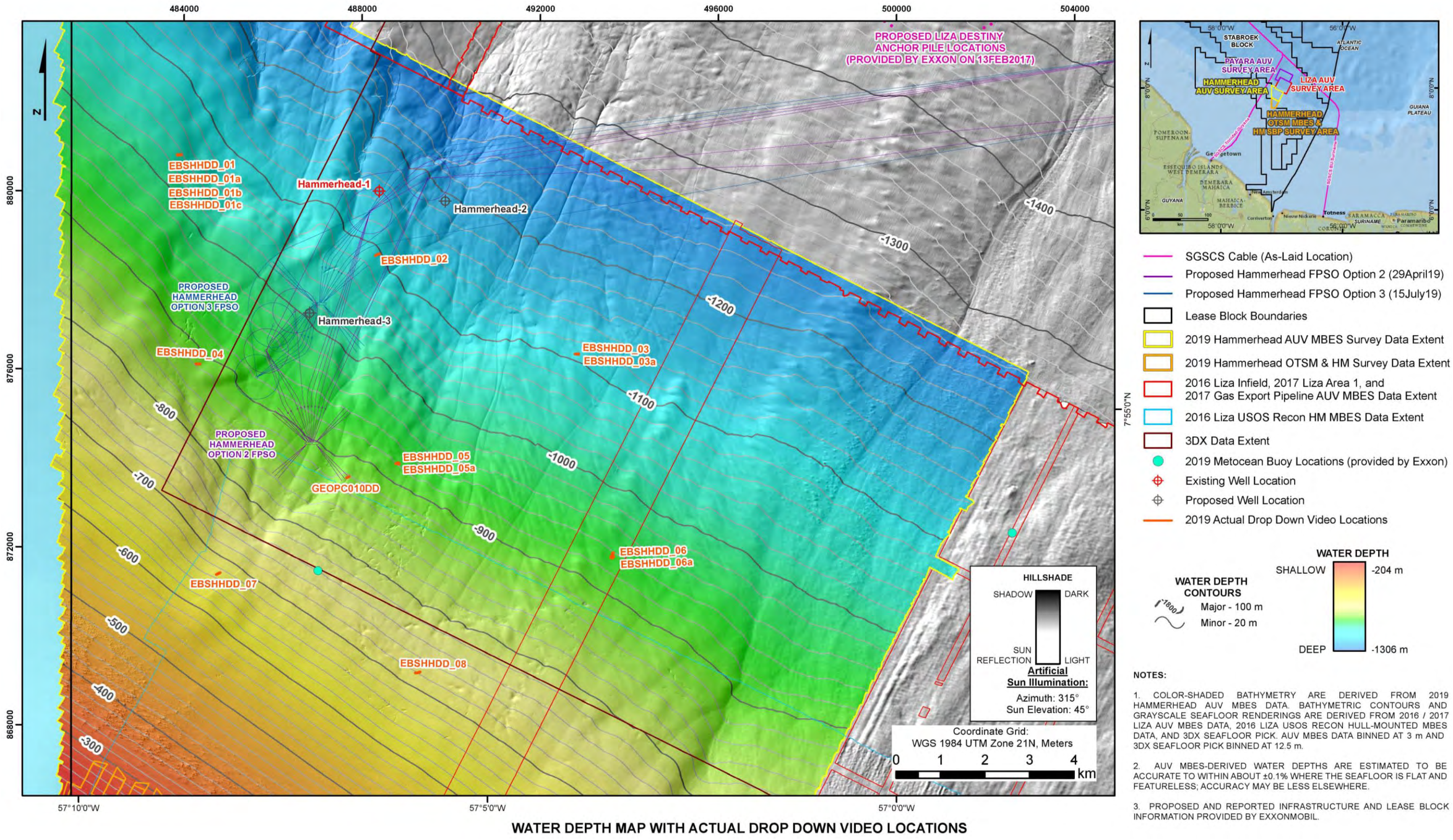


Figure 3.3: Completed environmental drop down camera transects overlaid on bathymetry, Hammerhead development

4. SEDIMENT CHARACTERISATION

4.1 Introduction

Sediment samples were analysed for their particle size distribution (PSD) using a combination of two techniques; sieve analysis for all material retained by a 1 mm sieve followed by laser diffraction analysis of the finer material. The results of the particle size analysis (PSA) were treated statistically to characterise the sediment type (Wentworth scale) and particle size homogeneity (sorting).

The proportion of TOC was determined by combustion and non-dispersive infrared detection following inorganic carbon removal.

Relative standard deviation (RSD) indicates the extent of variability in a dataset in relation to the mean value. The RSD value expresses the standard deviation as a percentage of the mean. For the purpose of this report, RSD of less than 30 % will be considered low variability, 30 % to 70 % will be considered moderate variability and more than 70 % will be considered high variability.

Appendix B provides full details of the analytical techniques employed and Appendix D displays the histograms of particle size class summary for each station.

4.2 Results

Table 4.1 summarises the particle size distribution. Median particle size (µm) ranged from 6 µm at two stations to 14 µm at station EBSHH_07, with a mean of 8 µm and moderate interstation variability (RSD 34 %). Mean particle size (µm) ranged from 7 µm at station EBSHH_04 to 19 µm at station EBSHH_07, with a mean of 10 µm and moderate interstation variability (RSD 38 %). Mean particle size (phi) ranged from 5.75 phi at station EBSHH_07 to 7.08 phi at station EBSHH_04, with a mean of 6.61 phi. Mean particle size within the Hammerhead survey area was smaller than that recorded in the Payara development in 2018 (mean 363 µm and 1.87 phi; Fugro, 2019a).

The Wentworth (1922) description classifies sediment by grain size. The Wentworth description, assigned from mean particle size, ranged from very fine silt at two stations, fine silt at five stations to medium silt at station EBSHH_07.

Whilst marine sediments may feature a unimodal symmetrical particle size distribution, they may also feature non-symmetrical or multimodal distributions. For unimodal symmetrical distributions, all central values are equivalent (e.g. mean is equal to median). However, where sediment distributions deviate from this, differences in central values may occur. Sediments across the current survey were broadly unimodal. However, station EBSHH_01 featured a trimodal distribution, whilst stations EBSHH_07 and EBSHH_08 featured a bimodal distribution. Median particle sizes (µm) were broadly similar to mean particles sizes (µm). However, median particle sizes were consistently slightly lower than mean particle sizes across the survey area, with the highest discrepancy reported at station EBSHH_07.

Standard deviation (SD) of particle size indicates the degree of spread of individual size classes about the mean and provides the basis of a sorting index, in which low values indicate sediments to be fairly homogeneous (good sorting) while high values suggest a relatively large scatter of particle sizes about the mean (poor sorting). Standard deviation values ranged from 2.02 at station EBSHH_04 to 2.78 at

station EBSHH_07, with a mean of 2.28. Consequently, all sediments within the survey area were categorised as very poorly sorted.

Skewness indicates the tendency of particle size classes to be skewed about the mean, either towards coarser sediment (negative skewness) or finer sediment (positive skewness). Skewness values ranged from -0.83 at station EBSHH_03 to -0.18 at station EBSHH_07, with a mean value of -0.58. Consequently, all sediments within the survey area were coarse skewed. Mean particle size within the Hammerhead survey area was more coarse skewed than that recorded in the Payara development in 2018 (mean 0.19 phi; Fugro, 2019a).

Table 4.2 summarises the sediment characteristics, including granulometry and organic content (as TOC), across the Hammerhead development survey area. Figure 4.1 presents the physical composition of the sediments at each station, whilst Figure 4.2 presents the fractional composition of the sediments spatially across the survey area.

The sediment composition was broadly similar across the survey area (Table 4.2 and Figure 4.1). Sediments were largely comprised of the fines fraction, which ranged from 67.84 % at station EBSHH_07 to 91.97 % at station EBSHH_04, with a mean of 85.00 % and low interstation variability (RSD 9 %). The proportion of the sand fraction ranged from 8.03 % at station EBSHH_04 to 32.07 % at station EBSHH_07, with a mean of 14.97 % and moderate interstation variability (RSD 53 %). No gravel was present in stations EBSHH_04, EBSHH_06 and EBSHH_08, with the proportion of gravel low (≤ 0.09 %) in all other stations (Table 4.2). The sediment within the Hammerhead survey area comprised a higher proportion of the fines fraction than that recorded in historic datasets, in the Payara development (mean 44.5 %; Fugro, 2019a) and the Liza field in 2016 (mean 60.78 %; Fugro, 2016). Conversely, the sediment within the Hammerhead survey area comprised a lower proportion of the gravel fraction than that recorded in historic datasets in the Payara development (mean 0.12 %; Fugro, 2019a) and the Liza field in 2016 (mean 0.11 %; Fugro, 2016).

The Folk descriptions classify sediment by the relative proportion of sediment fractions. The Folk description (BGS modified), assigned from the relative proportion of the gravel, sand and fines fractions, classified all sediment sampled in the survey area as sandy mud, with the exception of stations EBSHH_04 and EBSHH_05, which were classified as mud.

The TOC content ranged from 0.53 % at station EBSHH_03 to 0.74 % at stations EBSHH_01 and EBSHH_08, with a mean of 0.64 % and low interstation variability (RSD 9 %). The mean TOC content reported within the current survey was higher than that recorded in historic datasets in the Payara development (mean 0.31 %; Fugro, 2019a) and the Liza field in 2016 (mean 0.32 %; Fugro, 2016).

Table 4.1: Summary of Particle Size Distribution, Hammerhead Development

Station	Modality	Median [µm]*	Mean [µm]*	Mean [phi]*	Wentworth Description†	SD [phi]*	Sorting Index‡	Skewness [phi]*
EBSHH_01	Trimodal	7	10	6.64	Fine silt	2.47	Very poorly sorted	-0.66
EBSHH_02	Unimodal	7	9	6.84	Fine silt	2.13	Very poorly sorted	-0.68
EBSHH_03	Unimodal	6	8	7.00	Very fine silt	2.26	Very poorly sorted	-0.83
EBSHH_04	Unimodal	6	7	7.08	Very fine silt	2.02	Very poorly sorted	-0.73
EBSHH_05	Unimodal	7	8	6.96	Fine silt	2.06	Very poorly sorted	-0.65
EBSHH_06	Unimodal	7	8	6.90	Fine silt	2.22	Very poorly sorted	-0.71
EBSHH_07	Bimodal	14	19	5.75	Medium silt	2.78	Very poorly sorted	-0.18
EBSHH_08	Bimodal	12	14	6.17	Fine silt	2.27	Very poorly sorted	-0.21
Minimum	-	**6**	**7**	**5.75**	-	**2.02**	-	**-0.83**
Maximum		**14**	**19**	**7.08**		**2.78**		**-0.18**
Mean		**8**	**10**	**6.67**		**2.28**		**-0.58**
Standard Deviation		**3.0**	**3.9**	**0.470**		**0.248**		**0.244**
RSD [%]		**34**	**39**	**-**		**-**		**-**
Payara Development (Fugro, 2019a)#								
Mean	-	**-**	**49.9**	**4.39**	-	**3.11**	-	**0.439**
RSD [%]		**-**	**31**	**-**		**-**		**-**

Notes:
RSD = Relative standard deviation
SD = Standard deviation
* = Geometric/Logarithmic method of moments (Pettijohn et al., 1973; Gradistat statistics)
† = Wentworth description (Wentworth, 1922)
‡ = Sorting based on geometric Folk and Ward (1957) graphical measures (Gradistat statistics)
# = Mean and RSD values estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)

Table 4.2: Summary of Sediment Characteristics, Hammerhead Development

Station	Fractional Composition			Fines		Folk Description (BGS modified)	TOC [%]
	Gravel [%]	Sand [%]	Fines [%]	Silt [%]	Clay [%]		
EBSHH_01	0.08	16.74	83.18	51.41	31.77	Sandy mud	0.74
EBSHH_02	0.02	10.76	89.22	59.37	29.85	Sandy mud	0.58
EBSHH_03	0.05	10.81	89.14	53.84	35.30	Sandy mud	0.53
EBSHH_04	0.00	8.03	91.97	58.50	33.47	Mud	0.63
EBSHH_05	0.03	9.24	90.73	59.30	31.44	Mud	0.66
EBSHH_06	0.00	11.88	88.12	55.32	32.80	Sandy mud	0.69
EBSHH_07	0.09	32.07	67.84	42.95	24.89	Sandy mud	0.55
EBSHH_08	0.00	20.21	79.79	57.22	22.57	Sandy mud	0.74
Minimum	**0.00**	**8.03**	**67.84**	**42.95**	**22.57**		**0.53**
Maximum	**0.09**	**32.07**	**91.97**	**59.37**	**35.30**		**0.74**
Mean	**0.03**	**14.97**	**85.00**	**54.74**	**30.26**	**-**	**0.64**
Standard Deviation	**0.04**	**8.01**	**8.03**	**5.53**	**4.37**		**0.082**
RSD [%]	**107**	**53**	**9**	**10**	**14**		**13**
Payara Development (Fugro, 2019a)*							
Mean	**0.12**	**55.3**	**44.5**	**25.9**	**18.7**	**-**	**0.31**
RSD [%]	**143**	**14**	**17**	**18**	**17**		**9**
Liza Field (Fugro, 2016)†							
Mean	**0.11**	**39.11**	**60.78**	**-**	**-**	**-**	**0.32**
RSD [%]	**418**	**56**	**36**	**-**	**-**		**78**

Notes:

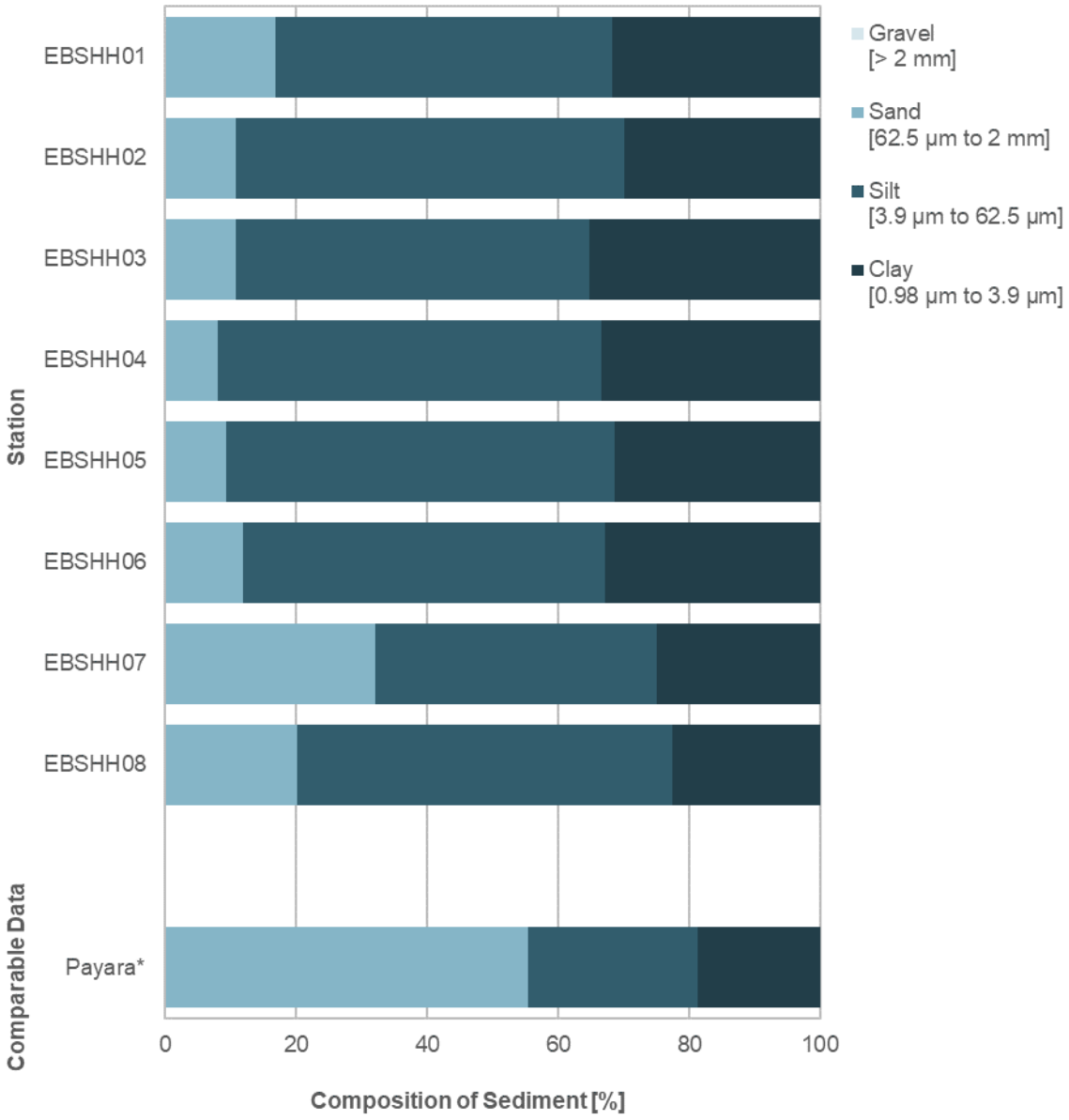
Fines = silt and clay content Silt = +4.0 to +8.0 ø units or 3.9 µm to 62.5 µm Clay = +8.0 to +10.0 ø units or 0.98 µm to 3.9 µm

TOC = Total organic carbon

RSD = Relative standard deviation

* = Mean and RSD values estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)

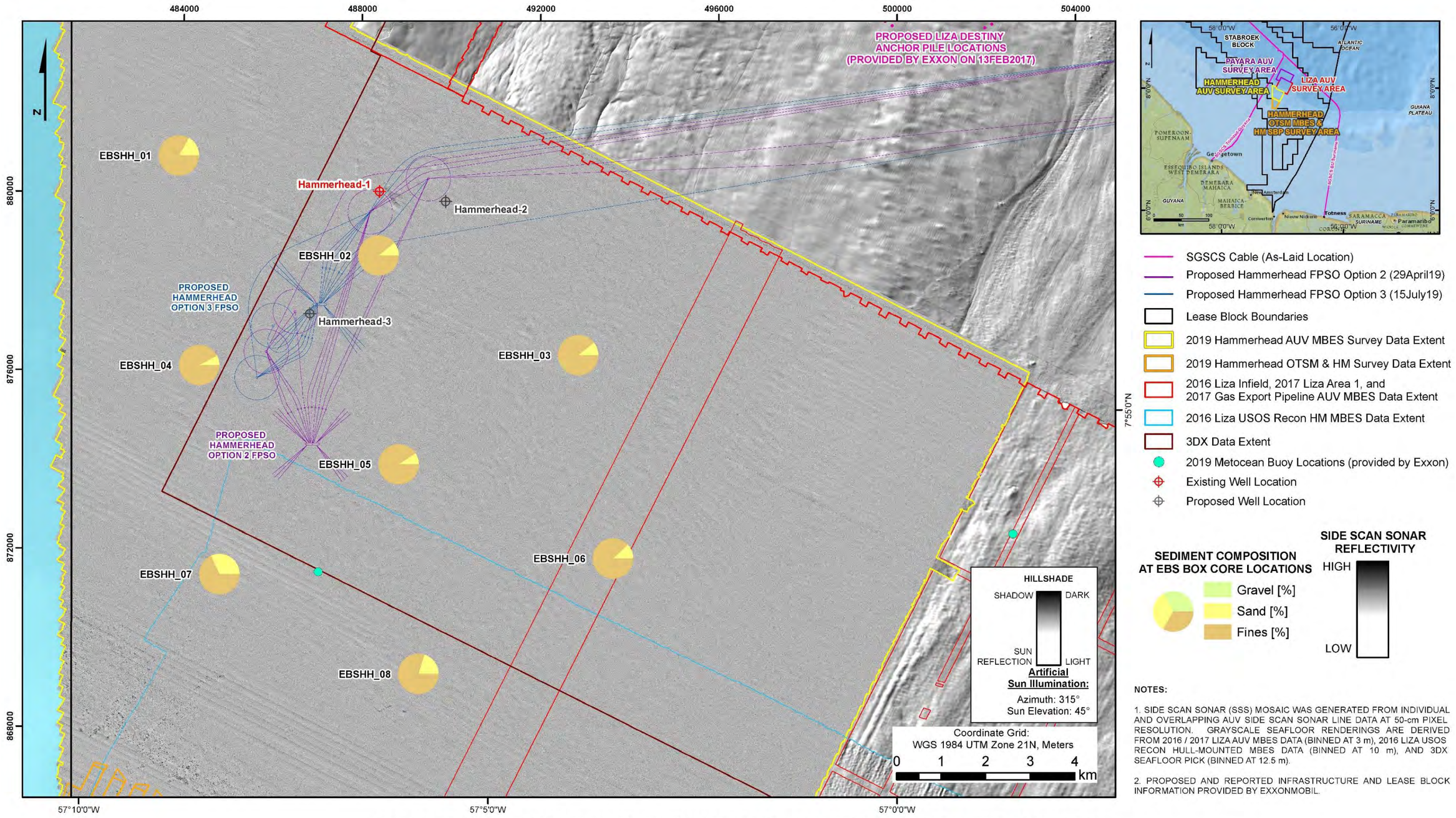
† = Mean and RSD values estimated from an environmental survey in the neighbouring Liza field in 2016 (Fugro, 2016)



Notes:

* = Mean values estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)

Figure 4.1: Sediment composition, Hammerhead development



SIDE SCAN SONAR MOSAIC WITH ACTUAL EBS SAMPLING LOCATIONS SHOWING SEDIMENT COMPOSITION

Figure 4.2: Sediment fractional composition overlaid on a side scan sonar (SSS) mosaic, Hammerhead development

5. SEDIMENT HYDROCARBONS

5.1 Introduction

The sediment samples were analysed for hydrocarbon content including THC, total n-alkanes (nC_{12} to nC_{36}) and PAHs, specifically the United States Environmental Protection Agency's 16 priority PAH pollutants (US EPA 16 PAHs) and alkylated PAHs.

Samples were extracted by ultrasonication of wet sediments with mixed solvents. The sample extracts were then cleaned up using absorption column chromatography. The extracts were analysed for THC, unresolved complex mixture (UCM), individual and total n-alkanes (nC_{12} to nC_{36}) and the subsequent carbon preference index (CPI) using GC-FID. Aromatic hydrocarbons were analysed by GC-MS.

The total hydrocarbon material present was quantified using response factors calculated from the analysis of mixed oil standard solutions over an appropriate range. The UCM was determined by subtracting the area of all the resolved peaks from the total hydrocarbon area and applying the total hydrocarbon response factor. The concentration of individual n-alkanes present in the sediments was determined by measuring the response of each component (nC_{12} to nC_{36}) by GC-FID. Standard solutions containing an appropriate range and concentration of n alkanes were run to calibrate the instrument and to acquire response factors for quantification purposes. Individual n-alkanes were quantified using a series of internal standards. A total n-alkane (nC_{12} to nC_{36}) value for each sediment sample was calculated by summing the concentrations of individual n-alkanes.

The distributions and concentrations of 2 to 6 ring PAHs within the samples were determined by GC-MS. Standard solutions containing an appropriate range and concentration of aromatic hydrocarbons were run to calibrate the instrument and acquire response factors for quantification purposes. Individual aromatic compounds were quantified using a series of deuterated internal standards. The total 2 to 6 ring PAH values for each sediment sample was calculated by summing the concentrations of individual aromatic compounds.

Appendix B provides full details of the analytical techniques employed.

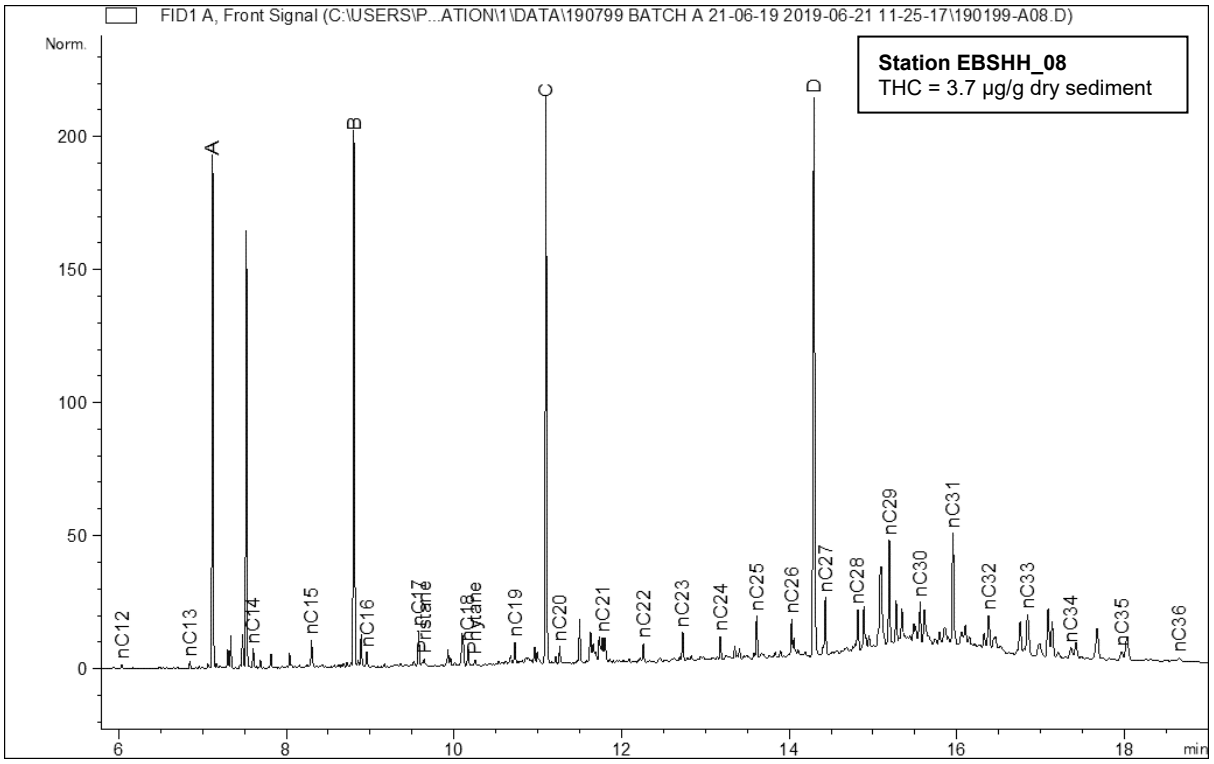
5.2 Results

5.2.1 Gas Chromatography–Flame Ionisation Detection (GC-FID) Hydrocarbon Profiles

A visual comparison of the GC-FID profiles can provide information on the potential origins of the hydrocarbons present in marine sediments samples. The GC-FID profiles illustrating the hydrocarbon components detected in each of the sediment samples are provided in Appendix E1 to support more detailed discussions (Section 10.3) relating to the hydrocarbon components identified by GC-FID analysis of the sediments. Figure 5.1 displays an example gas chromatogram, representative of the grab samples across the Hammerhead development survey area.

The GC-FID profiles obtained for all the sediment samples were broadly similar. The example chromatogram in Figure 5.1 is characterised by a small 'hump' of unresolved material peaking late in the chromatogram window and a homologous series of trace level resolved n-alkanes. The slight prevalence of the heavier odd number n-alkanes (nC_{27}, nC_{29}, nC_{31}), indicates trace inputs of biogenic material from terrestrial run-off. The peak present prior to nC_{14}, pronounced at stations EBSHH_01,

EBSHH_02, EBSHH_04, EBSHH_05 and EBSHH_08 is potentially a biogenic signature from the survey area. The GC-FID profiles for the Hammerhead sediments are all characteristic of background sediments.



Notes:
THC = Total hydrocarbon content
A, B, C and D peaks refer to the internal standards added for quantification

Figure 5.1: Gas chromatographic profile for typical surface sediment (station EBSHH_08), Hammerhead development

5.2.2 Total Hydrocarbon and n-Alkanes (nC_{12} to nC_{36}) Content

Table 5.1 presents the concentrations of total hydrocarbons, UCM, total n-alkanes and CPI ratios (nC_{12} to nC_{36}) and pristane/phytane ratios reported from the surface sediment across the Hammerhead development survey area. Appendix E.2 presents individual n-alkane concentrations for the sediments analysed across the Hammerhead development survey area. Table 5.1 also includes hydrocarbon data reported from neighbouring locations (e.g. the Liza field in 2016 (Fugro, 2016) and the Payara development in 2018 (Fugro, 2019a)). Note that the data from the Liza field is not directly comparable as it is over the nC_{10} to nC_{40} range and so is included for information only.

Total hydrocarbon content (THC) reported for the survey area ranged from 2.0 µg/g at station EBSHH_07 to 3.7 µg/g at station EBSHH_08, with low interstation variation (RSD 22%) and a mean of 2.61 µg/g. The mean THC concentrations observed at the Payara development (0.7 µg/g; Fugro, 2019a) were lower than that observed at the Hammerhead development.

Unresolved complex mixture (UCM) reported for the survey area ranged from 1.0 µg/g at stations EBSHH_01 and EBSHH_07 to 1.9 µg/g at station EBSHH_08, with a mean concentration

of 1.28 µg/g. Variation across all stations was low (RSD 25 %). The mean UCM (1.28 µg/g) was higher at the Hammerhead development in comparison to the mean UCM concentrations recorded in the historic survey at the Payara development (0.4 µg/g; Fugro, 2019a).

The total n-alkane (nC_{12} to nC_{36}) concentration ranged from 0.15 µg/g at station EBSHH_07 to 0.32 µg/g at station EBSHH_07, with a mean concentration of 0.25 µg/g. Variation across all stations was low (RSD 20 %). Mean concentrations recorded at the Payara development (0.08 µg/g; Fugro, 2019a) were lower than those at the Hammerhead development.

The CPI ratio for the nC_{12} to nC_{36} n-alkanes ranged from 1.81 at station EBSHH_08 to 2.13 at station EBSHH_07 with a mean value of 1.95 and low interstation variability (RSD 5 %). The mean CPI value recorded at the Payara development (2.22; Fugro, 2019a) was broadly comparable to those observed at the Hammerhead development.

The pristane/phytane (Pr/Ph) ratios ranged from 0.92 at station EBSHH_02 to 1.58 at station EBSHH_03, with a mean value of 1.25 and low variation (RSD 18 %). The mean Pr/Ph ratio recorded at the Payara development (2.42; Fugro, 2019a) was higher than that observed at the Hammerhead development.

Table 5.1: Summary of Sediment Hydrocarbon Analysis, Hammerhead Development

Station	THC*	UCM*	n-Alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
EBSHH_01	2.2	1.0	0.07	0.14	0.21	0.97	2.55	1.83	0.0016	0.0012	1.35
EBSHH_02	2.3	1.2	0.06	0.20	0.26	1.16	2.34	1.96	0.0014	0.0015	0.92
EBSHH_03	2.3	1.1	0.07	0.17	0.24	1.47	2.37	2.05	0.0019	0.0012	1.58
EBSHH_04	2.5	1.1	0.07	0.19	0.26	1.08	2.45	1.92	0.0015	0.0013	1.15
EBSHH_05	3.1	1.3	0.08	0.20	0.28	1.07	2.63	1.99	0.0017	0.0017	1.01
EBSHH_06	2.8	1.6	0.07	0.20	0.27	1.33	2.22	1.94	0.0018	0.0012	1.49
EBSHH_07	2.0	1.0	0.03	0.11	0.15	1.29	2.53	2.13	0.0017	0.0014	1.21
EBSHH_08	3.7	1.9	0.07	0.25	0.32	1.17	2.04	1.81	0.0028	0.0021	1.30
Minimum	**2.0**	**1.0**	**0.03**	**0.11**	**0.15**	**0.97**	**2.04**	**1.81**	**0.0014**	**0.0012**	**0.92**
Maximum	**3.7**	**1.9**	**0.08**	**0.25**	**0.32**	**1.47**	**2.63**	**2.13**	**0.0028**	**0.0021**	**1.58**
Mean	**2.6**	**1.3**	**0.07**	**0.18**	**0.25**	**1.19**	**2.39**	**1.95**	**0.0018**	**0.0014**	**1.25**
Standard Deviation	**0.56**	**0.32**	**0.015**	**0.043**	**0.051**	**0.162**	**0.193**	**0.106**	**0.00043**	**0.00032**	**0.226**
RSD [%]	**22**	**25**	**23**	**23**	**20**	**14**	**8**	**5**	**24**	**22**	**18**
Payara Development (Fugro, 2019a)†											
Mean	**0.7**	**0.4**	**0.02**	**0.06**	**0.08**	**1.13**	**2.71**	**2.22**	**0.0007**	**0.0003**	**2.42**
RSD [%]	**11**	**9**	**19**	**17**	**16**	**5**	**6**	**5**	**16**	**18**	**17**
Liza Field (Fugro, 2016)‡											
Mean	**2.8**	**1.8**	**0.06**	**0.21**	**0.27**	**1.29**	**2.62**	**2.22**	**0.002**	**0.003**	**1.28**
RSD [%]	**32**	**33**	**50**	**43**	**41**	**19**	**10**	**9**	**100**	**100**	**39**

Notes:
THC = Total hydrocarbon content
UCM = Unresolved complex mixture
CPI = Carbon preference index
Pr/Ph = Ratio of pristane to phytane
RSD = Relative standard deviation
* = Concentrations expressed as µg/g of dry sediment
† = Mean and relative standard deviation values estimated from a historical environmental survey at the Payara development (Fugro, 2019a). Hydrocarbon range nC_{12}-nC_{36}
‡ = Mean and relative standard deviation values estimated from a historical environmental survey at the Liza field (Fugro, 2016). Hydrocarbon range nC_{12}-nC_{36}

5.2.3 Sediment Aromatic Hydrocarbon Content

The distribution and concentration of aromatic compounds in seabed sediments were analysed by GC-MS. The aromatic compounds quantified were the naphthalenes (2 ring aromatics), 3 to 6 ring PAHs and the dibenzothiophenes (sulphur containing heteroaromatics). Table 5.2 summarises the total concentrations of aromatic hydrocarbons, including the US EPA 16 PAH and naphthalenes, phenanthrenes and dibenzothiophenes (NPD).

Appendix E.3 presents the individual aromatic hydrocarbons and their alkyl homologue concentrations across the Hammerhead development survey area, with the US EPA 16 PAH concentrations presented in Appendix E.3 including reference values where available. The distributions of aromatic hydrocarbons are displayed as three-dimensional plots for ease of interpretation in Appendix E.4.

Total 2 to 6 ring PAH concentrations ranged from 0.034 µg/g at station EBSHH_07 to 0.064 µg/g at station EBSHH_08, with a mean concentration of 0.047 µg/g and low interstation variation (RSD 24 %). The mean total 2 to 6 ring PAH concentration was above the mean observed at the Payara development (0.004 µg/g; Fugro 2019a) while the mean total 2 to 6 ring PAH concentration observed at the Liza field (0.048 µg/g; Fugro 2016) was comparable. The total 2 to 6 ring PAH concentrations at all stations were below the NOAA ERL and ERM values (Buchman, 2008).

Total US EPA 16 PAH concentrations ranged from 2.4 µg/g (station EBSHH_07) to 7.5 µg/g (station EBSHH_08) with a mean of 5.1 µg/g and displayed moderate interstation variation (RSD 33%). The mean concentration exceeded the Payara development mean (0.004 µg/g; Fugro 2019).

The proportion of petrogenically derived NPD to total 2 to 6 ring PAH material ranged from 14 % (station EBSHH_08) to 23 % (station EBSHH_01) with a mean of 19 % and low interstation variability (RSD 17 %).

Figure 5.2 displays the concentrations of total 2 to 6 ring PAHs in relation to THC values across the Hammerhead development survey area. In general, there is a correlation between THC and PAH content, indicating that increased sediment PAH concentrations are typically related to an increase in total hydrocarbons.

Table 5.2: Summary of Sediment Hydrocarbon Analysis, Hammerhead Development

Station	Total 2 to 6 Ring PAH*	Total US EPA 16 PAH†	NPD	
			Total*	[%]
EBSHH_01	0.035	3.9	0.008	23
EBSHH_02	0.036	4.0	0.008	22
EBSHH_03	0.046	4.8	0.009	20
EBSHH_04	0.055	6.6	0.009	16
EBSHH_05	0.057	6.7	0.009	16
EBSHH_06	0.049	5.1	0.009	18
EBSHH_07	0.034	2.4	0.007	21
EBSHH_08	0.064	7.5	0.009	14
Minimum	**0.034**	**2.4**	**0.007**	**14**
Maximum	**0.064**	**7.5**	**0.009**	**23**
Mean	**0.047**	**5.1**	**0.008**	**19**
Standard Deviation	**0.0113**	**1.72**	**0.0008**	**3.2**
RSD [%]	**24**	**33**	**9**	**17**
Payara Development (Fugro, 2019a) ‡				
Mean	**0.004**	**1.2**	**0.001**	**26**
RSD [%]	**33**	**17**	**33**	**6**
Liza Field (Fugro, 2016)#				
Mean	**0.048**	**-**	**0.016**	**33**
RSD [%]	**94**	**-**	**94**	**-**
Marine Sediment Assessment Criteria (Buchman, 2008)^				
ERL	**4.022**	**-**	**-**	**-**
ERM	**44.792**	**-**	**-**	**-**

Notes:
Total 2 to 6 ring PAH = Total 2 to 6 ring polycyclic aromatic hydrocarbons (PAH), including alkyl homologues
Total US EPA 16 PAH = Total United States Environmental Protection Agency's 16 (US EPA PAH) priority polycyclic aromatic hydrocarbons
ERL = Effects range low
ERM = Effects range median
Total NPD = Total naphthalene, phenanthrene/anthracene and dibenzothiophene
NPD [%] = Percentage of total 2 to 6 ring PAH concentration comprised of NPD
* = Concentrations expressed as µg/g of dry sediment
† = Concentrations expressed as ng/g of dry sediment
‡ = Mean and relative standard deviation values estimated from a survey in the neighbouring Payara development (Fugro, 2019a)
# = Mean and relative standard deviation values estimated from a survey in the neighbouring Liza field (Fugro, 2016)
^ = NOAA screening values for marine sediments (Buchman, 2008)

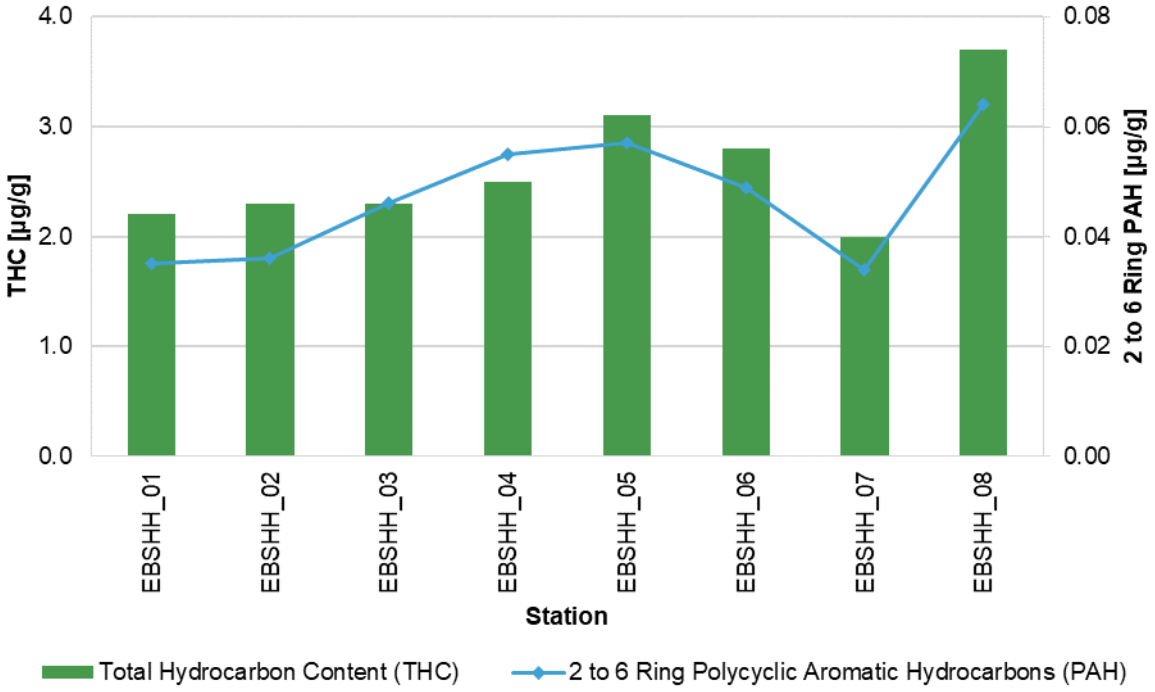


Figure 5.2: Comparison of sediment total hydrocarbon content (THC) and total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations, Hammerhead development

6. SEDIMENT METALS

6.1 Introduction

Sediments collected from the Hammerhead development survey area were analysed for selected elements: aluminium, arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium and zinc using ICP-MS and ICP-OES.

The sediment samples were analysed using an aqua regia digest technique. This provides a strong partial digest, releasing into solution metals associated with the fines fraction within the sediments (but does not extract all trace elements associated with the coarse fraction). As macrofaunal communities can exhibit a preference for finer sediments, the concentrations of metals released by an aqua regia digest are typically considered indicative of those influencing biological interactions.

The sediment samples underwent an aqua regia digest followed by multi-element analysis by inductively coupled plasma-mass spectrometry (ICP-MS) or by inductively coupled plasma-optical emission spectrometry (ICP-OES). These methods were used to analyse aluminium, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, selenium and zinc. Analysis of mercury was by cold vapour-atomic fluorescence spectroscopy (CV-AFS). Appendix B provides full details of the analytical techniques employed.

6.2 Results

Table 6.1 summarises the concentrations of the extractable metals in the sediment samples from an aqua regia digest. Table 6.1 also includes metals concentrations reported in neighbouring locations (e.g. the Liza field in 2016 (Fugro, 2016) and the Payara development in 2018 (Fugro, 2019a)). Sediments sampled in the Liza field were subjected to a hydrofluoric acid digest, a total digest, which releases all metals from the sediment, including those bound within the sediment alumino-silicate matrix and typically not biologically available. Consequently, the dataset from the Liza field is not directly comparable and is included for information only. Metals concentrations reported within the Payara development were from an aqua regia digest and comparisons will be made to this dataset throughout the remainder of this section.

Figure 6.1 summarises the concentrations of the extractable metals in the sediment samples following normalisation by aluminium.

All metals concentrations exhibited low interstation variability across the survey area (RSD ≤ 21 %; Table 6.1).

Arsenic concentrations ranged from 5.8 µg/g at station EBSHH_07 to 11 µg/g at station EBSHH_02, with a mean of 8.9 µg/g (Table 6.1). Arsenic concentrations exceeded the NOAA ERL (8.2 µg/g; Buchman, 2008) at all stations, except stations EBSHH_07 and EBSHH_08. No arsenic concentrations exceeded the NOOA ERM (70.0 µg/g, Buchman, 2008). Mean arsenic concentrations reported within the current survey were less than those reported within the Payara development in 2018 (mean 37.8 µg/g). However, the relatively elevated mean arsenic concentration reported in 2018 was largely due to one high result, with arsenic concentrations reported within the current survey broadly comparable to the majority of arsenic concentrations reported within the Payara development in 2018 (Fugro, 2019a).

Cadmium concentrations ranged from 0.11 µg/g at station EBSHH_08 to 0.17 µg/g at station EBSHH_06, with a mean of 0.14 µg/g. No cadmium concentrations exceeded the NOOA ERL (1.20 µg/g; Buchman, 2008). Cadmium concentrations reported within the Payara development in 2018 were all less than the minimum reporting value (MRV) of < 0.2 µg/g (Fugro, 2019a).

Chromium concentrations ranged from 37 µg/g at station EBSHH_07 to 57 µg/g at station EBSHH_02, with a mean of 50 µg/g. No chromium concentrations exceeded the NOOA ERL (81.0 µg/g; Buchman, 2008). Chromium concentrations reported within the current survey were generally higher than those reported within the Payara development in 2018 (mean 30.3 µg/g; Fugro, 2019a).

Copper concentrations ranged from 11 µg/g at station EBSHH_07 to 20 µg/g at station EBSHH_02, with a mean of 17 µg/g. No copper concentrations exceeded the NOOA ERL (34.0 µg/g; Buchman, 2008). Copper concentrations reported within the current survey were broadly comparable to those reported within the Payara development in 2018 (mean 15.1 µg/g; Fugro, 2019a).

Mercury concentrations ranged from 0.025 µg/g at station EBSHH_07 to 0.043 µg/g at stations EBSHH_02 and EBSHH_04, with a mean of 0.038 µg/g. No mercury concentrations exceeded the NOOA ERL (0.150 µg/g; Buchman, 2008). Mercury concentrations reported within the current survey were generally slightly higher than those reported within the Payara development in 2018 (mean 0.0236 µg/g; Fugro, 2019a).

Nickel concentrations ranged from 20 µg/g at station EBSHH_07 to 39 µg/g at station EBSHH_03, with a mean of 33 µg/g. Nickel concentrations exceeded the NOAA ERL (20.9 µg/g; Buchman, 2008) at all stations, except station EBSHH_07. No nickel concentrations exceeded the NOOA ERM (51.6 µg/g; Buchman, 2008). Nickel concentrations reported within the current survey were generally higher than those reported within the Payara development in 2018 (mean 20.0 µg/g; Fugro, 2019a).

Lead concentrations ranged from 14 µg/g at station EBSHH_07 to 22 µg/g at station EBSHH_02, with a mean of 19 µg/g. No lead concentrations exceeded the NOOA ERL (46.7 µg/g; Buchman, 2008). Lead concentrations reported within the current survey were generally higher than those reported within the Payara development in 2018 (mean 12.3 µg/g; Fugro, 2019a).

Zinc concentrations ranged from 61 µg/g at station EBSHH_07 to 97 µg/g at station EBSHH_02, with a mean of 85 µg/g. No zinc concentrations exceeded the NOOA ERL (150 µg/g; Buchman, 2008). Mean zinc concentrations reported within the current survey were generally higher than those reported within the Payara development in 2018 (mean 60.5 µg/g; Fugro, 2019a).

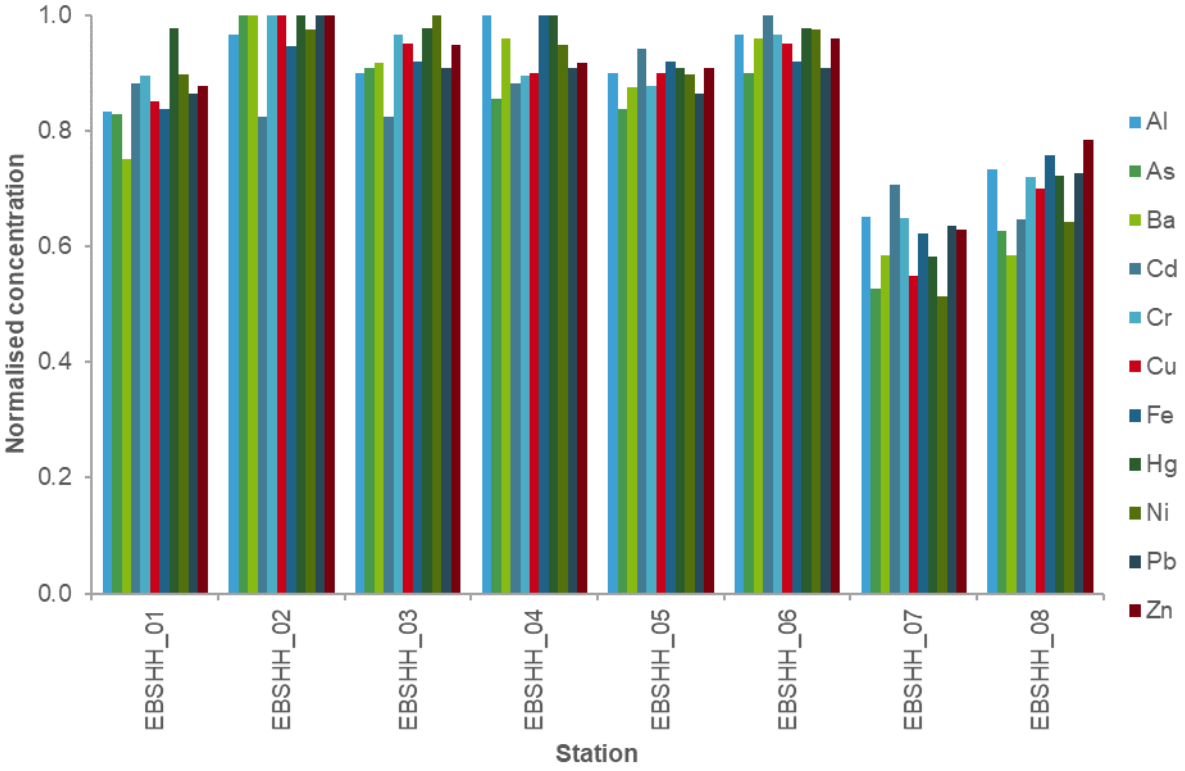
The overall trend in individual metals concentrations is presented in Figure 6.1 and is assessed by comparing the maximum normalised elemental concentrations. Normalising the elemental data for the sediment samples to the highest concentration for each element highlights that station EBSHH_02 generally features the highest metals concentrations across the survey area, whilst station EBSHH_07 generally features the lowest metals concentrations.

Table 6.1: Summary of Sediment Metals Analysis, Hammerhead Development

Station	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Se	Zn
EBSHH_01	50000	9.1	180	0.15	51	17	**31000**	0.042	35	19	< 1	85
EBSHH_02	58000	11	240	0.14	57	20	**35000**	0.043	38	22	< 1	97
EBSHH_03	54000	10	220	0.14	55	19	**34000**	0.042	39	20	< 1	92
EBSHH_04	60000	9.4	230	0.15	51	18	**37000**	0.043	37	20	< 1	89
EBSHH_05	54000	9.2	210	0.16	50	18	**34000**	0.039	35	19	< 1	88
EBSHH_06	58000	9.9	230	0.17	55	19	**34000**	0.042	38	20	< 1	93
EBSHH_07	39000	5.8	140	0.12	37	11	**23000**	0.025	20	14	< 1	61
EBSHH_08	44000	6.9	140	0.11	41	14	**28000**	0.031	25	16	< 1	76
Minimum	**39000**	**5.8**	**140**	**0.11**	**37**	**11**	**23000**	**0.025**	**20**	**14**	**< 1**	**61**
Maximum	**60000**	**11**	**240**	**0.17**	**57**	**20**	**37000**	**0.043**	**39**	**22**	**< 1**	**97**
Mean	**52100**	**8.9**	**199**	**0.14**	**50**	**17**	**32000**	**0.038**	**33**	**19**	**-**	**85**
SD	**7380**	**1.7**	**40.5**	**0.020**	**7.1**	**3.0**	**4540**	**0.0067**	**7.0**	**2.5**	**-**	**11.6**
RSD [%]	**14**	**19**	**20**	**14**	**14**	**18**	**14**	**18**	**21**	**14**	**-**	**14**
Payara Development (Fugro, 2019a)*												
Mean	**36400**	**37.8**	**165**	**-**	**30.3**	**15.1**	**33 700**	**0.0236**	**20.0**	**12.3**	**-**	**60.5**
RSD [%]	**15**	**227**	**23**	**-**	**17**	**12**	**106**	**10**	**16**	**12**	**-**	**37**
Liza Field (Fugro, 2016)†												
Mean	**43432**	**11.59**	**175**	**0.120**	**36.1**	**20.2**	**30 472**	**0.0285**	**27.0**	**15.5**	**0.230**	**69.7**
RSD [%]	**30**	**154**	**35**	**28**	**28**	**27**	**53**	**25**	**31**	**26**	**60**	**26**
Marine Sediment Assessment Criteria (Buchman, 2008)‡												
ERL	**-**	**8.20**	**-**	**1.20**	**81.0**	**34.0**	**-**	**0.150**	**20.9**	**46.7**	**-**	**150**
ERM	**-**	**70.0**	**-**	**9.60**	**370**	**270**	**-**	**0.710**	**51.6**	**218**	**-**	**410**

Notes:
Concentrations expressed in µg/g dry sediment
Al = Aluminium As = Arsenic Ba = Barium Cd = Cadmium Cr = Chromium Cu = Copper Fe = Iron
Hg = Mercury Ni = Nickel Pb = Lead Se = Selenium Zn = Zinc
ERL = Effects range low ERM = Effects range median
SD = Standard deviation RSD = Relative standard deviation
* = Mean and RSD values estimated from an environmental survey in the neighbouring Payara development in 2018. Aqua regia digest (Fugro, 2019a)
† = Mean and RSD values estimated from an environmental survey in the neighbouring Liza field in 2016. Hydrofluoric acid digest (Fugro, 2016)
‡ = NOAA screening values for marine sediments (Buchman, 2008)

Key:	Below NOAA ERL	Above NOAA ERL	Above NOAA ERM



Notes:

Al = Aluminium	As = Arsenic	Ba = Barium	Cd = Cadmium	Cr = Chromium	Cu = Copper
Fe = Iron	Hg = Mercury	Ni = Nickel	Pb = Lead	Zn = Zinc	

Figure 6.1: Relative (maximum normalised) elemental concentrations in sediments, Hammerhead development

7. WATER SAMPLES

7.1 Introduction

Water column profiles were acquired at a total of eight stations in the Hammerhead development area. Profiles were acquired from both deployment and recovery from sea surface to near seabed using a Valeport Midas+ deepwater conductivity temperature depth (CTD) profiler recording depth, salinity, dissolved oxygen (DO), pH, turbidity and temperature. Two profiles were acquired at all stations resulting in two downward and two upward datasets; with the exception of stations EBSHHW_04, EBSHHW_07 and EBSHHW_08, where due to equipment malfunction, one profile was acquired at each station.

Seawater samples were collected at the eight sampling stations for the analysis of key indicators of water quality. Discrete water samples were collected at three depths; the surface (10 m), below the thermocline and 20 m above the seabed. Subsamples were analysed for TSS, TOC, nitrogen compounds, hydrocarbon content and metals content.

Full details of methodologies are found in Appendix B.

7.2 Water Profiles

7.2.1 Results

Figure 7.1 presents an example water column profile (EBSHHW_01) displaying temperature, salinity, conductivity, turbidity, dissolved oxygen saturation and pH. Results from all stations showed a stratified water column, with a defined thermocline, halocline, pH boundary and oxygen boundary, below which these parameters notably dropped. Turbidity returned similar values throughout the water column. The full set of results are presented in Appendix F.

7.2.1.1 Temperature

Temperatures across the survey area ranged from 5.0°C to 27.9°C, with a mean of 10.6°C. The largest intrastation variability was reported at station EBSHHW_01 where temperatures of 5.0°C were recorded near the seabed and 27.8°C near the surface, with a temperature range of 22.8°C. Intrastation variability ranged from 54 % to 66 %. A surface temperature of ca. 28 C was recorded from the surface and decreased to ca. 10°C by ca. 400 m at all stations.

7.2.1.2 Salinity

Salinity ranged from 34.4 practical salinity units (PSU) to 36.9 PSU, with a mean of 35.0 PSU. Intrastation variability ranged from 1 % to 2 %. A distinct halocline was observed to a depth of ca. 200 m, where after salinity remained constant at ca. 35.0 PSU at all stations for the remainder of the water profile.

7.2.1.3 Conductivity

Conductivity ranged from 33.5 mS/cm to 57.6 mS/cm, with a mean value of 39.2 mS/cm. Intrastation variability was similar across the survey area, ranging from 16 % to 20 %. Values were ca. 57 mS/cm at surface level and decreased to ca. 35 mS/cm at approximately 400 m for all stations. A gradual decline from 35 mS/cm at 400 m to ca. 34 mS/cm at the lowest recorded depths in the profile was observed for all stations.

7.2.1.4 Turbidity

Turbidity data have been manually de-spiked to remove anomalously high values, interpreted to be caused by floating matter passing in close proximity to the turbidity sensor. These high values are not considered representative of water column conditions within the survey area and were excluded to prevent skewing of the turbidity statistics presented. Turbidity values ranged from 0.513 formazin turbidity units (FTU) to 2.54 FTU across the survey area, with a mean value of 1.70 FTU. Turbidity values remained relatively constant throughout the water column.

7.2.1.5 Dissolved Oxygen (DO)

Dissolved oxygen (DO) saturation ranged from 33.4 % to 108 %, with a mean of 46.9 %. Intrastation variability ranged from 28 % to 45 %. Dissolved oxygen saturations of ca. 108 % were recorded at the surface, decreasing to ca. 40 % by approximately 300 m at all stations. Concentrations then remained relatively constant to a depth of ca. 800 m, where a slight increase was observed for the remainder of the profile.

7.2.1.6 pH

The pH values were alkaline throughout the Hammerhead survey area and ranged from 7.75 to 8.28, with a mean of 7.33. Intrastation variation was low (RSD ca. 1 %). pH values of ca. 8.3 were recorded at the surface to depths and decreased to ca. 7.8 by 200 m.

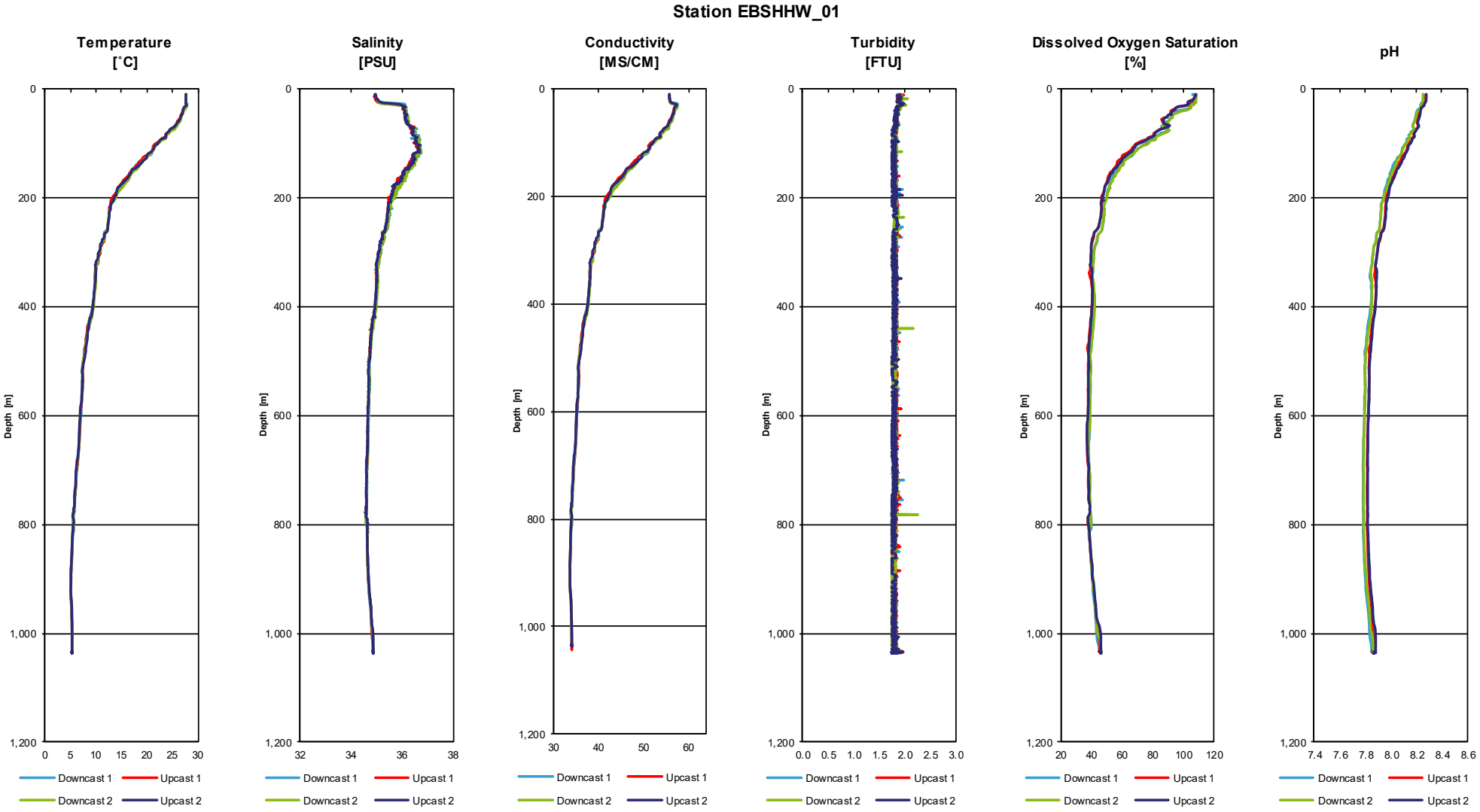


Figure 7.1: Water column profile at sampling station EBSHHW01, Hammerhead development

7.3 Nutrients and Total Suspended Solids (TSS)

7.3.1 Introduction

Water samples from the Hammerhead survey area were analysed by Kaizen LAB for key indicators of water quality including ammoniacal nitrogen, nitrate, nitrite and total Kjeldahl nitrogen (TKN) concentrations and TOC and TSS content, with results displayed in Tables 7.1 and 7.2.

7.3.2 Results

Nitrite and TKN concentrations were below their MRVs (< 0.01 mg/L and < 2.00 mg/L, respectively) at all depths at all stations sampled within the Hammerhead survey area (Table 7.1).

Mean ammoniacal nitrogen concentrations provided little evidence of stratification and were comparable at each sampled depth. In surface seawater samples, ammoniacal nitrogen concentrations ranged from 1.57 mg/L at stations EBSHHW_01 and EBSHHW_04 to 7.62 mg/L at station EBSHHW_05. In mid depth samples, concentrations ranged from 1.34 mg/L at stations EBSHHW_02 and EBSHHW_03 to 4.93 mg/L at station EBSHHW_01. In the bottom depth samples, concentrations ranged from 1.57 mg/L at station EBSHHW_04 to 3.36 mg/L at station EBSHHW_06. Interstation sample variability ranged from low to moderate (RSD 23 % to 61 %). The moderate RSD values observed at surface (61 %) and mid depth (43 %) are largely the result of the relatively high ammoniacal nitrogen concentrations observed at the surface of station EBSHHW_05 (7.62 mg/L) and mid depth of station EBSHHW_01 (4.93 mg/L) (Table 7.1).

Mean nitrate concentrations provided little evidence of stratification and were comparable at each sampled depth. In surface seawater samples, nitrate concentrations ranged from 0.50 mg/L at station EBSHHW_05 to 2.30 mg/L at station EBSHHW_01. In mid depth samples, concentrations ranged from 0.90 mg/L at station EBSHHW_03 to 2.40 mg/L at station EBSHHW_05. In the bottom depth samples, concentrations ranged from 1.90 mg/L at station EBSHHW_01 to 4.20 mg/L at station EBSHHW_03. Interstation sample variability ranged from low to moderate (RSD 26 % to 34 %). Moderate RSD values observed at surface (34 %) and mid depth (30 %) are largely the result of the relatively low nitrate concentrations observed at the surface of station EBSHHW_05 (0.50 mg/L) and mid depth of station EBSHHW_03 (0.9 mg/L) (Table 7.1).

The TSS values across the Hammerhead development water samples showed little evidence of stratification as the mean TSS values for each depth profile were comparable. In surface seawater samples, TSS ranged from 25.6 mg/L at station EBSHHW_05 to 56.4 mg/L at station EBSHHW_03. In mid depth samples, concentrations ranged from 34.4 mg/L at station EBSHHW_02 to 92.4 mg/L at station EBSHHW_07. In the bottom depth samples, TSS concentrations ranged from 42.4 mg/L at station EBSHHW_08 to 108 mg/L at station EBSHHW_06. Interstation sample variability ranged from low to moderate (RSD 21 % to 35 %). Moderate RSD values observed at mid (33 %) and bottom (35 %) are a result of the high TSS values observed at station EBSHHW_07 Mid (92.4 mg/L) and station EBSHHW_06 Bottom (108 mg/L) (Table 7.2). The mean TSS values in the current survey were higher than those from the Payara development (Fugro, 2019a) and the Liza field survey (Fugro, 2016) at comparable depths.

The mean TOC values observed for each depth at the Hammerhead development were comparable suggesting no evidence of stratification. Surface depth values ranged from 1.16 mg/L (EBSHHW_07) to

2.16 mg/L (EBSHHW_03). Mid depth values ranged from 1.02 mg/L (EBSHHW_04) to 1.44 mg/L (EBSHHW_08). Bottom depth values ranged from 0.93 mg/L (EBSHH_08) to 1.33 mg/L (EBSHHW_05) (Table 7.2).

The mean TOC values observed were higher than those observed at the Payara development (Fugro, 2019a) but lower than the mean values recorded at the Liza field survey (Fugro, 2016) at comparable depths.

Table 7.1: Summary of Water Column Nitrogen Compound Concentrations, Hammerhead Development

Station	Ammoniacal Nitrogen [mg/L]			Nitrate [mg/L]			Nitrite [mg/L]			Total Kjeldhal Nitrogen [mg/L]		
	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom
EBSHHW_01	1.57	4.93	2.02	2.30	1.30	1.90	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_02	2.91	1.34	2.46	1.40	2.30	2.20	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_03	2.24	1.34	2.46	1.60	0.90	4.20	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_04	1.57	2.24	1.57	1.50	1.50	3.20	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_05	7.62	2.69	3.14	0.50	2.40	3.30	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_06	3.14	2.91	3.36	1.60	1.70	2.50	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_07	2.69	3.81	2.69	1.20	1.80	2.40	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
EBSHHW_08	3.81	3.58	2.46	1.50	1.40	3.00	< 0.01	< 0.01	< 0.01	< 2.00	< 2.00	< 2.00
Minimum	**1.57**	**1.34**	**1.57**	**0.50**	**0.90**	**1.90**	**< 0.01**	**< 0.01**	**< 0.01**	**< 2.00**	**< 2.00**	**< 2.00**
Maximum	**7.62**	**4.93**	**3.36**	**2.30**	**2.40**	**4.20**	**< 0.01**	**< 0.01**	**< 0.01**	**< 2.00**	**< 2.00**	**< 2.00**
Mean	**3.19**	**2.86**	**2.52**	**1.45**	**1.66**	**2.84**	**-**	**-**	**-**	**-**	**-**	**-**
Standard Deviation	**1.95**	**1.24**	**0.57**	**0.499**	**0.504**	**0.739**	**-**	**-**	**-**	**-**	**-**	**-**
RSD [%]	**61**	**43**	**23**	**34**	**30**	**26**	**-**	**-**	**-**	**-**	**-**	**-**

Notes:
RSD = Relative standard deviation

Table 7.2: Summary of Total Suspended Solids and Total Organic Carbon Content, Hammerhead Development

Station	Total Suspended Solids [mg/L]			Total Organic Carbon [mg/L]		
	Surface	Mid	Bottom	Surface	Mid	Bottom
EBSHHW_01	44.2	57.2	52.4	1.66	1.36	1.00
EBSHHW_02	55.4	34.4	48.0	1.94	1.14	1.15
EBSHHW_03	56.4	49.2	48.2	2.16	1.34	1.20
EBSHHW_04	52.8	53.0	54.6	1.63	1.02	1.12
EBSHHW_05	25.6	53.8	57.6	1.74	1.08	1.33
EBSHHW_06	51.6	37.2	108	1.93	1.23	1.12
EBSHHW_07	51.4	92.4	55.4	1.16	1.38	1.18
EBSHHW_08	53.8	54.4	42.4	1.43	1.44	0.93
Minimum	**25.6**	**34.4**	**42.4**	**1.16**	**1.02**	**0.93**
Maximum	**56.4**	**92.4**	**108**	**2.16**	**1.44**	**1.33**
Mean	**48.9**	**54.0**	**58.4**	**1.71**	**1.25**	**1.13**
Standard Deviation	**10.1**	**17.6**	**20.7**	**0.315**	**0.155**	**0.122**
RSD [%]	**21**	**33**	**35**	**18**	**12**	**11**
Payara Development (Fugro, 2019a)*						
Mean	**33.9**	**31.2**	**32.0**	**-**	**-**	**-**
RSD [%]	**35**	**36**	**25**	**-**	**-**	**-**
Liza Field (Fugro, 2016)†						
Mean	**6.7**	**3.1**	**3.4**	**2.3**	**1.9**	**1.8**
RSD [%]	**63**	**42**	**47**	**35**	**42**	**28**

Notes:
RSD = Relative standard deviation
* = Mean and relative standard deviation values estimated from a historical environmental survey at the Payara development (Fugro, 2019a)
† = Mean and relative standard deviation values estimated from a historical environmental survey at the Liza field (Fugro, 2016)

7.4 Hydrocarbons

7.4.1 Introduction

The water column samples were analysed for hydrocarbon content including THC, total n-alkanes (nC_{12} to nC_{36}) and PAHs, specifically the US EPA 16 PAHs and alkylated PAHs. Total hydrocarbon analysis is displayed in Table 7.3 and PAH content of water samples in Table 7.4.

7.4.2 Results

7.4.2.1 Total Hydrocarbon Content (THC)

The THC concentrations were below the MRV of 10 µg/L at the majority of stations, with the exception of samples EBSHHW_05 (Bottom) (25.3 µg/L) and EBSHHW_07 (Mid and Bottom) (12.2 µg/L and 11.0 µg/L respectively), where concentrations were broadly comparable with the mean of the Liza field survey (16.2 µg/L; Fugro, 2016).

The UCM concentrations were below the MRV of 10 µg/L from all sampled depths at all stations with the exception of sample EBSHHW_05 (Bottom), which had a concentration of 13.8 µg/L. This value was

higher than the mean values observed at the Payara development (3.0 µg/L; Fugro, 2019a) and the Liza field survey (8.9 µg/L; Fugro, 2016).

Total n-alkane concentrations (nC_{12-36}) ranged from 0.19 µg/L in samples EBSHHW_03 (Mid) and EBSHHW_02 (Bottom) to 2.75 µg/L in sample EBSHHW_05 (Bottom). Intrastation variability was high (RSD 112 %), likely due to the high total n-alkane concentration observed in sample EBSHHW_05 (Bottom) (2.75 µg/L). The mean total n-alkane concentration observed at the Hammerhead development (0.46 µg/L) was broadly comparable to the mean observed at the Payara development (0.48 µg/L; Fugro, 2019a). The mean total n-alkane concentration recorded at the Liza field survey (Fugro, 2016) was 2.09 µg/L, considerably higher than the 0.46 µg/L observed at the Hammerhead development.

There was no clear spatial trend in concentrations of THC, UCM or n-alkanes across the survey area and no clear relationship between concentrations of these analytes and depth.

The CPI ratio (nC_{12-36}) displayed low intrastation variation (RSD 11%), with values ranging from 0.78 in sample EBSHHW_08 (Surface) to 1.23 in sample EBSHHW_02 (Surface). The mean CPI ratio (nC_{12-36}) observed at the Hammerhead development (0.97) was lower than that observed at Payara development (1.86; Fugro, 2019a). The mean CPI ratio (nC_{12-36}) observed at the Liza field was 0.94 (Fugro, 2016), comparable to that observed during the current survey.

The pristane to phytane ratio displayed moderate variation (RSD 38%), with values ranging from 0.54 in sample EBSHHW_01 (Bottom) to 4.66 in sample EBSHHW_02 (Surface). The mean pristane to phytane ratio (2.21) observed at the Hammerhead development was comparable to the mean value recorded at the Payara development (2.18; Fugro, 2019a). The mean pristane to phytane ratio recorded at the Liza field (1.33; Fugro, 2016) was lower than that recorded at the Hammerhead development.

7.4.2.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Total 2 to 6 ring PAH concentrations displayed moderate variability (RSD 36 %) between samples, ranging from 0.028 µg/L in sample EBSHHW_08 (Mid) to 0.096 µg/L in sample EBSHHW_05 (Bottom). The mean total 2 to 6 ring PAH concentration for the current survey (0.037 µg/L), was lower than the mean values observed at the Payara development (0.076 µg/L; Fugro, 2019a), and the Liza field survey (0.075 µg/L; Fugro, 2016).

Total US EPA 16 PAH concentrations displayed a moderate variability (RSD 65 %), largely due to the high concentration (15.3 µg/L) recorded in sample EBSHHW_05 (Bottom).

Total NPD displayed moderate variability (RSD 37 %) with values ranging from 0.010 µg/L in sample EBSHHW_02 (Mid) to 0.038 µg/L in sample EBSHHW_05 (Bottom). Percentage NPD displayed low variability (RSD 13 %) with values ranging from 28 % in sample EBSHHW_01 (Mid) to 47 % in sample EBSHHW_05 (Mid).

Table 7.3: Summary of Water Column Hydrocarbon Analysis, Hammerhead Development

Station	THC*	UCM*	n-alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
EBSHHW_01 (Surface)	< 10.0	< 10.0	0.09	0.25	0.34	0.59	1.00	0.87	0.0091	0.0029	3.10
EBSHHW_01 (Mid)	< 10.0	< 10.0	0.08	0.15	0.23	0.58	1.07	0.87	0.0067	0.0027	2.51
EBSHHW_01 (Bottom)	< 10.0	< 10.0	0.11	0.19	0.30	0.73	1.21	1.00	0.0056	0.0104	0.54
EBSHHW_02 (Surface)	< 10.0	< 10.0	0.08	0.17	0.25	0.93	1.40	1.23	0.0071	0.0015	4.66
EBSHHW_02 (Mid)	< 10.0	< 10.0	0.09	0.16	0.26	0.56	1.33	0.97	0.0125	0.0039	3.21
EBSHHW_02 (Bottom)	< 10.0	< 10.0	0.08	0.11	0.19	0.64	1.13	0.88	0.0040	0.0023	1.73
EBSHHW_03 (Surface)	< 10.0	< 10.0	0.09	0.38	0.47	0.81	1.17	1.09	0.0075	0.0025	3.01
EBSHHW_03 (Mid)	< 10.0	< 10.0	0.08	0.11	0.19	0.64	1.23	0.93	0.0077	0.0044	1.77
EBSHHW_03 (Bottom)	< 10.0	< 10.0	0.10	0.17	0.27	0.66	1.14	0.93	0.0071	0.0040	1.78
EBSHHW_04 (Surface)	< 10.0	< 10.0	0.08	0.34	0.42	0.92	0.98	0.97	0.0085	0.0041	2.06
EBSHHW_04 (Mid)	< 10.0	< 10.0	0.08	0.31	0.39	0.57	1.00	0.89	0.0086	0.0032	2.69
EBSHHW_04 (Bottom)	< 10.0	< 10.0	0.11	0.20	0.30	0.76	1.51	1.19	0.0066	0.0030	2.18
EBSHHW_05 (Surface)	< 10.0	< 10.0	0.08	0.17	0.25	0.76	1.14	1.00	0.0084	0.0036	2.30
EBSHHW_05 (Mid)	< 10.0	< 10.0	0.10	0.40	0.49	0.59	1.19	1.04	0.0090	0.0036	2.46
EBSHHW_05 (Bottom)	25.3	13.8	0.32	2.43	2.75	0.80	1.03	1.00	0.0700	0.0234	2.99
EBSHHW_06 (Surface)	< 10.0	< 10.0	0.08	0.16	0.25	0.84	1.09	1.00	0.0075	0.0043	1.73
EBSHHW_06 (Mid)	< 10.0	< 10.0	0.11	0.14	0.25	0.69	1.21	0.94	0.0076	0.0037	2.05
EBSHHW_06 (Bottom)	< 10.0	< 10.0	0.13	0.17	0.30	0.63	1.03	0.84	0.0115	0.0047	2.44
EBSHHW_07 (Surface)	< 10.0	< 10.0	0.11	0.31	0.42	0.77	1.02	0.95	0.0095	0.0050	1.89
EBSHHW_07 (Mid)	12.2	< 10.0	0.12	0.66	0.78	0.70	1.04	0.98	0.0101	0.0052	1.96
EBSHHW_07 (Bottom)	11.0	< 10.0	0.13	0.72	0.85	0.70	0.98	0.93	0.0076	0.0066	1.16
EBSHHW_08 (Surface)	< 10.0	< 10.0	0.08	0.21	0.30	0.80	0.78	0.78	0.0084	0.0053	1.57
EBSHHW_08 (Mid)	< 10.0	< 10.0	0.12	0.28	0.40	0.66	1.29	1.06	0.0089	0.0070	1.27
EBSHHW_08 (Bottom)	< 10.0	< 10.0	0.15	0.24	0.39	0.66	1.14	0.92	0.0124	0.0063	1.98
Minimum	**< 10.0**	**< 10.0**	**0.08**	**0.11**	**0.19**	**0.56**	**0.78**	**0.78**	**0.0040**	**0.0015**	**0.54**
Maximum	**25.3**	**13.8**	**0.32**	**2.43**	**2.75**	**0.93**	**1.51**	**1.23**	**0.0700**	**0.0234**	**4.66**
Mean	**-**	-	**0.11**	**0.35**	**0.46**	**0.71**	**1.13**	**0.97**	**0.0109**	**0.0052**	**2.21**
Standard Deviation	**-**	-	**0.049**	**0.469**	**0.514**	**0.106**	**0.156**	**0.103**	**0.0127**	**0.00431**	**0.828**
RSD [%]	**-**	**-**	**46**	**134**	**112**	**15**	**14**	**11**	**117**	**84**	**38**

Station	THC*	UCM*	n-alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
Payara Development (Fugro, 2019a)†											
Mean	-	3.0	0.19	0.29	0.48	1.69	2.15	1.86	0.0075	0.0056	2.18
RSD [%]	-	33	46	45	31	61	39	33	38	23	133
Liza Field (Fugro, 2016)‡											
Mean	16.2	8.9	0.27	1.82	2.09	0.95	0.94	0.94	0.016	0.013	1.33
RSD [%]	40	56	26	168	148	31	8	9	31	43	38

Notes:

THC = Total hydrocarbon content

UCM = Unresolved complex mixture

CPI = Carbon preference index

Pr/Ph = Ratio of pristane to phytane

RSD = Relative standard deviation

* = Concentrations expressed as µg/L

† = Mean and relative standard deviation values estimated from an environmental survey in the Payara development (Fugro, 2019a). Hydrocarbon range nC_{12}-nC_{36}

‡ = Mean and relative standard deviation values estimated from an environmental survey in the neighbouring Liza field (Fugro, 2016). nC_{12}-nC_{36}

Table 7.4: Summary of Water Column Polycyclic Aromatic Hydrocarbons (PAHs) Analysis, Hammerhead Development

Station	Total 2 to 6 Ring PAH*	Total US EPA16 PAH†	NPD	
			Total*	[%]
EBSHHW_01 (Surface)	0.038	3.4	0.013	34
EBSHHW_01 (Mid)	0.047	2.7	0.013	28
EBSHHW_01 (Bottom)	0.035	3.7	0.015	43
EBSHHW_02 (Surface)	0.036	3.3	0.015	42
EBSHHW_02 (Mid)	0.029	2.8	0.010	34
EBSHHW_02 (Bottom)	0.030	3.3	0.012	40
EBSHHW_03 (Surface)	0.038	2.8	0.015	39
EBSHHW_03 (Mid)	0.033	2.6	0.012	36
EBSHHW_03 (Bottom)	0.029	4.1	0.012	41
EBSHHW_03 (Surface)	0.039	3.5	0.013	33
EBSHHW_04 (Mid)	0.029	2.5	0.012	41
EBSHHW_04 (Bottom)	0.039	3.6	0.013	33
EBSHHW_05 (Surface)	0.039	2.7	0.012	31
EBSHHW_05 (Mid)	0.032	3.6	0.015	47
EBSHHW_05 (Bottom)	0.096	15.3	0.038	40
EBSHHW_06 (Surface)	0.039	2.6	0.013	33
EBSHHW_06 (Mid)	0.031	3.3	0.014	45
EBSHHW_06 (Bottom)	0.032	3.4	0.012	38
EBSHHW_07 (Surface)	0.036	3.1	0.016	44
EBSHHW_07 (Mid)	0.043	4.4	0.019	44
EBSHHW_07 (Bottom)	0.034	3.6	0.013	38
EBSHHW_08 (Surface)	0.036	4.5	0.013	36
EBSHHW_08 (Mid)	0.028	3.9	0.012	43
EBSHHW_08 (Bottom)	0.031	3.9	0.013	42
Minimum	**0.028**	**2.5**	**0.010**	**28**
Maximum	**0.096**	**15.3**	**0.038**	**47**
Mean	**0.037**	**3.9**	**0.014**	**39**
Standard Deviation	**0.0134**	**2.50**	**0.0053**	**5**
RSD [%]	**36**	**65**	**37**	**13**
Payara Development (Fugro, 2019a)‡				
Mean	**0.076**	**4.0**	**0.027**	**37**
RSD [%]	**33**	**16**	**14**	**19**
Liza Field (Fugro, 2016)#				
Mean	**0.075**	**9.5**	**0.037**	**51**
RSD [%]	**19**	**28**	**26**	**14**

Notes:
Total 2 to 6 ring PAH = Total 2 to 6 ring polycyclic aromatic hydrocarbons (PAH), including alkyl homologues
Total US EPA16 PAH = Total United States Environmental Protection Agency's 16 (US EPA PAH) priority polycyclic aromatic hydrocarbons
Total NPD = Total naphthalene, phenanthrene/anthracene and dibenzothiophene
NPD [%] = Percentage of total 2 to 6 ring PAH concentration comprised of NPD
* = Concentrations expressed as µg/L
† = Concentrations expressed as ng/L
‡ = Mean and relative standard deviation values estimated from an environmental survey in the Payara development (Fugro, 2019a)
#= Mean and relative standard deviation values estimated from an environmental survey in the neighbouring Liza field (Fugro, 2016)

7.5 Metals

7.5.1 Introduction

Water column samples collected from the Hammerhead survey area were analysed for selected elements: aluminium, arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc using ICP-MS and ICP-OES. Sample analysis was conducted by Kaizen LAB.

Concentrations of metals in the water samples were compared to their respective US EPA criterion continuous concentration (CCC) and criterion maximum concentration (CMC) values (US EPA, 2018). Concentrations below these values are considered concentrations at which detrimental effects are rarely observed in biota.

7.5.2 Results

Table 7.5 summarises the concentrations of metals in the water samples. Table 7.5 also includes metals concentrations reported in neighbouring locations (e.g. the Liza field in 2016 (Fugro, 2016) and the Payara development in 2018 (Fugro, 2019a). Sediments sampled in the Liza field were analysed by the National Laboratory Service, with metals concentrations reported within the Payara development analysed by Kaizen LAB.

Aluminium concentrations were above the MRV (< 50 µg/L) in three surface samples and one bottom sample, with the highest concentration (85 µg/L) reported from the surface of station EBSHHW02. Aluminium concentrations within the current survey were broadly comparable to those reported within the Payara development in 2018, when concentrations ranged from < 80.0 µg/L to 142 µg/L (Fugro, 2019a).

Arsenic concentrations ranged from 1.26 µg/L in the surface sample of station EBSHHW06 to 2.21 µg/L in the middle depth sample of station EBSHH_07, with a mean of 1.67 µg/L and low interstation variability (RSD 15 %). Arsenic concentrations within the current survey were broadly comparable to those recorded in historic datasets, in the Payara development (mean 1.70 µg/L; Fugro, 2019a) and the Liza field in 2016 (mean 1.43 µg/L; Fugro, 2016). Arsenic concentrations were below the US EPA CCC threshold of 36 µg/L in all samples (US EPA, 2018).

Mercury concentrations were below the MRV (< 0.100 µg/L) in all water samples, except the surface sample of station EBSHHW01 where a concentration of 0.119 µg/L was reported. Mercury concentrations within the current survey are broadly comparable to those reported in historic datasets, in the Payara development (majority < 0.01 µg/L, maximum 0.113 µg/L; Fugro, 2019a) and the Liza field in 2016 (all < 0.01 µg/L; Fugro, 2016). Mercury concentrations were below the US EPA CCC threshold of 0.94 µg/L in all samples (US EPA, 2018).

No other analysed metals exceeded their respective MRVs in any water samples acquired within the Hammerhead development. All other analysed metal concentrations were below their respective US EPA CCC thresholds (US EPA, 2018).

Table 7.5: Summary of Water Column Metals Analysis, Hammerhead Development

Station	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Se	Zn
EBSHHW_01 (Surface)	52	1.88	< 50	< 0.40	< 8.0	< 8.0	< 200	0.119	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_01 (Mid)	< 50	1.85	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_01 (Bottom)	< 50	1.88	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_02 (Surface)	85	1.46	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_02 (Mid)	< 50	1.36	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_02 (Bottom)	< 50	1.68	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_03 (Surface)	< 50	1.42	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_03 (Mid)	< 50	1.43	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_03 (Bottom)	< 50	1.62	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW04 (Surface)	< 50	1.63	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_04 (Mid)	< 50	1.87	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_04 (Bottom)	58	2.12	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_05 (Surface)	< 50	1.51	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_05 (Mid)	< 50	1.70	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_05 (Bottom)	< 50	1.72	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_06 (Surface)	< 50	1.26	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_06 (Mid)	< 50	1.71	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_06 (Bottom)	< 50	1.50	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_07 (Surface)	67	1.92	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_07 (Mid)	< 50	2.21	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_07 (Bottom)	< 50	1.59	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_08 (Surface)	< 50	1.75	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_08 (Mid)	< 50	1.67	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
EBSHHW_08 (Bottom)	< 50	1.69	< 50	< 0.40	< 8.0	< 8.0	< 200	< 0.100	< 5.0	< 3.0	< 6.0	< 200
Minimum	**< 50**	**1.26**	**< 50**	**< 0.40**	**< 8.0**	**< 8.0**	**< 200**	**< 0.100**	**< 5.0**	**< 3.0**	**< 6.0**	**< 200**
Maximum	**85**	**2.21**	**< 50**	**< 0.40**	**< 8.0**	**< 8.0**	**< 200**	**0.119**	**< 5.0**	**< 3.0**	**< 6.0**	**< 200**
Mean	**-**	**1.67**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Standard Deviation	**-**	**0.243**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
RSD [%]	**-**	**15**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Station	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Se	Zn
Payara Development (Fugro, 2019a)*												
Minimum	< 80.0	1.42	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
Maximum	142	2.19	12.4	< 0.600	222	< 12.0	< 80.0	0.113	< 4.00	1.42	< 6.00	173
Mean	-	1.70	-	-	-	-	-	-	-	-	-	-
RSD [%]	-	9	-	-	-	-	-	-	-	-	-	-
Liza Field (Fugro, 2016)†												
Minimum	-	< 1	< 100	< 0.03	< 0.5	< 0.2	< 100	< 0.01	-	< 0.04		< 0.4
Maximum	-	1.77	< 100	0.064	0.778	0.985	< 000	< 0.01	-	0.625		26.40
Mean	-	1.43	-	0.043	0.656	0.385	-	-	-	0.144	-	6.42
RSD [%]	-	13	-	23	16	58	-	-	-	93	-	103
US EPA Saltwater Quality Standards (US EPA, 2018)												
CCC	-	36	-	7.9	-	3.1	-	0.94	8.2	8.1	71	81
CMC	-	69	-	33	-	4.8	-	1.8	74	210	290	90

Notes:

Concentrations expressed in µg/L

Al = Aluminium As = Arsenic Ba = Barium Cd = Cadmium Cr = Chromium Cu = Copper Fe = Iron

Hg = Mercury Ni = Nickel Pb = Lead Se = Selenium Zn = Zinc

RSD = Relative standard deviation

CCC = Criterion continuous concentration

CMC = Criterion maximum concentration

US EPA = United States Environmental Protection Agency

* = Mean and RSD values estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)

† = Mean and RSD values estimated from an environmental survey in the neighbouring Liza field in 2016 (Fugro, 2016)

Key:	Below CCC Value	Above CCC Value	Above CMC Value

8. SEABED HABITATS

8.1 Introduction

To assess the habitats present within the survey area, detailed analysis of video and stills photography data was undertaken by experienced Fugro marine biologists/taxonomists. Video photography data were reviewed in conjunction with the still photographs, noting the locations of any observed change in sediment type and/or associated faunal community.

Appendix C provides the detailed video and photographic log. Appendix G provides detailed digital seabed stills photographs.

The 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (Institute of Terrestrial Ecology, 1996) has been used to broadly classify the observed seabed habitats. Due to a lack of more detailed habitat guidelines and background literature for South American marine habitats, the European Nature Information System (EUNIS) habitat classification (EUNIS, 2012a) has also been used, which has comparable overarching descriptors of habitats. However, due to regionally different species, in- depth biotope complex classifications cannot be applied.

8.2 Results

8.2.1 Seabed Habitats and Fauna

The seabed observed at all drop-down stations comprised mud with minimal shell material and corresponded with areas of low sonar reflectivity. Analysis of the photographic data from these stations showed the seabed to be comprised of one broad habitat: 'Sublittoral soft seabeds (11.22) (Institute of Terrestrial Ecology, 1996), the equivalent EUNIS habitat was 'Sublittoral mud' (A5.3), "sublittoral mud and cohesive sandy mud extending from the extreme lower shore to offshore, circalittoral habitats". This biotope is predominantly found in sheltered harbours, sealochs, bays, marine inlets and estuaries and stable deeper/offshore areas where the reduced influence of wave action and/or tidal streams allow fine sediments to settle (EUNIS, 2012b).

Areas of high and moderate sonar reflectivity corresponded with exposed, elevated bedrock interspersed with sandy mud and varying proportions of gravel and shell material, running parallel to the shelf break on transects TR01 to TR06. These areas were assigned the broad habitat 'Deep-sea floor' (11.21) (Institute of Terrestrial Ecology, 1996), the EUNIS (2012) classification system allows this habitat to be spilt into two further categories: Areas of elevated, exposed bedrock were assigned 'Deep-sea rock and artificial hard substrata' (A6.1), deep-sea benthic habitats with substrates predominantly of bedrock, immobile boulders or artificial hard substrates (EUNIS, 2012c). The gravelly, muddy sand also observed at these transects were assigned the EUNIS (2012) classification of 'Deep-sea muddy sand' (A6.4), Deep-sea benthic habitats with substrates predominantly of muddy sand (EUNIS, 2012d).

Table 8.1 summarises the hierarchy of the assigned EUNIS (2012) classifications, and equivalent Biotopes/Ecosystems Nomenclature, Habitats of South America' Classification (1996), based on the video and photographic data.

Figure 8.1 displays example photographs of the assigned EUNIS (2012) classifications, and equivalent Biotopes/Ecosystems Nomenclature, Habitats of South America' Classification (1996), based on the video and photographic data.

Table 8.1: Habitat Classifications, Hammerhead Development

EUNIS (2012) Habitat Classification			**Biotopes/Ecosystems Nomenclature, Habitats of South America' Classification (1996)**
Environment Level 1	**Broad Habitat Level 2**	**Habitat Level 3**	
A Marine	A5 Sublittoral sediment	A5.3 Sublittoral mud	Sublittoral soft seabeds (11.22)
	A6 Deep-seabed	A6.1 Deep-sea rock and artificial hard substrata	Deep-sea floor (11.21)
		A6.4 Deep-sea muddy sand	
Notes: EUNIS = European Nature Information System			

8.2.1.1 Sublittoral Soft Seabeds (11.22) (Institute of Terrestrial Ecology, 1996)/Sublittoral Mud (A5.3) (EUNIS 2012)

This habitat, observed at all drop-down video stations, can be described as "benthic communities colonising soft sediments such as mud, sand or gravel of the infralittoral and circalittoral zones." (Institute of Terrestrial Ecology, 1996), the equivalent EUNIS (2012) classification is 'Sublittoral Mud' (A5.3). Epifauna was sparse within this habitat at the Hammerhead survey area. Sessile tax such as burrowing anemones (Cerianthidae), sea cucumber (Holothuroidea), carnivorous sponge (*Chondrocladia* sp.), sea pens (Pennatulacea) and possible buried xenophyophore (Xenophyophoroidea) were occasionally recorded. Mobile taxa were rarely observed and included shrimp (Caridea) and unidentified fish (Pisces). Faunal tubes, tracks and burrows were observed in the soft sediment.

8.2.1.2 Deep-sea floor (11.21) (Institute of Terrestrial Ecology, 1996)/Deep-sea Rock and Artificial Hard Substrata (A6.1) and Deep-sea Muddy Sand (A6.4) (EUNIS 2012)

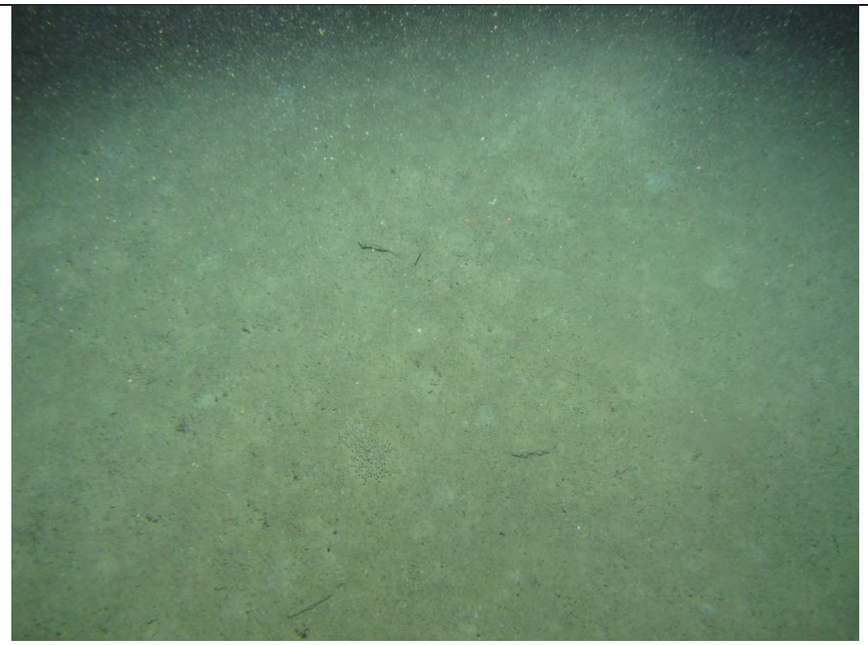
This habitat, observed at all transects can be described as described as: "Bathyal, abyssal, hadal and hydro-thermal benthic communities of the continental slope, the abyssal plain and its features." (Institute of Terrestrial Ecology, 1996); and may be further categorised using the EUNIS (2012) classification system.

Fauna was sparse in areas classified further as deep-sea muddy sand (A6.4). Mobile taxa such as pencil urchin (Cidaridae), small unidentified fish (Pisces) and starfish (Asteroidea) were occasionally observed. Other taxa were also sparse with sea cucumbers (Holothuroidea) recorded. Faunal burrows arranged in a honeycomb formation were frequently observed.

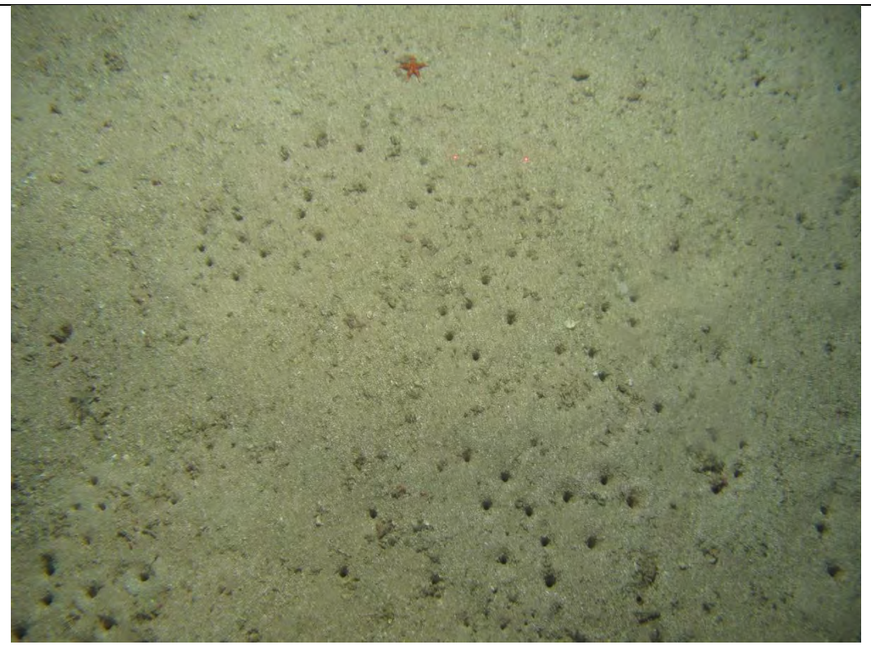
Epifauna, specifically sessile taxa, was more diverse in areas further classified as 'deep-sea rock and artificial hard substrata' (A6.1). Sessile taxa observed in association with exposed bedrock include sponges, including encrusting, thin tubular, ramifying and cup growth forms (Porifera), coralline algae (Corallinales), sea fan (Gorgoniidae), sea whip (Octocorallia), faunal turf (Bryozoa/Hydrozoa/Porifera), black coral (Antipatharia including *Stichopathes* sp. and *Tanacetipathes* sp.) and stony coral (Scleractinia). Mobile taxa recorded were dominated by echinoderms including brittlestars (Ophiuroidea)

associated with sea fans and black coral, starfish (Asteroidea) and sea urchins (Diadematidae). Other mobile fauna observed included: lobster (Palinuridae), damsel fish (Pomacentridae), jack fish (*Seriola* sp.), and small, unidentified reef dwelling fish (Pisces).

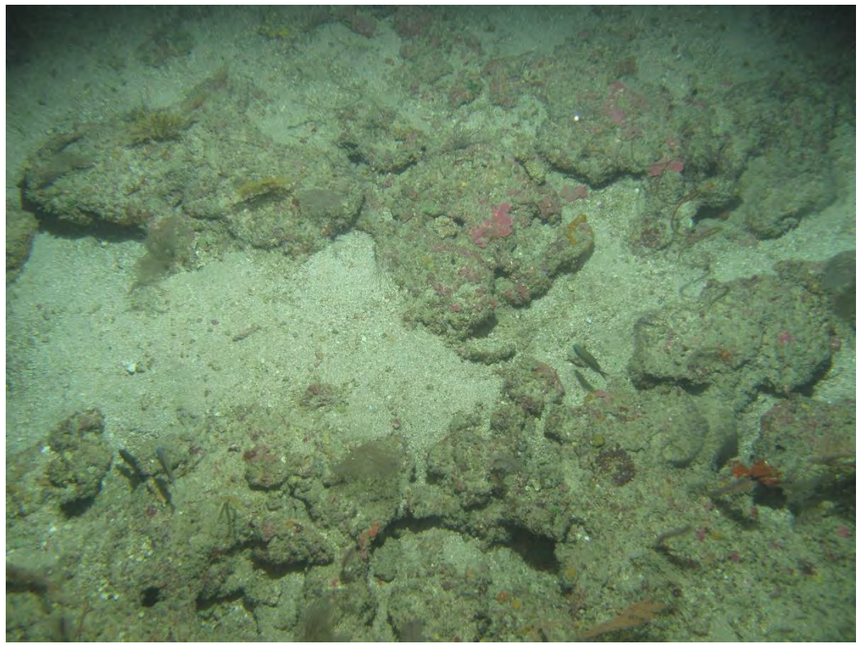
A



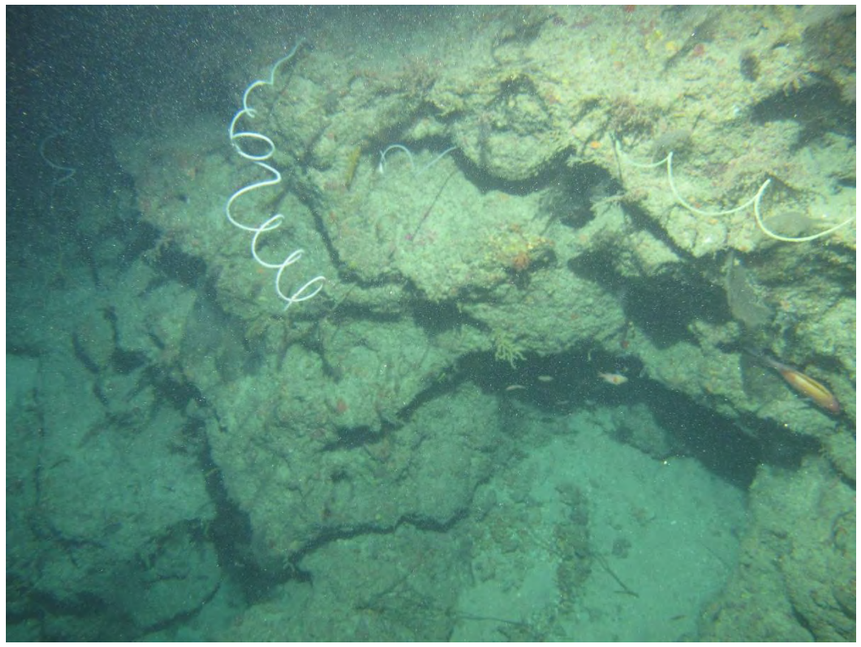
B



C



D



A: Photograph EBSHHDD_03_01
Biotope: Sublittoral soft seabeds (11.22) (Institute of Terrestrial Ecology, 1996)/
Sublittoral mud (A5.3) (EUNIS 2012)
Sediment: Mud with minimal shell material
Fauna Description: Burrowing anemone (Cerianthidae), shrimp (Caridea), unidentified fish (Pisces). Faunal tubes and burrows

B: Photograph TR02_45
Biotope: Deep-sea floor (11.21) (Institute of Terrestrial Ecology, 1996)/
Deep-sea muddy sand (A6.4) (EUNIS 2012)
Sediment: Gravelly, muddy sand
Fauna Description: Small unidentified fish (Pisces), pencil urchin (Cidaridae), possible soft coral (Alcyonacea), starfish (Asteroidea).
Small faunal holes in honeycomb formation

C: Photograph TR02_45
Biotope: Deep-sea floor (11.21) (Institute of Terrestrial Ecology, 1996)/
Deep-sea rock and artificial hard substrata (A6.1) (EUNIS 2012)
Sediment: Exposed, elevated bedrock interspersed with gravelly muddy sand
Fauna Description: Coralline algae (Corallinales), encrusting yellow sponge (Porifera), black coral including bottlebrush black coral (*Tanacetipathes* sp.), sea fan (Gorgoniidae), sea whip (Octocorallia), wire coral (*Stichopathes* sp.), branching stony coral (Scleractinia), soft coral (Alcyonacea), reef dwelling fish (Pisces), faunal turf (Hydrozoa/Bryozoa/Porifera), tube dwelling worms (Sabellidae/Serpulidae), clavate soft coral (Alcyoniidae), brittlestar (Ophiuroidea)

D: Photograph TR05_23
Biotope: Deep-sea floor (11.21) (Institute of Terrestrial Ecology, 1996)/
Deep-sea rock and artificial hard substrata (A6.1) (EUNIS 2012)
Sediment: Exposed, elevated bedrock
Fauna Description: Coralline algae (Corallinales), encrusting yellow sponge (Porifera), black coral including bottlebrush black coral (*Tanacetipathes* sp.), wire coral (*Stichopathes* sp.), branching stony coral (Scleractinia), reef dwelling fish (Pisces)

Figure 8.1: Example seabed sediment photographs of Hammerhead development

9. SEDIMENT MACROFAUNA

9.1 Introduction

This section presents the results of the macrofaunal analysis of samples collected across the survey area. A total of eight stations were sampled for macrofaunal content using a US NEL 0.25 m^2 box corer. Each of the 0.25 m^2 USNEL box core samples were subsampled to provide two macrofaunal samples (0.1 m^2 each), both of which were processed for analysis (FA and FB). Appendix B provides full details of the analytical techniques employed.

The sediment macrofauna is defined as those animals living in or on the seabed that are retained on a sieve mesh of 0.5 mm. Before any analysis was undertaken, the reported macrofaunal dataset underwent rationalisation to prevent spurious enhancement of community statistics and allow comparison to historical datasets. Analysis was completed with juveniles removed from the dataset as juveniles are not considered part of the permanent community. Any phyla considered parasitic were also removed for this reason. Several damaged and indeterminable specimens were reported within the original dataset. Where damaged specimens were indeterminable from identified taxa and could be merged without reducing taxonomic resolution, specimens were merged (e.g. *Spiophanes* and damaged Spionidae were merged to Spionidae). However, several damaged specimens were removed from the rationalised dataset prior to analysis to avoid spurious enhancement of diversity indices.

Following rationalisation, intrastation variability for the survey area varied from moderate to high. Stations ranged in average similarity between samples from 18.5 % (station EBSHH_05) to 41.4 % (station EBSHH_08). The data from samples for each station were combined to obtain numbers of taxa and individuals per 0.2 m^2 for each station, as well as diversity indices. Individual sample data were combined in this manner to achieve a more accurate representation of the numbers of taxa and individuals present in a given area of the seabed. This is accepted practise in marine benthic monitoring.

The results of the macrofaunal analysis are presented in the form of figures and tables; the main features of the communities identified are highlighted in the text. A full list of taxa identified and enumerated (individuals per 0.1 m^2) from the survey area are presented in Appendix H.

9.2 Results

9.2.1 Phyletic Composition

Table 9.1 summarises the abundance of taxonomic groups identified across the survey area and Figures 9.1 and 9.2 display the data graphically.

A total of 190 taxa and 608 individuals were identified within grab samples from the survey area. Of these taxa, 45 were recorded as juveniles, parasitic or damaged specimens. Additionally, 10 indeterminable taxa were merged into five taxa. To represent the permanent macrofaunal community and to avoid spurious enhancement of the species list, the dataset was rationalised and these taxa were removed prior to statistical analysis (see Appendix H).

The rationalised data comprised 140 benthic taxa, of which 57 (40.7 %) were arthropods, 46 (32.9 %) were annelids, 26 (18.6 %) were molluscs, 5 (3.6 %) were echinoderms and 6 (4.3 %) were other phyla, specifically sea anemones (within the phylum Cnidaria), ribbon worms (Nemertea) and peanut worms

(Sipuncula). A total of 477 individual animals were identified in the rationalised data, of which 162 (34.0 %) were arthropods, 132 (27.7 %) were annelids, 124 (26.0 %) were molluscs, 22 (4.6 %) were echinoderms and 37 (7.8 %) were other phyla (Table 9.1).

Table 9.1: Taxonomic Groups, Hammerhead Development

Taxonomic Group	Number of Taxa	Composition of Taxa [%]	Abundance	Composition of Individuals [%]
Annelida	46	32.9	132	27.7
Arthropoda	57	40.7	162	34.0
Mollusca	26	18.6	124	26.0
Echinodermata	5	3.6	22	4.6
Other phyla	6	4.3	37	7.8
Total	**140**	**100**	**477**	**100**

Notes:
Other phyla include: Cnidaria, Nemertea and Sipuncula
Macrofaunal samples were processed through a 0.5 mm sieve

Figures 9.1 and 9.2 illustrate the phyletic composition of taxa and individuals for each station (per 0.2 m^2), respectively. Consideration by station facilitates spatial comparison and highlights the broad similarities between stations across the survey area. When taxa were considered, arthropods, annelids and molluscs comprised the three most diverse phyla at all stations, although not necessarily in this order. Arthropods, annelids and molluscs accounted for a combined total of ≥ 84.2 % of the taxa at each station (Figure 9.1). When individuals were considered, these phyla also comprised the three most abundant phyla at the majority of stations, accounting for ≥ 79.2 % of the individuals at each station (Figure 9.2).

Despite these broad similarities, some differences were apparent. The single most diverse and most abundant phylum demonstrated differences between stations, and included arthropods, annelids and molluscs (Figures 9.1 and 9.2). Additionally, at station EBSHH_07, no echinoderms were reported (Figures 9.1 and 9.2), other phyla were more abundant than arthropods and the highest proportion of mollusc taxa and individuals was observed (Figure 9.2).

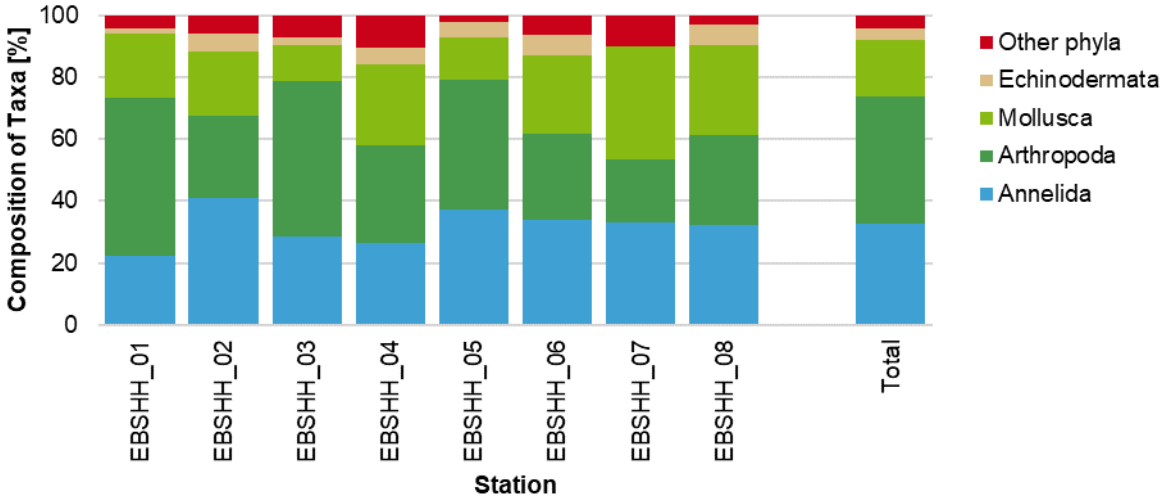


Figure 9.1: Phyletic composition of taxa, Hammerhead development

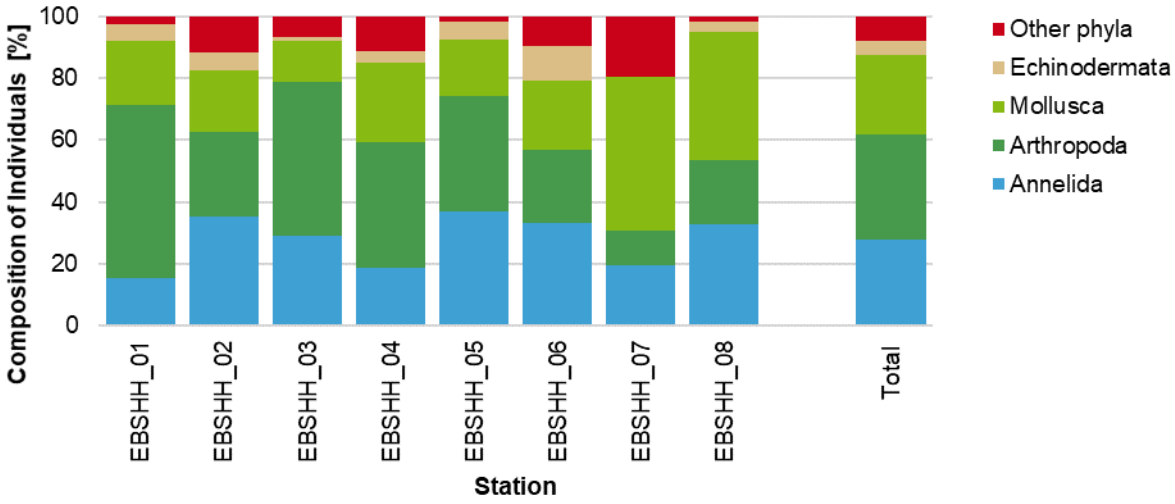


Figure 9.2: Phyletic composition of individuals, Hammerhead development

9.2.2 Characteristic Taxa

Table 9.2 presents the dominant taxa within the survey area and Table 9.3 presents the most abundant taxa per station. Due to the number of taxa reported at low abundance, often as a single specimen, the top five taxa were not distinguishable at the majority of stations. Where this occurred, only the taxa present within the top five taxa at other stations within the survey area have been listed (Table 9.3). Consequently, these taxa will be referred to as characteristic taxa throughout this section.

By ranking the taxa recorded at each station in terms of density and summing the rank scores for all stations to assign an overall rank abundance and dominance for each taxon, it is possible to examine which species were consistently abundant as well as dominant throughout the survey area. The dominance rank is less susceptible to bias caused by species that occur in high densities in only a few of the samples analysed.

All taxa were reported at low mean abundance within the survey area. The most abundant taxon, the bivalve mollusc *Ennucula*, was reported with a mean abundance of 3 individuals per 0.2 m^2 and was not present within the top ten most dominant taxa. The high rank abundance of *Ennucula* in comparison to rank dominance is due to the presence of this mollusc at only six of the eight stations (62.5 %; Table 9.2) and also it's relatively high abundance at the shallowest stations EBSHH_07 and EBSHH_08 (Appendix H).

There was some fidelity between rank abundance and rank dominance across the survey area, with eight of the top ten most abundant taxa also reported within the top ten most dominant taxa. The most dominant taxon was the tanaid crustacean *Typhlotanais*, which was present at abundances of ≥ 2 individuals per 0.2 m^2 at five of the eight stations. Isopod crustaceans of the family Desmosomatidae and molluscs of the class Caudofoveata were joint second most dominant taxa, with Desmosomatidae also the second most abundant taxon (Table 9.2).

None of the top ten most abundant or dominant taxa were reported within all stations across the survey area, with isopod crustaceans of the family Desmosomatidae, the polychaetes *Ophelina* and those of the family Spionidae all reported from seven of the eight stations (87.5 %; Table 9.2). This heterogeneity within the macrofaunal community was highlighted when the characteristic taxa at each station were considered. The most abundant taxon differed at each station, in part due to the low abundances recorded across the survey area. The most abundant taxa were from numerous phyla. and included the molluscs *Microgloma mirmidina* and *Ennucula*, the arthropods *Apseudes* sp. B and Desmosomatidae, the annelid *Aricidea*, the brittlestar *Ophiotholia* and the peanut worms *Aspidosiphon* (*Akrikos*) *zinni* and *Phascolosoma*? (Table 9.3). Of these, Desmosomatidae were present within the characteristic taxa at four of the eight stations, with *Aspidosiphon* (*Akrikos*) *zinni* and *Ophiotholia* within the characteristic taxa at three stations.

Table 9.2: Dominant Taxa by Rank Abundance and Dominance, Hammerhead Development

Taxon	Rank Abundance	Mean Station Abundance [0.2 m^2]	Rank Dominance	Frequency [%]
*Ennucula**	1	3	14*	62.5
Desmosomatidae	2	2	2	87.5
Typhlotanais	3	2	1	75.0
Ophiotholia	3	2	6	75.0
Aspidosiphon (*Akrikos*) *zinni*	5	2	7	62.5
Phascolosoma?*	6	2	13*	25.0
Ophelina	6	2	5	87.5
CAUDOFOVEATA	6	2	2	75.0
Fauveliopsis	9	1	4	75.0
Microgloma mirmidina	9	1	8	75.0
Spionidae†	11†	1	10	87.5
Dacrydium†	13†	1	9	37.5

Notes:
Rank abundance is calculated based on the total number of individuals across the survey area
Rank dominance is calculated based on frequency and abundance
Frequency = Percentage of the stations from which the taxa were recorded
Top ten most abundant or dominant taxa only are included
* = Present within the top ten most abundant taxa across the survey area, but not the top ten most dominant
† = Present within the top ten most dominant taxa across the survey area, but not the top ten most abundant

Table 9.3: Top 5 Most Abundant Taxa at Each Station, Hammerhead Development

Station EBSHH_01	Ind [0.2 m²]	Cum [%]	Station EBSHH_02	Ind [0.2 m²]	Cum [%]
Apseudes sp. B	5	6.5	*Aspidosiphon* (*Akrikos*) zinni	4	7.8
Desmosomatidae	4	11.7	Desmosomatidae	3	13.7
Parafilitanais	4	16.9	Dentaliidae sp. A	3	19.6
CAUDOFOVEATA	4	22.1	Ten other taxa*, including *Fauveliopsis*, TANAIDOMORPHA sp. A, *Yoldiella* and *Ophiotholia*	2	58.8
Ophiotholia	4	27.3			
Station EBSHH_03	**Ind [0.2 m²]**	**Cum [%]**	**Station EBSHH_04**	**Ind [0.2 m²]**	**Cum [%]**
Aricidea	5	6.6	Desmosomatidae	3	11.1
Desmosomatidae	4	11.8	*Typhlotanais*	3	22.2
Dacrydium	4	17.1	Four other taxa*, including *Aspidosiphon* (*Akrikos*) *zinni*, Dentaliidae sp. A and *Limopsis*	2	51.9
Six other taxa*, including *Phascolosoma*? and Harpiniinae	3	40.8			
Station EBSHH_05	**Ind [0.2 m²]**	**Cum [%]**	**Station EBSHH_06**	**Ind [0.2 m²]**	**Cum [%]**
Microgloma mirmidina	3	5.6	*Ophiotholia*	6	8.3
Nine other taxa*, including *Fauveliopsis*, *Ophelina*, CAUDOFOVEATA and *Yoldiella*	2	38.9	*Aspidosiphon* (*Akrikos*) *zinni*	5	15.3
			Typhlotanais	5	22.2
			Anobothrus	3	26.4
			Limopsis	3	30.6
Station EBSHH_07	**Ind [0.2 m²]**	**Cum [%]**	**Station EBSHH_08**	**Ind [0.2 m²]**	**Cum [%]**
Phascolosoma?	9	14.5	*Ennucula*	13	22.4
Neilonella?	8	27.4	*Paralacydonia paradoxa*	5	31.0
Ennucula	6	37.1	*Ophelina*	3	36.2
Semelidae sp. A	4	43.5	VENEROIDEA sp. A	3	41.4
Two other taxa*	3	53.2	Seven other taxa*, including *Fauveliopsis*, Harpiniinae and TANAIDOMORPHA sp. A	2	65.5

Notes:
Ind = Number of individuals of the taxa within the station (0.2 m²)
Cum = Cumulative percentage of the individuals relative to the total number of individuals recorded within the station (0.2 m²)
* = Due to the number of taxa reported at low abundance, the top five taxa were not distinguishable at the majority of stations. Where this occurred, only the taxa present within the top five taxa at other stations have been listed

9.2.3 Species Accumulation and Richness Estimation

Figure 9.3 displays the species accumulation plot. This was generated using sample data (0.1 m²) in PRIMER v7. The observed number of taxa obtained through repeated sampling (Sobs) were cumulatively plotted, as were richness estimates from repeated sampling as calculated by the Chao1, Chao2, Jacknife1 and Jacknife2 formulae. All displayed curves were smoothed (by random permutation of the data points) to aid interpretation.

The observed species accumulation curve was a relatively constant slope that appeared unlikely to be close to reaching the asymptote, suggesting that a proportion of the macrofaunal community within the survey area had not been detected by the sampling undertaken. The Jacknife richness estimators

followed a similar pattern, although Chao1 and Chao2 appeared to be approaching an asymptote. For Chao2 an increase in species count for a low number of samples was evident, which was reflective of the high number of taxa reported as individual specimens across the survey area (roughly a third of the taxa recorded; Appendix H), with the initial spike smoothed out as more samples were included in the calculation.

The richness estimators suggest that a moderate to high proportion of the survey area has described by the sampling effort undertaken, with estimates for the total macrofaunal diversity of the area ranging from 189 taxa (Chao1) to 214 taxa (Jacknife2), in comparison to the 140 taxa recorded. These estimates suggest that between 65.4 % and 74.1 % of the area's total faunal diversity has been detected by the sampling undertaken.

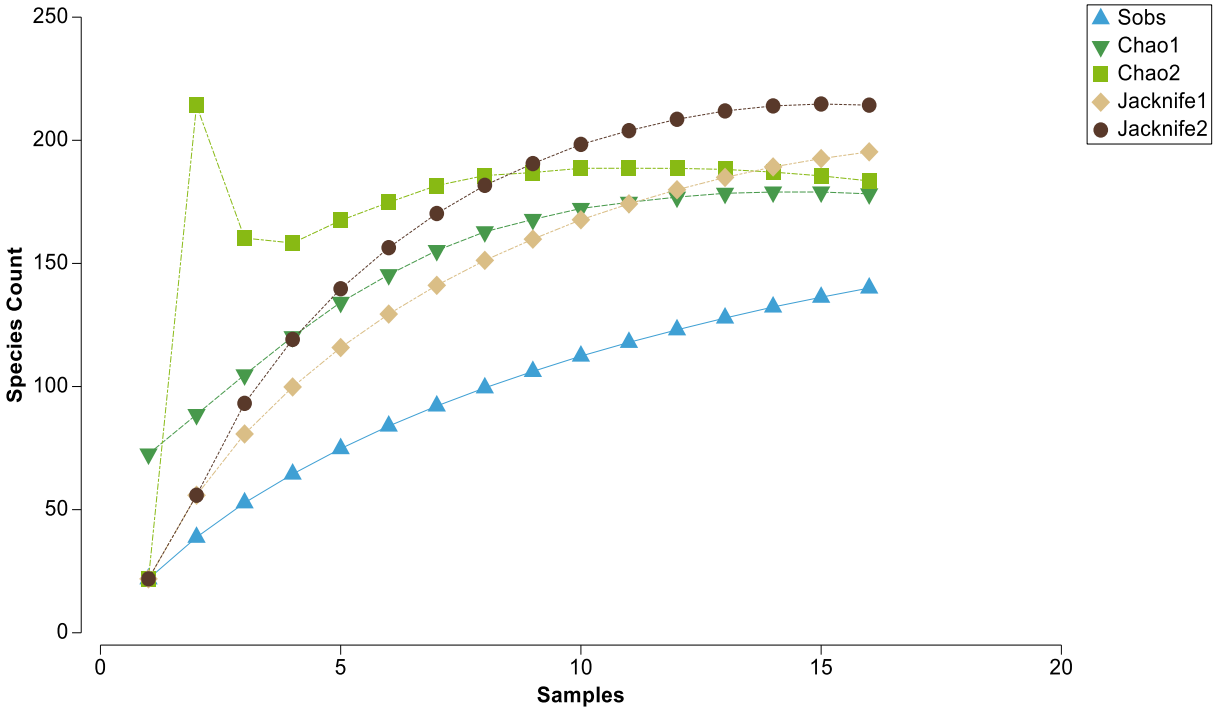


Figure 9.3: Species accumulation plot for sample data (0.1 m^2), Hammerhead development

9.2.4 Community Statistics

Table 9.4 presents the number of taxa and individuals identified from each station along with several commonly used diversity and evenness statistics. Figure 9.4 spatially displays the number of individuals per 0.2 m^2 overlaid on bathymetry data.

The number of taxa per 0.2 m^2 ranged from 19 at station EBSHH_04 to 49 at station EBSHH_01, with a mean of 37 and low interstation variability (RSD 28 %). The mean number of taxa per 0.2 m^2 was higher than that reported in slightly deeper waters (ca. 1800 m to ca. 2100 m) within the neighbouring Payara development in 2018 (mean 12; Fugro, 2019a).

The number of individuals per 0.2 m^2 ranged from 27 at station EBSHH_04 to 77 at station EBSHH_01, with a mean of 60 and low interstation variability (RSD 28 %) and no clear spatial pattern (Figure 9.4). The mean number of individuals per 0.2 m^2 was broadly comparable to that estimated from a wide depth

range (ca. 500 m to ca. 2800 m) in the Liza field in 2016 (mean 40, Fugro, 2016) and higher than that reported within the Payara development in 2018 (mean 19; Fugro, 2019a).

Diversity was high across the survey area, based on the Shannon-Wiener index ($H'Log_2$) referenced to the five ecological statuses outlined in Dauvin et al. (2012), classified as: bad if 0.00 to 1.00, poor if 1.00 to 2.00, moderate if 2.00 to 3.00, good if 3.00 to 4.00 and high if ≥ 4.00. Shannon-Wiener diversity index ranged from 4.11 at station EBSHH_04 to 5.38 at station EBSHH_01, with a mean of 4.88 and low interstation variability (RSD 10 %). The Brillouin's index (Hb) largely mirrored the Shannon-Wiener index across the survey area. The mean Shannon-Wiener diversity index reported in the current survey was higher than reported in slightly deeper waters within the Payara development in 2018 (mean 3.19; Fugro, 2019a) and from a wide depth range in the Liza field in 2016 (mean 2.42, Fugro, 2016).

The Pielou's evenness index (J) is a measure of the distribution of individuals between taxa. The Simpsons index of dominance considers the number and relative abundance of taxa, measuring community diversity by assigning higher weight to dominant taxa. Consequently, the complement of the Simpsons index of dominance (expressed as 1 – λ) also gives an indication of evenness. Evenness was high across the survey area indicating that faunal abundances were evenly distributed across the taxa recorded. The Pielou's evenness index ranged from 0.893 at station EBSHH_08 to 0.983 at station EBSHH_05 with a mean of 0.948 and low interstation variability (RSD 4 %). The complement of the Simpsons index of dominance (1 - λ) largely mirrored the complement of the Pielou's evenness index across the survey area. The mean Pielou's evenness index reported in the current survey was broadly comparable to that reported from a wide depth range in the Liza field in 2016 (mean 0.95, Fugro, 2016) and in slightly deeper waters within the Payara development in 2018 (mean 0.926; Fugro, 2019a).

Table 9.4: Macrofaunal Community Statistics (0.2 m^2), Hammerhead Development

Station	Numbers		Diversity Indices		Evenness	
	Taxa	Individuals	Shannon-Wiener ($H'Log_2$)	Brillouin (Hb)	Pielou (J)	Simpson (1 - λ)
EBSHH_01	49	77	5.38	3.04	0.958	0.971
EBSHH_02	34	51	4.94	2.72	0.970	0.963
EBSHH_03	42	76	5.19	2.97	0.963	0.969
EBSHH_04	19	27	4.11	2.16	0.967	0.936
EBSHH_05	43	54	5.33	2.89	0.983	0.973
EBSHH_06	47	72	5.28	2.97	0.950	0.967
EBSHH_07	30	62	4.41	2.53	0.899	0.934
EBSHH_08	31	58	4.42	2.49	0.893	0.923
Minimum	**19**	**27**	**4.11**	**2.16**	**0.893**	**0.923**
Maximum	**49**	**77**	**5.38**	**3.04**	**0.983**	**0.973**
Mean	**37**	**60**	**4.88**	**2.72**	**0.948**	**0.955**
SD	**10.2**	**16.5**	**0.498**	**0.309**	**0.0334**	**0.0203**
RSD [%]	**28**	**28**	**10**	**11**	**4**	**2**
Payara Development (Fugro, 2019a)*						
Mean	**12**	**19**	**3.19**	**1.62**	**0.926**	**0.855**
RSD [%]	**57**	**57**	**21**	**26**	**6**	**6**
Liza Field (Fugro, 2016)†						
Mean	**14**	**40**	**2.42**	**-**	**0.95**	**0.94**
RSD [%]	**50**	**55**	**23**	**-**	**6**	**10**

Notes:
SD = Standard deviation
RSD = Relative standard deviation
* = Mean and RSD values estimated from an environmental survey in the neighbouring Payara development in 2018, in depths of ca. 1800 m to ca. 2100 m. 0.2 m^2 stations processed through a 0.5 mm sieve (Fugro, 2019a)
† = Mean and RSD values estimated from an environmental survey in the neighbouring Liza field in 2016, in depths of ca. 500 m to ca. 2800 m. 0.1 m^2 stations processed through a 0.5 mm sieve. Number of taxa, diversity and evenness indices presented as original data. Number of individuals per 0.2 m^2 estimated from 20 per 0.1 m^2 and presented for comparison (Fugro, 2016)

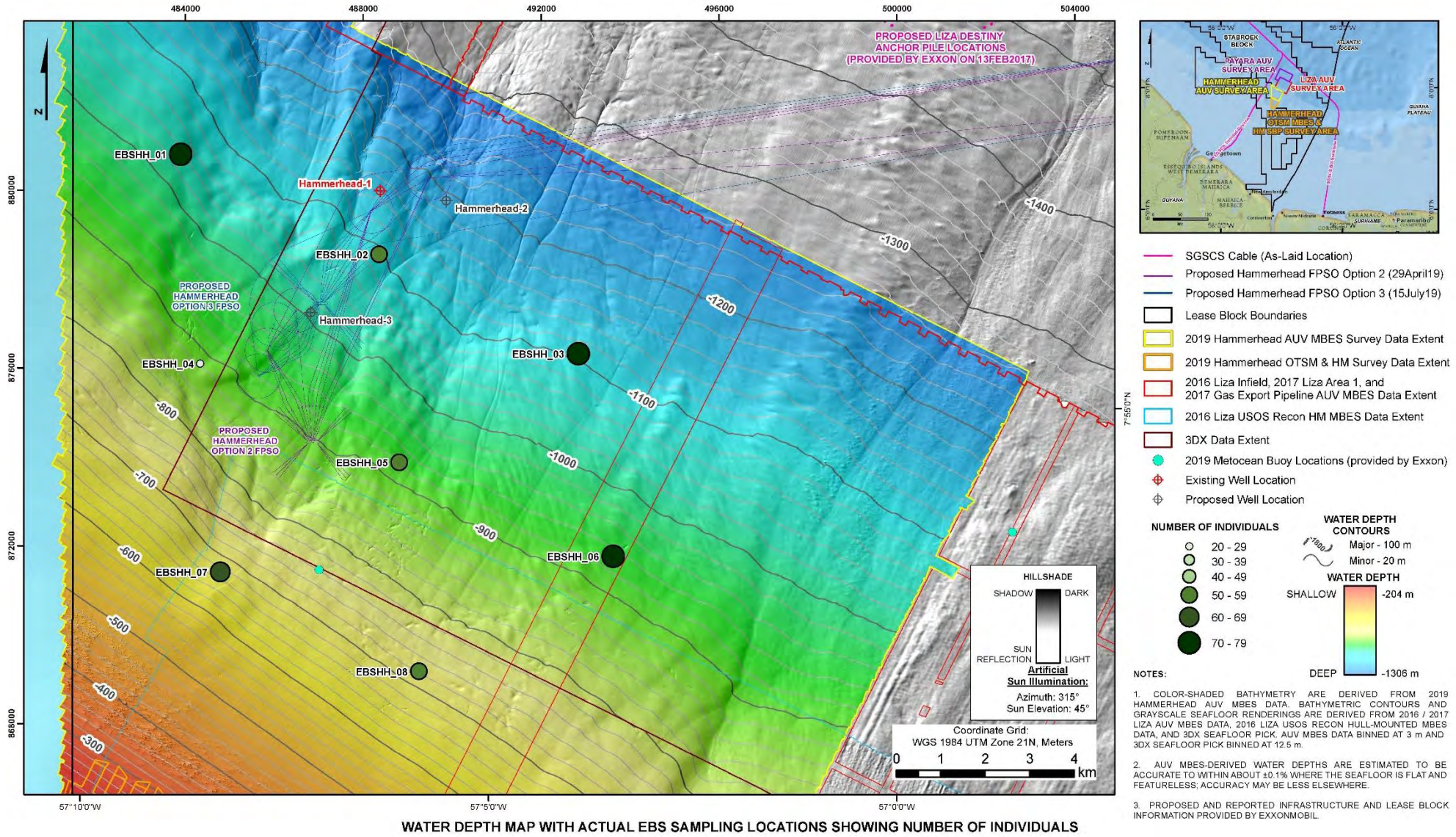


Figure 9.4: Number of individuals (0.2 m^2) overlaid on bathymetry data, Hammerhead development

9.2.5 Investigation of Faunal Similarities

Univariate statistics can summarise large and complex datasets (see Appendix B.3) to a certain extent, condensing a large data matrix to a much more manageable form and allowing direct comparison of variables. Multivariate analysis examines relationships among multiple variables at the same time, which allows assessment of structure and provides synthesised conclusions with less error and more robustness. In doing so, subtle trends in the data may be elucidated.

Various multivariable techniques were applied to the survey area data to investigate such patterns of similarity within the macrobenthic community, which were then further considered with the results from the univariate analyses.

Figures 9.5 and 9.6 present the multivariate statistical analyses of the community: hierarchical agglomerative clustering (CLUSTER) and non-metric multi-dimensional scaling (nMDS) from PRIMER.

9.2.5.1 Cluster Analysis

CLUSTER analysis groups stations according to their faunal similarity and the results are presented in the form of a dendrogram. Figure 9.5 presents the CLUSTER analysis dendrogram and demonstrates the pattern of similarity of untransformed station data. The SIMPROF algorithm was used to identify statistically significant (P = 0.05) differences between stations, with significant splits depicted as black lines and non-significant splits as red lines. Statistically significant splits may not be ecologically significant (Clarke et al., 2008), with ecological significance considered in subsequent sections of this report.

There was a low to moderate degree of faunal similarity across the Hammerhead development survey area, with stations clustering with between 19.3 % and 37.4 % similarity. From the dendrogram, two statistically significant clusters were apparent:

- Cluster A, consisting of two stations to the south of the survey area (stations EBSHH_07 and EBSHH_08 in water depths of < 800 m), grouped together with 33.3 % similarity to each other;
- Cluster B, consisting of the remaining six stations in deeper water (stations EBSHH_01 to EBSHH_06 in water depths of > 800 m), grouped with 22.5 % similarity to each other and 19.3 % similarity to cluster A.

The results of the CLUSTER analysis partially reflected those of the univariate analysis. When considered in conjunction with the characteristic taxa, it was apparent that the bivalve mollusc *Ennucula* was present in relatively elevated abundance (≥ 5 individuals per 0.2 m^2) at stations in cluster A only (Table 9.3). When community statistics were considered, it was apparent that the lowest evenness (both J and 1 - λ) was reported from stations in cluster A (Table 9.4).

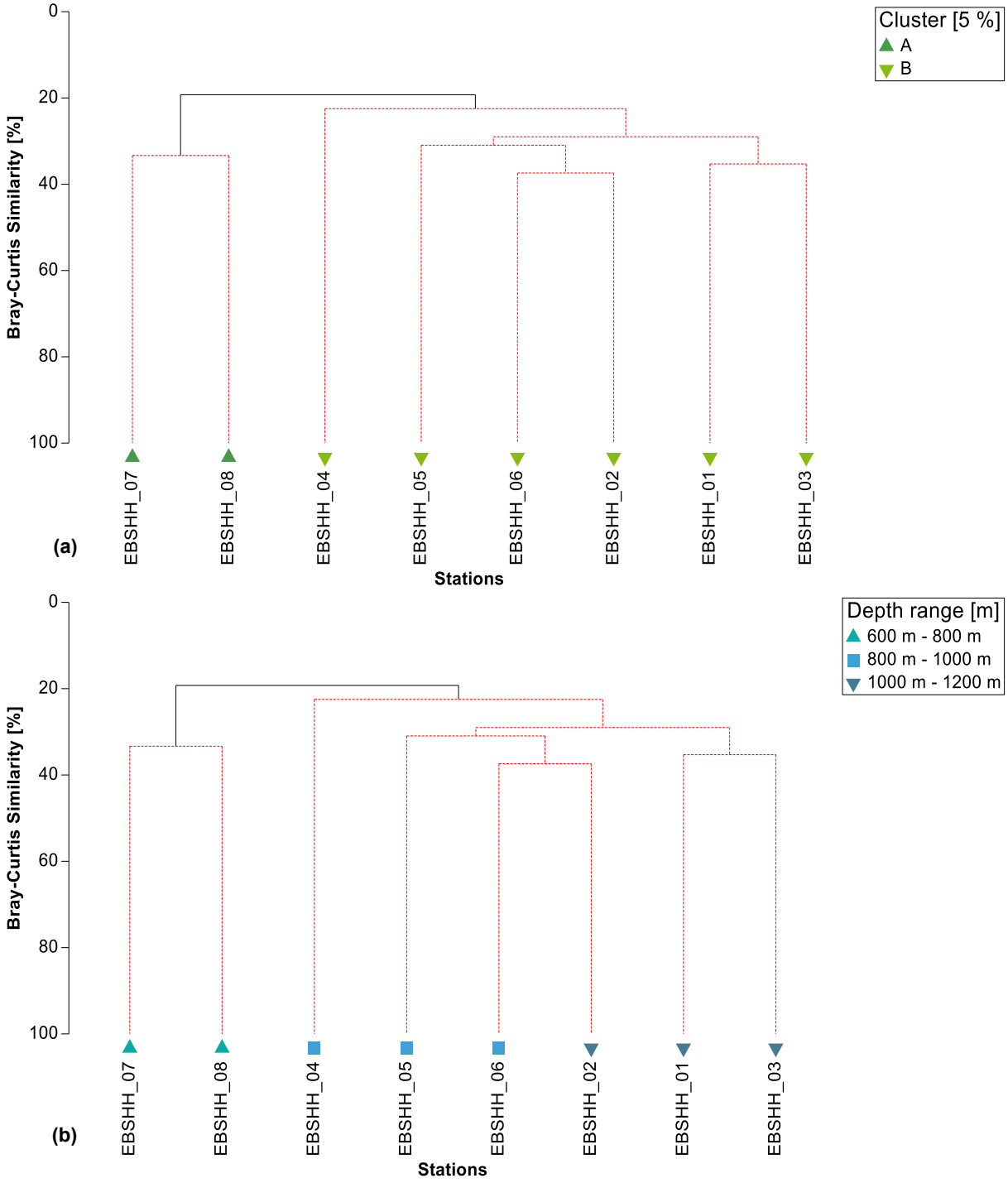


Figure 9.5: Classification by Bray-Curtis similarity for untransformed macrofaunal abundance station (0.2 m^2) data, Hammerhead development (a) clusters at 5 % significance (b) depth overlaid on clusters

9.2.5.2 Non-metric Multidimensional Scaling (nMDS)

Figure 9.6 displays the results of the nMDS, which is an ordination technique that arranges stations on a two-dimensional plot, so that their relative distances from each other reflect their faunal similarities. Depth has been considered as a factor within the nMDS. The stress coefficient of 0.05 provides a good representation of the data (Clarke and Warwick, 2001). This plot supports the results of the CLUSTER analysis and highlights the influence of depth, or parameters associated with depth (e.g. sediment

characteristics) on the macrofaunal community across the survey area. The macrofaunal communities at stations in shallower water (specifically stations EBSHH_07 and EBSHH_08) were more similar to one another than to other stations. Additionally, the macrofaunal community at two stations in deeper water to the north of the survey area (specifically stations EBSHH_01 and EBSHH_03) were more similar to one another than to other stations.

The nMDS highlights that the macrofaunal community at station EBSHH_04 was less than 30 % similar to all other stations. This reflects the univariate statistics, with station EBSHH_04 featuring the lowest number of taxa, individuals and consequently diversity (both H'Log$_2$ and Hb) across the survey area (Table 9.4). The separation of stations EBSHH_01 and EBSHH_03 within the nMDS analysis can also be partially explained by the univariate analysis, as stations EBSHH_01 and EBSHH_03 featured the highest number of taxa and the highest Brillouins diversity index within the survey area (Table 9.4).

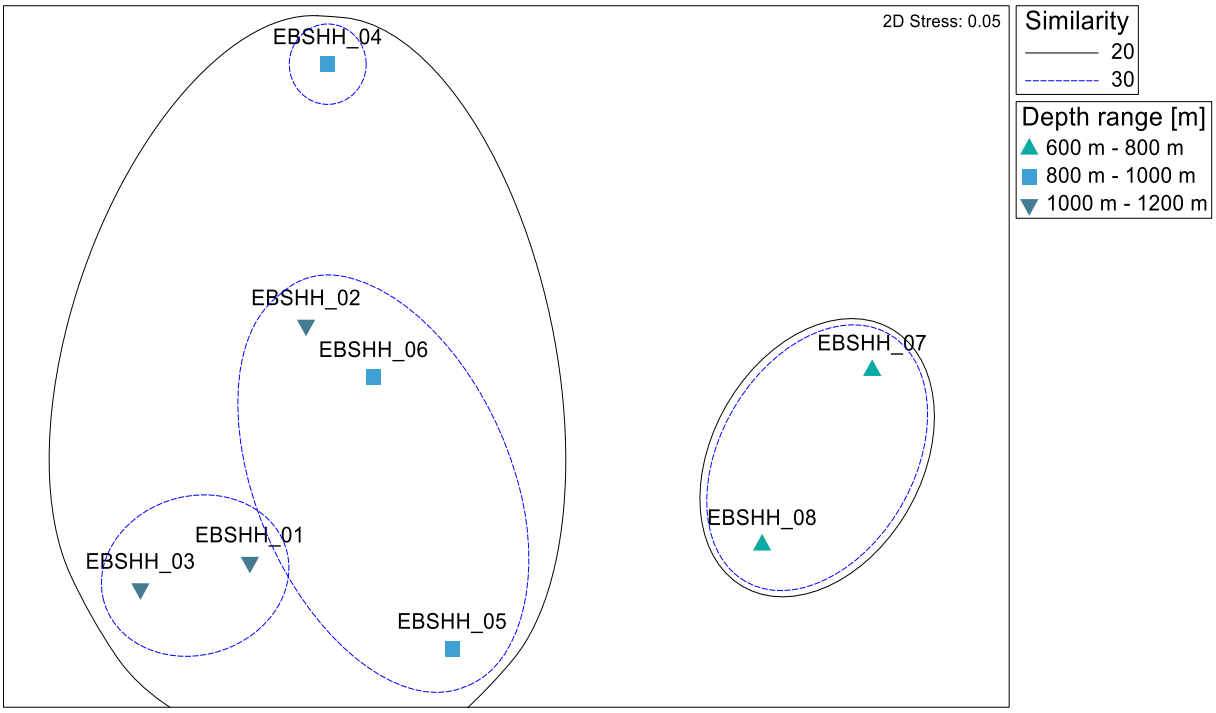


Figure 9.6: Non-metric multidimensional scaling (nMDS) orientation by Bray-Curtis for untransformed macrofaunal abundance station (0.2 m^2) data with consideration of depth, Hammerhead development

9.2.5.3 Similarity Percentage Analysis (SIMPER)

SIMPER analysis highlighted that the differences in the macrofaunal community across the survey area were largely reflective of elevated abundance (albeit still relatively low abundances) of several taxa within stations sampled within shallower water (< 800 m) and the presence or absence of taxa associated with different depth ranges.

The polychaete *Paralacydonia paradoxa*, the bivalve molluscs *Ennucula* and *Ledella pustulosa* and those of the family Veneroidea sp. A were all present at both stations sampled in water depths of 600 m to 800 m (cluster A) but were largely absent (or present at low abundance) from stations sampled in water depths of 800 m to 1200 m (cluster B). Conversely, the tanaid arthropod *Apseudes* sp. A was

present at the majority of stations sampled in water depths of 800 m to 1200 m (cluster B) and the polychaete *Aricidea* and bivalve mollusc *Dacrydium* were present in relatively high abundance at several of these, whilst all three taxa were absent from both stations sampled in water depths of < 800 m (cluster A).

The polychaete *Siboglinum* was present at all stations sampled in water depths of > 1000 m but not reported elsewhere in the survey area. The tanaid arthropod *Apseudes* sp. B was present at stations EBSHH_01 and EBSHH_03 only, both sampled in water depths of > 1000 m. Conversely the previously mentioned bivalve mollusc *Ennucula* was present at all stations sampled in water depths of < 1000 m but absent from all stations sampled in water depths of > 1000 m.

In summary, SIMPER analysis highlighted that the taxa largely responsible for the observed differences in the macrofaunal community across the survey area were restricted by depth, or parameters associated with depth. It is likely that these differences in the macrofaunal community are partially due to the low abundance of all taxa reported.

The relationship between macrofauna communities and physical and chemical determinants will be discussed further in Section 10.

10. DISCUSSION

10.1 Introduction

The survey and analytical strategies were designed to provide a comprehensive baseline dataset of the biological and physico-chemical characteristics in the vicinity of the Hammerhead development. An assessment of likely habitats and biotopes, with particular attention to environmentally sensitive habitats and species, was also conducted. The sampling plan included the collection of surface sediment from eight stations located in proximity to the proposed drill centres and wells for physico-chemical and biota analysis. The surface (0 cm to 2 cm) sediment samples collected (Section 3) were analysed for total TOC, hydrocarbons (including 2 to 6 ring aromatics) and heavy metal content. Selected physical characteristics were analysed using surface sediment samples of 0 cm to 5 cm. Macrofaunal analysis (> 0.5 mm) was carried out on duplicate 0.1 m^2 grab samples at each station. Water column samples were collected at three depths and analysed for TSS, TOC, hydrocarbons and metals content.

The previous sections of this report have presented the data generated from the analysis programme stated above with the aid of data tables and graphics. This discussion section will review the data with respect to regional comparison data from previous surveys in the area including the neighbouring Payara development (Fugro, 2019a) and the Liza development (Fugro, 2016). The data from this report were also compared to appropriate reference values (Buchman, 2008; US EPA, 2018) to determine whether the concentrations present in the sediments and water columns may potentially have a detrimental effect on the benthic communities in the Hammerhead development survey area.

In addition to the comparison of the analytical data against available references, statistical correlations of the sediment parameters recorded with the chemical and biological determinants in the survey are summarised (for the main environmental parameters) in Appendix I. The statistical analysis chosen was the Spearman's rank correlation coefficient (Spearman, 1904), sometimes referred to as Spearman's rho. This coefficient is used to test the association between two reported values for statistical dependence. It is a measure of rank correlation, or the similarity of the orderings of the data when ranked by each of the values. Correlations can only suggest a relationship and do not prove a causal link between status of the chemical or physical nature of the seabed and the infaunal community composition. Correlations occur as both positive and negative: they are positive when both reported values increase or decrease in unison, whilst negative correlations indicate that as one value increases the other decreases and vice-versa. Commonly observed positive correlations would include such variables as THC and PAH whereas common negative correlations would typically include factors such as distance from oil and gas infrastructure and THC (i.e. the farther from a platform, the lower the level of contamination observed).

Correlations analysis indicated that some correlations were apparent between intrinsic physico-chemical parameters within sediments, suggesting that trends in chemical determinants were influenced by both depth and sediment characteristics, with higher metals concentrations at deeper stations and those with a smaller particle size. However, the low variation demonstrated in the datasets summarised within the preceding sections of this report suggest that these may not be true ecological correlations. Whilst correlations are included within Appendix I, they have not been discussed in further detail.

10.2 Sediment Characterisation

The general physical and chemical characteristics of sediment particles have a significant effect on how other chemical components and biological species interact with seabed sediments. For example, the silt/clay fraction is known to adsorb petroleum hydrocarbons/heavy metals from seawater and through this pathway, these chemicals become incorporated into the sediment system (Meyers and Quinn, 1973). Granulometry data can therefore be critical when interpreting chemical and biological data obtained in this type of benthic study. In addition, since waste discharges (such as drill cuttings) often possess significantly different physical characteristics from the natural sediments present in the area, such data may also provide some information on the spread of discharged material.

With regard to macrofaunal communities, the species distributions and community structure can be greatly influenced by the nature of the sediment, which represents the effects of a complex set of hydrological factors, such as water movement, turbulence and suspended load, at one particular point in time. Some animals have a behavioural preference for sediment of a particular grain size (Meadows, 1964; Gray, 1981), while this factor and organic matter content are closely associated with other properties of the sediment such as density, porosity, permeability, oxygenation and bacterial count (Buchanan, 1984), all of which affect animal functions such as locomotion, attachment, tube construction and feeding. Specifically, the proportion of fine (silt/clay) material often influences the distribution of macrofaunal communities.

Sediments within the Hammerhead survey area demonstrated moderate interstation variability (RSD 40 %) in mean diameter, low variability for the proportion of fines (RSD 9 %), moderate variability for the proportion of sand (RSD 53 %) and high variability in gravel (RSD 107 %) content. Station EBSHH_07 displayed a higher mean particle size (18 µm) due to the higher proportions of sand (32.07 %) and gravel (0.09 %) recorded at this station.

Using the Folk (1954) sediment description in situ, the seabed was reported to comprise mud. This was supported in the laboratory by the Folk description (BGS modified) and the Wentworth (1922) classification. The Folk description (BGS modified) described the sediment as sandy mud at all stations except stations EBSHH_04 and EBSHH_05 where sediment was described as mud. The Wentworth (1922) classification described sediments across the majority of the survey area as fine silt, with very fine silt recorded at stations EBSHH_03 and EBSHH_04, and medium silt at station EBSHH_07. Sediments were described as very poorly sorted across the survey area. All stations were dominated by the fines fraction. The composition of sediments along the Guyana coast is influenced by riverine discharges from the Amazon basin, which are transported northwards via ocean currents (Eisma and Van der Marel, 1971). Secondary inputs are likely to be the discharge of sediments from the Essequibo-Demerara drainage basin (Nota, 1958). The quantity of gravel was highly variable across the Hammerhead survey area, with station EBSHH_07 having a slightly higher gravel content when compared to the other stations. All stations were classified as the biotope complex ‘Sublittoral soft seabeds’ (11.22; Table 8.1) (Institute of Terrestrial Ecology, 1996)’. This was further corroborated by the results of the PSD.

The sediment within the Hammerhead survey area comprised a lower proportion of gravel (mean 0.03 %) than available comparable datasets (e.g. the Payara development (mean 0.12 %; Fugro, 2019a), the Liza field in 2016 (mean 0.11 %; Fugro 2016). The proportion of fines within the

Hammerhead survey area (mean 85.00 %) was higher than the mean recorded in the Payara development (mean 44.5 %; Fugro, 2019a) and the Liza field (mean 60.78 %; Fugro, 2016).

The proportion of TOC within sediments in the Hammerhead survey area was low (mean 0.64 %) but is higher than had previously been reported in the Payara development (mean 0.31 %; Fugro, 2019a) and the Liza field (mean 0.32 %; Fugro, 2016).

10.3 Sediment Hydrocarbons

10.3.1 Total and Aliphatic Hydrocarbons

Marine sediments contain hydrocarbons derived from many sources which enter the marine environment via three general processes: biosynthesis (marine and land organisms biosynthesise hydrocarbons), geochemical processes (submarine and coastal/terrestrial oil-seeps) and anthropogenic sources (from accidental or intentional discharge of fossil fuel) (Farrington and Meyer, 1975; Myers and Gunnerson, 1976). Anthropogenic hydrocarbon inputs to the marine environment include marine transportation, offshore oil production, coastal oil refineries, accidental shipping losses, industrial and municipal waste (which includes sewage and dredged spoils). A significant contribution to the global budget enters the marine environment via urban and river run-off, atmospheric deposition (from combustion sources including PAHs) and natural seepages (Johnston, 1980; Dicks et al., 1987; NSTF, 1993; OSPAR, 2000; 2010).

Biosynthesised hydrocarbons are ubiquitous in the marine environment (Harada et al., 1995; Parinos et al., 2013). Odd carbon number, long chain n-alkanes are widely distributed in the plant kingdom (Eglinton et al., 1962; Douglas and Eglinton, 1966; Bush and McInerney, 2013) as components of cuticle waxes. These are common on the surfaces of leaves, stems, flowers and pollen and their presence in sediment is indicative of terrestrial inputs from adjacent land masses. Relatively high concentrations of nC_{29}, nC_{31} and nC_{33} are therefore a common feature of many marine sediments (Farrington et al., 1977).

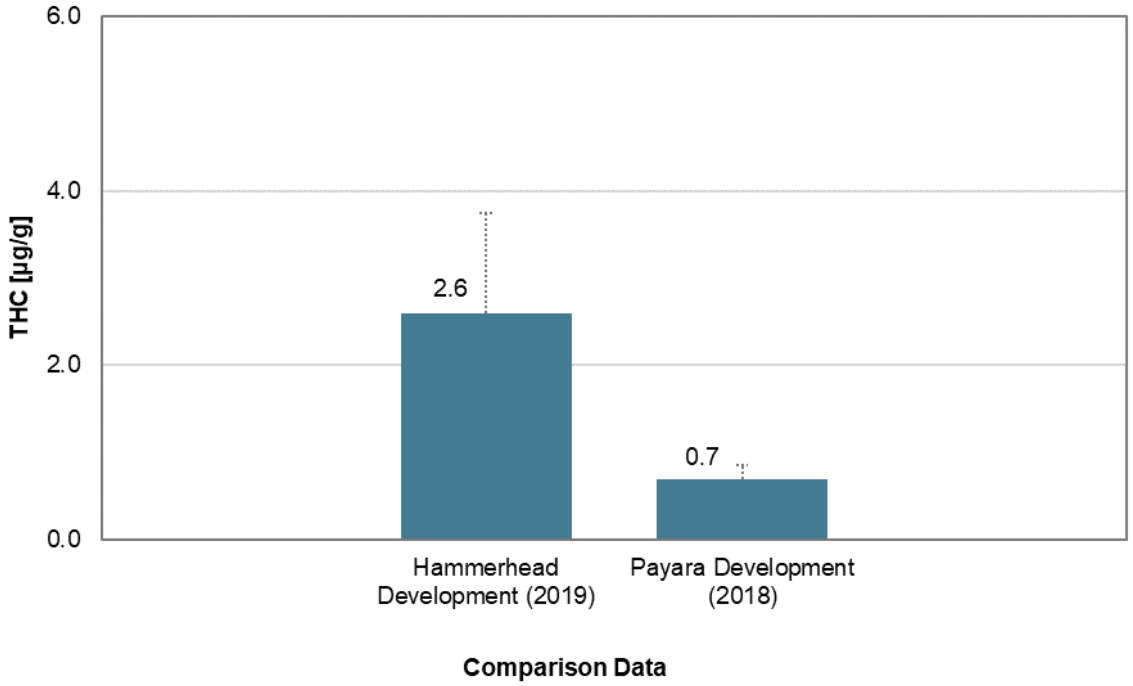
The gas chromatographic profiles collated from the survey area shared a common underlying hydrocarbon distribution. The chromatograms all contained a trace level homologous series of resolved n-alkanes from nC_{12} to nC_{36}. The profiles also contained a trace level unresolved ‘hump’ covering the nC_{19} to nC_{36} range. This feature is the UCM and is composed of a wide range of compounds, including cycloalkanes, which remain after substantial weathering and biodegradation of petrogenic hydrocarbons (Farrington et al., 1977). The presence of the UCM in the samples suggests some contribution to the sediments from petroleum hydrocarbon sources, possibly attributed to fossil fuel discharges from historic or current industrial activities in the marine environment (such as shipping or oil and gas development) or via terrestrial run-off. Evidence of terrestrial run off was observed through the slight prevalence of the n-alkanes nC_{29}, nC_{31} and nC_{33}, indicating trace inputs of biogenic material such as plant waxes. The prominent peak prior to nC_{14} at stations EBSHH_01, EBSHH_02, EBSHH_04, EBSHH_05 and EBSHH_08 may be a characteristic of the survey area or may have been introduced through sampling methods. The profiles observed at the Hammerhead survey area indicate background sediments.

The total hydrocarbon content (THC) reported for the survey area displayed low variability (RSD 22 %). The current survey area had a mean THC value of 2.6 µg/g, higher than the mean THC observed at the

Payara development (0.7 µg/g; Fugro, 2019a). Figure 10.1 displays the Hammerhead development mean THC value alongside regional comparable data. No spatial trends in THC were apparent, with any variation between stations likely to be a result of natural small-scale heterogeneity in sediment characteristics and associated THC values.

The ratio of odd to even carbon numbered normal alkanes is termed the carbon preference index (CPI) and has been calculated over various chain length ranges. Elevated ratios (i.e. those > 1.00) over the nC_{12} to nC_{36} carbon range are due to the domination of the odd-chain length n-alkanes (nC_{27} to nC_{33}) and are typically associated/observed with inputs from terrestrial run-off (leaf waxes, etc., discussed previously). The CPI for the nC_{12} to nC_{36} n-alkanes ranged from 1.81 at station EBSHH_08 to 2.13 at station EBSHH_07 with a mean value of 1.95, suggesting the influence of odd-chain length n-alkanes and biogenic material. Interstation variation across the Hammerhead survey area was low (RSD 5 %). The mean Hammerhead CPI value was comparable to the CPI value mean recorded at the Payara development (2.22; Fugro, 2019a).

The isoprenoidal alkanes pristane (Pr) and phytane (Ph) were reported in low concentrations in each of the sediment samples analysed. These compounds are present in significant concentrations in crude oils (Berthou and Friocourt, 1981). They may also be biosynthesised (Gunkel and Gassmann, 1980) and pristane, a breakdown product of the phytol moiety of chlorophyll is widespread in the marine ecosystem, probably being derived from zooplankton. Phytane is generally absent or present in only relatively low levels in uncontaminated natural systems (Blumer and Snyder, 1965). The Pr/Ph ratios reported in the sediments ranged from 0.92 at station EBSHH_02 to 1.58 at station EBSHH_03, with a mean value of 1.25 (Table 5.1). These values would typically suggest that the higher proportion of the pristane present in the sediments was derived from non-petrogenic sources.



Notes:
Error bars represent 95th percentile
THC = Total hydrocarbon content (expressed as µg/g dry sediment)
Hammerhead development (2019) = Mean estimated from current survey data
Payara development (2018) = Mean estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)

Figure 10.1: Comparison of sediment total hydrocarbon content (THC) values with regional/background datasets, Hammerhead development

10.3.2 Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) and their alkyl homologues have been detected in a wide range of marine sediments (Youngblood and Blumer, 1975; Laflamme and Hites, 1978; Neff, 1979). These compounds consist of two or more fused benzene rings in linear, angular or cluster arrangements. Polycyclic aromatic hydrocarbons technically contain only carbon and hydrogen atoms. However, other atoms (e.g. nitrogen, sulphur and oxygen) may be readily substituted into the benzene ring to form heterocyclic compounds that are present in significant concentrations in petroleum and refined products.

Monitoring of aromatic hydrocarbon type and content is important due to the particularly toxic nature (mutagenic/carcinogenic) of several PAHs even at very low concentrations. The US EPA has identified 16 priority PAHs to be monitored (Keith, 2015) and the CEMP specifies 9 PAHs of specific concern (OSPAR, 2014), which primarily reflect inputs from anthropogenic combustion sources (further alkylated and parent compounds are normally studied because of the information they provide on PAH origin and fate). Many PAHs have long been recognised as universal environmental pollutants with the heavier molecular weight PAHs (mainly 4 to 6 ring PAH) generally being regarded as carcinogens and mutagens. Indeed, 11 of 40 PAHs ranging from 3 to 6 ring structures have been listed as being strongly carcinogenic or mutagenic with a further 10 listed as weakly carcinogenic or mutagenic (Edwards, 1983).

As previously stated, PAHs are widely spread in the environment (Butler et al., 1984) with natural sources occurring primarily through synthesis by plants (Neff, 1979; Sims and Overcash, 1983), related to natural seeps of petroleum (NRC, 1983; Kennicutt et al., 1988) and to formation during natural forest and prairie fires (Youngblood and Blumer, 1975; Wakeham et al., 1979). By far the greatest proportion of PAHs released into the environment are formed during fossil fuel combustion and anthropogenic forest and agricultural fires (Edwards, 1983; Sims and Overcash, 1983). Once released into the atmosphere PAHs may be carried long distances adsorbed to particulate material (e.g. soot and fly ash; Windsor and Hites, 1979). Similarly, when deposited within the water environment PAHs may undergo further transport (e.g. by rivers or ocean currents) before final deposition in the sediments. Due to the low solubility and hydrophobic nature of PAHs, when deposited within the water column they tend to be adsorbed to suspended inorganic and organic particulate matter, which gradually settles out. Once deposited in the sediment PAHs are less susceptible to photochemical and biological degradation and may accumulate to relatively high concentrations.

Petroleum sources are rich in aromatic hydrocarbons, particularly 1 to 3 ring compounds (benzenes, naphthalenes and phenanthrenes); the levels of 4 to 6 ring compounds being relatively low. In addition, significant concentrations of organosulphur compounds (dibenzothiophenes) are normally present (Friocourt et al., 1982). The relative proportion of these compounds will vary between crude oils and refined petroleum.

The many possible origins of PAHs in marine sediments have been briefly discussed in this section. The source of the PAHs may be determined by investigation of the relative proportions of individual PAH concentrations (Neff, 1979; Garrigues et al., 1995; Budzinski et al., 1997) as well as examining the overall distributions of parent and alkylated PAHs present. Pyrogenically (or pyrolytic) derived PAHs signatures (i.e. forest fires, etc.) are dominated by higher molecular weight compounds (mainly 4 to 6 ring) and are predominantly unsubstituted. In contrast, PAH formed during the slow geological maturation of petroleum, are dominated by alkylated, low molecular weight (mainly 1 to 3 ring) compounds (Neff, 1979).

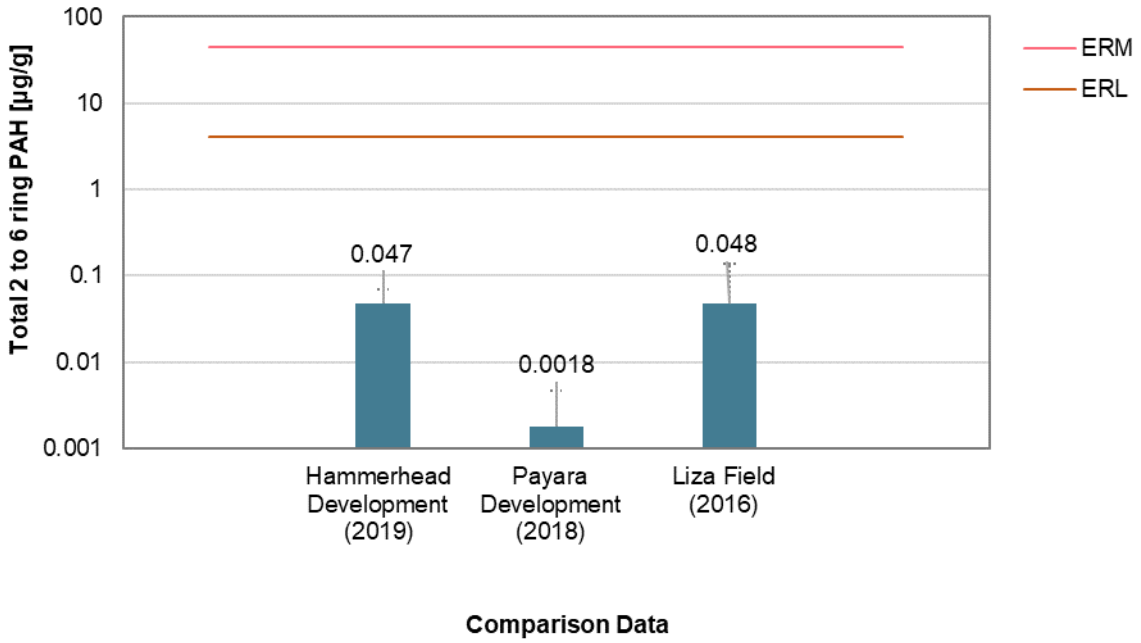
Most natural and anthropogenic contaminants have a higher affinity to fine particulate matter than coarse sediments, due to the increased adsorption capacity of organic matter and clay minerals. Natural sediment contaminant concentrations will be closely related to the distribution of fine grained material with the effects of other sources of contaminants, for example anthropogenic sources, at least partly obscured by sediment characteristics (ICES, 2009; 2012). PAHs are lipophilic and bind strongly to organic matter in sediments (Davies, 2004).

The potential environmental effects of 2 to 6 ring PAH compounds present were assessed by comparisons with available comparable environmental data. The PAH concentrations can be directly compared with their assigned ERL and ERM threshold values where available (Table 10.1 and Figure 10.2;).

Table 10.1: Comparison of Polycyclic Aromatic Hydrocarbons (PAH) with Regional and Reference Values, Hammerhead Development

Parameter	Hammerhead Development (2019) Mean	Payara Development (2019a) Mean	Liza Field (2016) Mean	NOAA ERL (Buchman, 2008)	NOAA ERM (Buchman, 2008)
Naphthalene	0.0011	0.0002	0.001	**0.160**	**2.10**
C_1-naphthalene	< 0.001	< 0.001	0.001	-	-
C_2-naphthalene	0.001	< 0.001	0.002	-	-
Acenaphthylene	< 0.0001	< 0.0001	0.0001	**0.044**	**0.640**
Acenaphthene	< 0.0001	< 0.0001	0.0003	**0.016**	**0.500**
Fluorene	0.0001	< 0.0001	0.0005	**0.019**	**0.540**
Phenanthrene	0.0008	0.0002	0.003	**0.240**	**1.50**
C_1-phenanthrene	0.001	< 0.001	0.002	-	-
C_2-phenanthrene	0.002	< 0.001	0.003	-	-
Dibenzothiophene	< 0.001	< 0.001	0.001	-	-
C_1-dibenzothiophene	< 0.001	< 0.001	0.001	-	-
Anthracene	0.0001†	< 0.001	0.0006	**0.0853**	**1.10**
Fluoranthene	0.0006	< 0.0001	0.0019	**0.600**	**5.10**
Pyrene	0.0005	0.0001	0.0012	**0.665**	**2.60**
Benz(a)anthracene	0.0002	< 0.0001	0.0006	**0.261**	**1.60**
Chrysene	0.0005	0.0001	0.0009	**0.384**	**2.80**
Benzo(a)pyrene	0.0002	< 0.0001	0.0004	**0.430**	**1.60**
Benzo(ghi)perylene	0.0004	0.0001	0.0005	-	-
Indeno(1,2,3-cd)pyrene	0.0003	0.0001	0.0004	-	-
Total 2 to 6 Ring PAH	**0.0470**	**0.0018**	**0.048**	**4.022***	**44.792***

Notes:
ERL = Effects range low
ERM = Effects range median
NOOA = National Oceanic and Atmospheric Administration
Values expressed as µg/g dry sediment
* = Total 2 to 6 ring PAH concentration (Buchman, 2008)
† = Where more than half the reported values were less than half minimum reporting (MRV). mean values calculated using MRV



Notes:
Log_{10} scale used to present data
Error bars represent 95th percentile
2 to 6 PAH = Total 2 to 6 ring PAH concentration (expressed as µg/g dry sediment)
ERM = Effects range median (Buchman, 2008)
ERL = Effects range low (Buchman, 2008)
Hammerhead development (2019) = Mean estimated from current survey data
Payara development (2018) = Mean estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)
Liza field (2016) = Mean estimated from an environmental survey in the neighbouring Liza field in 2016 (Fugro, 2016)

Figure 10.2: Comparison of sediment 2 to 6 ring aromatic hydrocarbons concentrations with regional/background data sets, Hammerhead development

Total 2 to 6 ring PAH concentrations ranged from 0.034 µg/g to 0.064 µg/g with a mean concentration of 0.047 µg/g (Table 5.2). In order to assess the potential environmental effects, these concentrations were compared to available regional data (Tables 5.2 and 10.1) and assigned NOAA ERL and ERM thresholds (Buchman, 2008), (Table 10.1 and Figure 10.2). The mean total 2 to 6 ring PAH concentration recorded at the Hammerhead development was higher than the mean recorded at the Payara development (0.0018 µg/g; Fugro, 2019a) but comparable to those recorded at the Liza field (0.048 µg/g; Fugro, 2016). For the US EPA 16 compounds assessed, the mean concentrations reported within the Hammerhead survey area were below the NOAA ERL and ERM threshold concentrations (Buchman, 2008). Consequently, it is unlikely that the PAH concentrations present in the Hammerhead sediments would have a detrimental effect on the marine macrofaunal community.

10.4 Sediment Metals

10.4.1 Heavy and Trace Metals

The analysis of samples for heavy metal content can provide further corroboration in conjunction with the physical characteristics and hydrocarbon content of marine sediments in assessing either the background levels or the dispersion of discharged material around offshore installations.

Metals and metalloids occur naturally in the marine environment and are widely distributed in both dissolved and sedimentary forms. Some are essential to marine life while others have no biological function and therefore are toxic to numerous organisms at certain levels (Paez-Osuna and Ruiz-Fernandez, 1995; Boening, 1999). Metals can enter the environment via natural methods such as riverine transport, coastal discharges, geological weathering and atmospheric fallout (Brady et al., 2015). Other routes into marine sediments are from anthropogenic activities such as direct discharges from industrial activities.

Trace metal contaminants in the marine environment tend to form associations with the non-residual phases of mineral matter, such as iron and manganese oxides and hydroxides, metal sulphides, clays, organics and carbonates (Warren and Zimmerman, 1993; Dang et al., 2015; Wang et al., 2015). Non-residual trace metals are associated with more reactive and available sediment components through processes such as adsorption onto mineral surfaces and organic complexation. Metals associated with these more reactive phases are prone to various environmental interactions and transformations (physical, chemical and biological) potentially increasing their mobility and biological availability (Tessier et al., 1979; Warren and Zimmerman, 1993; Du Laing et al., 2009). Residual trace metals are defined as those which are part of the crystal structure of the component minerals and are generally unavailable to organisms (de Orte et al., 2018). Therefore, in monitoring trace metal contamination of the marine environment, it is important to distinguish the more mobile non-residual trace metals from the residual metals held tightly in the sediment lattice (Chester and Voutsinou, 1981), which are of comparatively lesser environmental significance because of their low reactivity and availability.

In this study, an analytical procedure involving the digestion of sediment in aqua regia was employed to analyse the elemental content of the sediments. The aqua regia digest releases for analysis the ‘non-residual’ heavy metals, which are not incorporated in the mineral matrix and are therefore potentially available for biological uptake.

All bioavailable metals concentrations in the sediments within the Hammerhead survey area exhibited low interstation variability across the survey area (RSD ≤ 21 %; Table 6.1). Despite the low variability, metals concentrations were generally lowest at station EBSHH_07 and highest at station EBSHH_02.

Mean metals concentrations were generally higher within the Hammerhead development in the current study than reported within the Payara development in 2018 (Fugro, 2019a), with the exception of arsenic (Table 10.2). The mean arsenic concentration reported in 2018 was elevated largely due to one outlier and featured high interstation variability (Figure 10.3). Arsenic concentrations reported within the current survey are broadly comparable to the majority of arsenic concentrations reported within the Payara development in 2018 (Fugro, 2019a).

The metals of biological interest were compared against their respective NOAA ERL and ERM values (Buchman, 2008). Metals concentrations were generally below NOAA ERL levels (Buchman, 2008), with the exception of arsenic and nickel, which exceeded their respective ERL values at the majority of stations (Table 6.1, Figure 10.3). No metals concentrations exceeded NOAA ERM levels (Buchman, 2008).

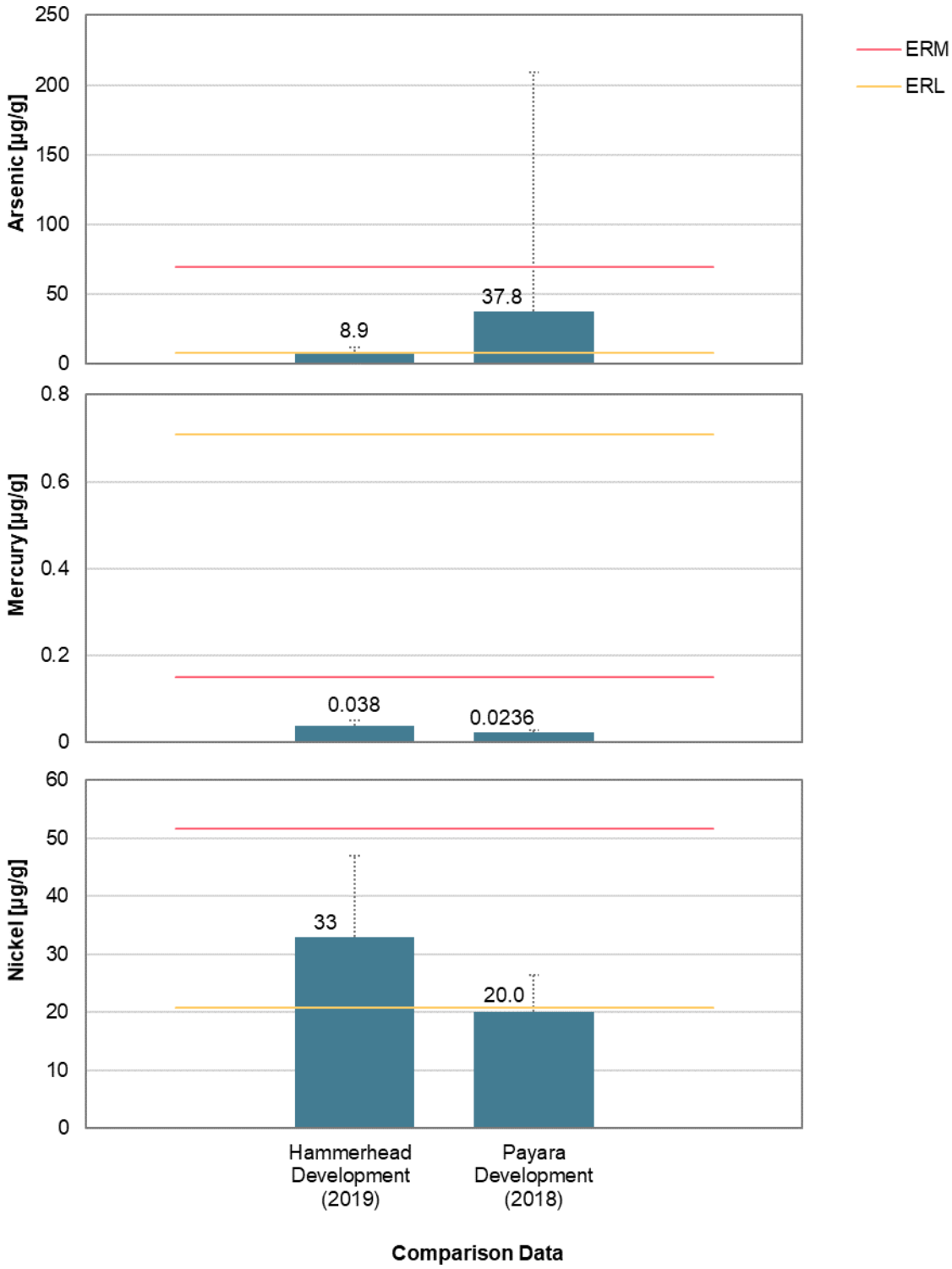
Metals could be, in part, introduced from contaminated terrestrial runoff from Guyana's mining industry via the main riverine inputs to the Guyana basin (TDI Brooks, 2014). Arsenic is a known by-product of gold mining, which is a key industry in Guyana. Arsenic enriched sediments, possibly related to gold mining, were previously observed in the region at the Liza field in 2016 and the Payara development in 2018 (Fugro, 2016; 2019a). Other potential sources of arsenic into the marine sediments are from geogenic sources, as arsenic is known to originate from arsenic bearing minerals such as arsenopyrite. The elevated concentrations of arsenic in this survey, as within the Payara development in 2018, coincide with higher concentrations of iron and such minerals can be transported to marine sediments from riverine discharges into the Atlantic.

If NOAA ERL and ERM values are exceeded, there is a higher probability that sediment quality will be impaired and impact the benthic community. However, elevated concentrations of both arsenic and nickel have been reported elsewhere within the region, with no observed impact on the macrofaunal community. For example, within the Payara development in 2018, reported concentrations were comparable to the current study and approached or exceeded the ERL values (Fugro, 2019a). Correlation analysis provided no indication, within the current survey or within the Payara development in 2018, that the metals concentrations reported influence the sediment macrofauna within this region. Consequently, there is unlikely to be any negative impact on the macrofaunal community from the concentrations of metals present in the sediment.

Table 10.2: Comparison of Sediment Metals Concentrations with Background and Reference Values, Hammerhead Development

Parameter	Hammerhead Development (2019) Mean	Payara Development (2018) Mean	Marine Sediment Assessment Criteria (Buchman, 2008)	
Aqua Regia Digest			**ERL**	**ERM**
Arsenic	8.9	37.8	**8.20**	**70.0**
Cadmium	0.14	-	**1.20**	**9.60**
Chromium	50	30.3	**81.0**	**370**
Copper	17	15.1	**34.0**	**270**
Mercury	0.038	0.0236	**0.150**	**0.710**
Nickel	33	20.0	**20.9**	**51.6**
Lead	19	12.3	**46.7**	**218**
Zinc	85	60.5	**150**	**410**

Notes:
Concentrations expressed in µg/g dry weight
ERL = Effects range low
ERM = Effects range median



Notes:
Error bars represent 95th percentile
Hammerhead development (2019) = Mean of current survey in Hammerhead development survey area
Payara development (2019a) = Mean of in the neighbouring Payara development in 2018 (Fugro, 2019a)
ERL/ERM = Effects range low/median (Buchman, 2008)
Hammerhead development (2019) = Mean estimated from current survey data
Payara development (2018) = Mean estimated from an environmental survey in the neighbouring Payara development in 2018 (Fugro, 2019a)

Figure 10.3: Comparison of sediment arsenic, mercury and nickel concentrations (means) with regional/background data sets, Hammerhead development

10.5 Water Samples

10.5.1 Water Profiles

Water column profile results from all stations displayed a defined thermocline, halocline, pH boundary and oxygen boundary. Surface temperatures were comparable between stations, decreasing with water depth, a thermocline was present at approximately 400 m at all stations. Turbidity results were constant throughout the water column.

Salinity was generally lowest at the sea surface, likely to be influenced by precipitation and freshwater input from the Essequibo River in Guyana. A distinct halocline was observed at approximately 200 m, after which salinity remained at approximately 35.0 PSU.

The oxygen content of natural waters varies with temperature, salinity, turbulence, the photosynthetic activity of algae and plants, and atmospheric pressure. Biological respiration, including that related to decomposition processes, reduces dissolved oxygen concentrations. The solubility of oxygen decreases as temperature increases. Dissolved oxygen decreases with an increase in salinity. Dissolved oxygen saturation ranged from 33.4 % near the seabed to 108 % near the surface, demonstrating that surface waters within the survey area were at near oxygen saturation, at the time of survey, with no indication of oxygen depletion.

At all water sampling stations, the pH decreased slowly with increasing depth. The US EPA quote a normal range for seawater as pH 6.5 to 8.5 (US EPA, 2018) and the seawater pH values for the current survey conform to this range.

10.5.2 Nutrients and Total Suspended Solids (TSS)

In water the forms of nitrogen that are of most interest are nitrate, nitrite, ammonia and organic nitrogen. Nitrate is the final oxidation product of nitrogen compounds in seawater and is considered the most thermodynamically stable oxidation level under aerobic conditions; it is one of the most important nutrients controlling primary production. Nitrite forms the intermediate between the reduction of nitrate and the oxidation of ammonia in sea and estuarine water. The concentrations of nitrite are typically low except in transition zones between oxic and anoxic conditions (Mordy et al., 2010). In oxygenated natural water systems, nitrite is rapidly oxidised to nitrate and consequently, concentrations of nitrite would be expected to be low.

The concentrations of the various chemical parameters measured in the water samples collected in the Hammerhead survey area were low, with both nitrite and TKN concentrations below the MRV throughout indicating that there is no notable anthropogenic pollution present in the survey area. Little evidence of stratification was demonstrated, with the mean concentrations of reported nitrogen compounds broadly comparable at all sampled depths.

Total suspended solids are important indicators of water quality and can be indicative of sediment transport and discharge from drilling activities. No evidence of stratification was present for the Hammerhead water column samples, suggesting a well-mixed distribution of TSS throughout the water column. The mean TSS values in the current survey were higher than those from the Payara development (Fugro, 2019a) and the Liza field survey (Fugro, 2016) at comparable depths. There are large seasonal variations in suspended particulate matter and the current survey was conducted during

the rainy season, potentially accounting for the higher suspended solids content due to increased riverine discharges from the Amazon River (Martinez, et al. 1999). TSS content in the Hammerhead water column is likely to originate from the northward movement of suspended material from the Amazon River and other major rivers that discharge into the Atlantic (Pujos and Froidefond, 1995).

TOC consists of both dissolved and particulate organic carbon and can be an approximate indicator of productivity in marine waters where anthropogenic inputs are not present. The mean TOC values observed at the Hammerhead development were comparable at different depths suggesting no evidence of stratification. The mean TOC values observed were higher than those recorded at the Payara development (Fugro, 2019a), but lower than the mean values recorded at the Liza field survey (Fugro, 2016).

10.5.3 Hydrocarbons

Hydrocarbon content can be used as an indicator of petrogenic inputs into water columns. This is because soluble fractions of hydrocarbons can partition between dissolved and particulate bound phases in the water column (Latimer and Zheng, 2003; Thibodeaux et al., 2011). THC and PAH levels were generally low and therefore considered to be representative of background concentrations.

10.5.4 Metals

Heavy and trace metal concentrations were low in most water samples, being close to or below their respective MRVs in the majority of samples across the Hammerhead development. Metals concentrations were broadly comparable to those reported previously in the region, in the Liza field and the Payara development (Fugro, 2016; 2019a). No metals concentrations exceeded the US EPA CCC or CMC values (US EPA, 2018). Consequently, the metals concentrations within the water samples are unlikely to negatively impact the benthic or pelagic biota.

No trends were observed between metals concentrations and depth in the Hammerhead water samples.

10.6 Seabed Habitats

The ‘Biotopes/Ecosystems Nomenclature, Habitats of South America’ (Institute of Terrestrial Ecology, 1996) allowed the Hammerhead survey area to be broadly split in to two biotope complexes: ‘Sublittoral soft seabeds (11.22) observed on drop-down video stations and ‘Deep-sea floor” (11.21) observed on transects TR01 to TR06.

More detailed habitat classifications were assigned to the survey area using the EUNIS (2012) classification system. Areas of low sonar reflectivity, assigned ‘Sublittoral soft seabeds (11.22) (Institute of Terrestrial Ecology, 1996), corresponded with the level three EUNIS (2012) classification of ‘Sublittoral mud’ (A5.3). The Institute of Terrestrial Ecology (1996) habitat classification of ‘Deep-sea floor” (11.21), assigned to areas with gravelly, muddy sand and elevated exposed seabed was further split in to two EUNIS habitat classifications. Gravelly, muddy sand sediments where epifaunal diversity and abundance was low, were classified ‘Deep-sea muddy sand’ (A6.4), although epifauna communities were sparse pencil urchins (Cidaridae), small unidentified fish (Pisces), sea cucumber (Holothuroidea) and starfish (Asteroidea) were occasionally observed; bioturbation in the form of faunal holes was recorded, suggesting an active infaunal community. The EUNIS (2012) classification of ‘deep-sea rock and artificial hard substrata’ (A6.1) was assigned to elevated, exposed bedrock; epifaunal community

comprised predominantly of sessile taxa such as sponges (Porifera), sea fan (Gorgoniidae), sea whip (Octocorallia), black coral (Antipatharia), wire coral (*Stichopathes* sp.) and stony coral (Scleractinia). Epifaunal abundance and diversity increased in areas where hard substrate was prevalent.

10.7 Macrofaunal Communities

Seabed sediments provide support, protection and the food source for many macrofaunal species. The sediment macrofauna, most of which are infaunal (living within the sediment), are therefore particularly vulnerable to external influences which alter the sediments' physical, chemical or biological nature. Such infaunal animals are largely sedentary and are thus unable to avoid unfavourable conditions. Each species has its own response and degree of sensitivity to changes in the physical and/or chemical environment and consequently the species composition and their relative abundance in a particular location provides a reflection of the health and condition of the immediate environment, both current and historical. The recognition that aquatic contaminant inputs may alter sediment characteristics, together with the relative ease of obtaining quantitative samples from specific locations, has led to the widespread use of infaunal communities in monitoring the impact of disturbances to the marine environment over a long period of time.

Phyletic composition of the macrofaunal community within the Hammerhead development was broadly comparable to previously reported macrofaunal communities within the area, with arthropods, annelids and molluscs consistently the most diverse and abundant phyla in surveys within the area, and echinoderms and other phyla reported at relatively low abundance and diversity (Table 10.3). Peanut worms (Sipuncula), ribbon worms (Nemertea) and taxa within the phylum Cnidaria are frequently reported within the other phyla within the area. The phyletic composition reported within the current survey is typical of deep-sea macrofaunal communities, which are generally dominated by annelids, followed by small-bodied arthropods and molluscs. Polychaetes typically comprise more than a third of the number of taxa and approximately half of the number of individuals in sedimentary deep-sea communities (Gage and Tyler, 1991).

Due to the low abundance of all taxa, the characteristic taxa varied between stations. Across the survey area the molluscs *Ennucula* and *Microgloma mirmidina* and those of the class Caudofoveata, the arthropods *Typhlotanais*, and those of the family Desmosomatidae, the annelids *Ophelina* and *Fauveliopsis*, the brittlestar *Ophiotholia* and the peanut worms *Aspidosiphon* (*Akrikos*) *zinni* and *Phascolosoma*? were the most abundant. Several other locally abundant taxa were identified, including the arthropod *Apseudes* sp. B and the annelid *Aricidea.* Despite the heterogeneity across the survey area, all characteristic taxa are typical of sedimentary deep-sea environments.

Paraonidae (e.g. *Aricidea*) is one of the most abundant polychaete families in sedimentary deep-sea communities. Opheliidae (e.g. *Ophelina*) and Cirratuliformia (e.g. *Fauveliopsis*) are also typical. Bivalves are the most abundant molluscs within deep-sea habitats, with the Nuculidae (e.g. *Ennucula* and *Microgloma mirmidina*) prominent (Gage and Tyler, 1991). The dominance of bivalves over gastropods within the current survey reflects the high fines content of the sediment recorded at all stations (≥ 67.8 %). Tanaids and isopods are extremely diverse within the deep-sea, in comparison to shallower waters. Within the tanaids, this is particularly true for those in the suborder Tanaidomorpha (e.g. *Typhlotanais*), with the larger suborder Apseudomorpha (e.g. *Apseudes* sp. B) more rarely represented, featuring elevated abundance with greater depth (Gage and Tyler, 1991). The worm-like

mollusc Aplacophora (e.g. Caudofoveata) and the phylum Sipuncula (e.g. *Aspidosiphon* (*Akrikos*) *zinni* and *Phascolosoma*?) are often relatively abundant in the deep-sea (Gage and Tyler, 1991). Within deep-sea communities, errant megafauna are generally dominated by the echinoderms, with brittlestars of the class Ophiuroidea (e.g. *Ophiotholia*) amongst the most commonly reported.

Table 10.3: Taxonomic Groups, Hammerhead Development and Historical Comparable Data

Taxonomic Group	Hammerhead Development (Current Survey)*	Payara Development (Fugro, 2019a)†	Liza Field (Fugro, 2016)‡
Composition of Taxa [%]			
Annelida	32.9	35.6	40.0
Arthropoda	40.7	39.0	38.2
Mollusca	18.6	16.9	12.7
Echinodermata	3.6	3.4	3.0
Other phyla	4.3	5.1	6.0
Composition of Individuals [%]			
Annelida	27.7	51.0	42.7
Arthropoda	34.0	30.3	39.1
Mollusca	26.0	9.0	8.7
Echinodermata	4.6	2.6	1.6
Other phyla	7.8	7.1	7.9

Notes:
* = Other phyla include: Cnidaria, Nemertea and Sipuncula
† = Data from an environmental survey in the neighbouring Payara development in 2018, in depths of ca. 1800 m to ca. 2100 m. 0.2 m^2 stations processed through a 0.5 mm sieve. Other phyla included: Sipuncula (Fugro, 2019a)
‡ = Data from an environmental survey in the neighbouring Liza field in 2016, in depths of ca. 500 m to ca. 2800 m. 0.1 m^2 stations processed through a 0.5 mm sieve. Other phyla include: Cnidaria, Nemertea and Echiura (Fugro, 2016)
Macrofaunal samples were processed through a 0.5 mm sieve in all surveys

Univariate analysis indicated that diversity was high across the survey area (mean H'Log^2 4.88; Dauvin et al., 2012), higher than reported in slightly deeper waters within the Payara development in 2018 (Fugro, 2019a) and from a wide depth range in the Liza field in 2016 (Fugro, 2016). Evenness was also high indicating that faunal abundances were evenly distributed across the taxa recorded. The mean Pielou's evenness index reported in the current survey was broadly comparable to that reported from the Liza field in 2016 and within the Payara development in 2018 (Fugro, 2016; 2019a). Deep-sea macrofaunal communities generally feature high taxonomic diversity (Gage and Tyler, 1991).

There was a low to moderate degree of faunal similarity across the Hammerhead development survey area, with stations clustering with between 19.3 % and 37.4 % similarity. Such similarities are likely due to the number of taxa reported at low abundance, often as a single specimen within the survey area. When untransformed data was considered, two statistically significant clusters were apparent, with the macrofaunal community at the two shallowest stations (stations EBSHH_07 and EBSHH_08 in water depths of < 800 m) significantly different to that at the remaining six deeper stations.

Table 10.4: Comparison of the Top Ten Most Abundant Taxa in the Region

Hammerhead Development (Current Survey)	Payara Development (Fugro, 2019a)*	Liza Field (Fugro, 2016)†
Ennucula	*Spiophanes*	*Spiophanes* (dam.)
Desmosomatidae	Balanidae sp. A	*Myriochele*
Typhlotanais	Oweniidae	Ampeliscidae
Ophiotholia	*Bathyglycinde profunda*	Ampharetidae (dam.)
Aspidosiphon (Akrikos) zinni	***Aspidosiphon zinni***	*Glabroapseudes*
Phascolosoma?	*Kirkegaardia*	*Monticellina*
Ophelina	Ampeliscidae	**Desmosomatidae**
CAUDOFOVEATA	*Paradoneis*	*Harpinia* sp. A
Fauveliopsis	Five other taxa including *Collettea*, Ophiuridae sp. A, *Heteromesus*, **Opheliidae**, Cirratulidae	*Leptanthura affinis*
Microgloma mirmidina		***Aspidosiphon zinni***

Notes:
* = Top ten taxa from an environmental survey in the neighbouring Payara development in 2018, in depths of ca. 1800 m to ca. 2100 m. 0.2 m^2 stations processed through a 0.5 mm sieve (Fugro, 2019a)
† = Top ten taxa from an environmental survey in the neighbouring Liza field in 2016, in depths of ca. 500 m to ca. 2800 m. 0.1 m^2 stations processed through a 0.5 mm sieve. Number of taxa, diversity and evenness indices presented as original data. Number of individuals per 0.2 m^2 estimated from 20 per 0.1 m^2 and presented for comparison (Fugro, 2016)
Bold = taxa reported in the current survey and at least one previous survey

Multivariate statistics highlighted that differences in the macrofaunal community were largely reflective of marginally increased abundance of several taxa within shallower stations, and the presence or absence of taxa associated with different depth ranges. For example, tanaid arthropods (particularly *Apseudes* sp. A) were present in higher abundance at the majority of stations sampled in deeper waters (> 800 m). Additionally, several bivalve molluscs (e.g. *Ennucula* and *Ledella pustulosa* and those of the family Veneroidea sp. A) were reported from shallower stations but were absent (or present at low abundance) from deeper stations. As discussed above, all these taxa are typical of deep-sea communities, with bivalves generally favouring sedimentary habitats.

Despite the differences suggested in the macrofaunal community with depth in preceding sections of this report, depth was not significantly correlated with any macrofaunal parameters. As previously mentioned, no significant correlations were demonstrated between macrofaunal parameters and the physical or chemical parameters. This is in part due to the low interstation variability in the majority of parameters across the survey area. The mean particle size was highest at shallower stations EBSHH_07 and EBSHH_08 (Table 4.1), where the highest proportions of sand were also reported (Table 4.2). Consequently, it is likely that the differences observed in the macrofaunal community are the result of small differences in one or several parameters associated with depth rather than depth itself (e.g. natural sediment characteristics).

11. CONCLUSIONS

The aim of this report has been to evaluate the existing physical/chemical components in the marine environment within the survey area. A review of the environmental data in context with other cited studies from the region and estimated sediment effects threshold values (US EPA, 2018, Buchman, 2008) was also undertaken. Based on the overall assessment of the survey area, the following key conclusions can be stated:

The sediments across the Hammerhead survey area were all classed as very poorly sorted, with the exception of station EBSHH_04 which was described as poorly sorted, sediment composition was primarily fines and sands. Using the Wentworth (1922) sediment description, five stations were classified as ‘fine silt’, two were classified as ‘very fine silt’ and one station was classified as ‘medium silt’.

The gas chromatographic profiles obtained from sediments collected from within the Hammerhead survey area were typical of background sediments, displaying weathered low-level petroleum and biogenic hydrocarbons and associated UCM, commonly found in marine sediments. The total 2 to 6 ring PAH concentrations were low across the survey area, with the United States Environmental Protection Agency’s 16 priority PAH pollutants (US EPA 16 PAH) below their respective ERL values at all stations.

All bioavailable metals concentrations in the sediments within the Hammerhead survey area exhibited low interstation variability across the survey area (RSD ≤ 21 %). Metals concentrations were generally below the NOAA ERL threshold, with the exception of arsenic and nickel, which exceeded their respective ERL values at the majority of stations. No metals concentrations exceeded the NOAA ERM thresholds. Despite arsenic and nickel exceeding their respective ERL values, both metals were reported in concentrations that were comparable to available regional data and thus are considered typical of the region.

Water profiles showed a stratified water column, with a defined thermocline, halocline and oxygen boundary down to ca. 400 m, after which values remained relatively constant. Turbidity remained constant throughout the profile.

The nitrogen compounds, TOC and TSS values derived from the Hammerhead water samples showed no evidence of stratification as the mean values for all parameters for each depth profile were comparable.

Water sample THC and PAH concentrations across the survey were low and values were indicative of background concentrations. There were no clear spatial trends in concentrations of the hydrocarbon parameters across the survey area and no clear relationship between concentrations of these analytes and depth.

The metals concentrations reported in water samples within the Hammerhead development were low, with the majority of metals present in concentrations close to or below their respective MRVs. No metals concentrations exceeded their respective US EPA CCC or CMC values (US EPA, 2018). No spatial or depth patterns were observed. As such, the metals concentrations within the water samples are unlikely to negatively impact the benthic or pelagic biota.

Analysis of the photographic data allowed the Hammerhead survey area to be split in to two broad habitats in accordance with 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (Institute of Terrestrial Ecology, 1996). 'Sublittoral soft seabeds' (11.22) and 'deep-sea floor' (11.21). The EUNIS (2012) classification allowed these habitats to be further split in to three distinct habitats: Areas designated 'Sublittoral soft seabeds (11.22) (Institute of Terrestrial Ecology, 1996) corresponded with fine sediments and were assigned the level three EUNIS (2012) classification of 'sublittoral mud' (A5.3). Areas assigned 'deep-sea floor" (11.21) (Institute of Terrestrial Ecology, 1996) were further spilt into two separate habitats: 'deep-sea muddy sand' (A6.4) defined areas with gravelly, muddy sand sediments with low epifaunal diversity and abundance. 'Deep-sea rock and artificial hard substrata' (A6.1) defined elevated, exposed bedrock with higher epifaunal diversity and abundance.

Within the faunal community present at the Hammerhead survey area, arthropods were the most diverse and abundant phyla, followed by annelids and then molluscs, this is similar to the faunal communities previously recorded at the Payara development (Fugro, 2019a) and the Liza field (Fugro, 2016).

Univariate analysis demonstrated that although abundance of all taxa was low, macrofaunal diversity was high. Multivariate statistics highlighted that differences in the macrofaunal community were largely reflective of a marginally elevated abundance of several taxa within shallower stations, and the presence or absence of taxa associated with different depth ranges. The differences in the macrofaunal community are likely driven by small differences in the sediment characteristics associated with depth rather than depth itself, with the macrofaunal community across the survey area typical of deep-sea sedimentary habitats.

No meaningful correlations were observed between the macrofaunal community and the rest of the physico-chemical parameters sampled across the Hammerhead survey area.

Overall, the environmental data obtained from the Hammerhead survey area is typical of background conditions.

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I. CORRELATIONS-SEDIMENTS

A. GUIDELINES ON USE OF REPORT

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B. METHODOLOGIES

B.1 LABORATORY ANALYSIS - SEDIMENTS

B.1.1 Particle Size Analysis (PSA)

Particle size analysis (PSA) was conducted by Fugro GB Marine Limited (FGBML).

B.1.1.1 Dry Sieve Analysis

Particle size distribution (PSD) analysis was undertaken in accordance with FGBML in-house methods based on the National Marine Biological Association Quality Control scheme's (NMBAQC) best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis, and BS1377: Parts 1: 2016 and 2: 1990.

Representative material > 1 mm was split from the bulk subsample and oven dried before sieving through a series of sieves with apertures corresponding to 0.5 phi intervals between 63 mm and 1 mm as described by the Wentworth scale (Wentworth, 1922). The weight of the sediment fraction retained on each mesh was subsequently measured and recorded.

B.1.1.2 Laser Diffraction

Particle size distribution (PSD) analysis was undertaken in accordance with FGBML in-house methods based on the NMBAQC best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis, and BS ISO 13320: 2009.

Representative material < 1 mm was removed from the bulk subsample for laser analysis, a minimum of three triplicate analyses (mixed samples) or one triplicate analyses (sands) were analysed using the laser sizer at 0.5 phi intervals between < 1 mm to < 3.9 µm. Laser diffraction was carried out using a Malvern Mastersizer 2000 with a Hydro 2000G dispersion unit.

B.1.2 Total Organic Carbon (TOC)

Sediment samples were analysed for total organic carbon (TOC) by Exova Jones Environmental.

The dry, homogenised sample was treated with hydrochloric acid, then rinsed with deionised water to remove mineral carbon. The sample was then combusted in an Eltra TOC furnace/analyser in the presence of oxygen. Organic carbon was oxidised to CO_2 and measured by non-dispersive infrared analysis. This method does not quantify volatile organic carbon, which should be determined by another technique. The minimum reporting value (MRV) for this method was < 0.02 % w/w.

B.1.3 Hydrocarbon Analysis in Sediments

Hydrocarbon analysis of sediments was carried out by FGBML.

B.1.3.1 General Precautions

To effectively eliminate all possible sources of hydrocarbon contamination from the analysis the following precautionary measures were taken prior to sample work-up:

- All solvents were purchased as high purity grade. Each batch was checked for purity by concentrating approximately 400 mL down to a small volume (< 1 mL) and analysing by gas chromatography (GC);
- All water used was distilled through an all glass still and dichloromethane extracted to minimise contamination from plasticisers;
- All glassware was cleaned using an acid/base machine wash. The glassware was rinsed with acetone then finally with dichloromethane prior to use;
- Procedural blanks, replicate analyses and laboratory reference material were run with each batch.

B.1.3.2 Ultrasonication Extraction for Hydrocarbons in Sediment

Sediment samples were thawed, homogenised and accurately weighed into a 250 mL conical flask. A solution containing an appropriate amount of the following internal standards was added to each sample using a microsyringe.

Aliphatic Standards	Aromatic Standards
Heptamethylnonane	D_8 naphthalene
D_{34} Hexadecane	D_{10} acenaphthene
D_{42} Eicosane	D_{10} phenanthrene
Squalane	D_{10} pyrene
	D_{12} chrysene
	D_{12} perylene

Methanol (50 mL) and solvent were mixed with the sediment. Dichloromethane (DCM) (60 mL) was then added and the sample mixed again. The flasks were then capped with solvent cleaned aluminium foil and ultrasonicated for 30 minutes.

After being allowed to settle the solvent was decanted through a GF-C filter paper into a 1 litre separating funnel. The extract was then partitioned with 100 mL of DCM extracted distilled water and the DCM layer run-off into a clean 500 mL round-bottomed flask. The ultrasonic extraction was repeated a further two times using 50 mL DCM and 15 minutes of ultrasonication. Each time the filtered extract was partitioned with the remaining methanol/water in the separating funnel. The DCM extracts were bulked and reduced in volume to approximately 2 mL using a rotary evaporator, then further reduced to approximately 1 mL under a gentle stream of nitrogen prior to clean-up.

Correction factors for wet/dry sediments were obtained by drying a subsample of the homogenised sediment to constant weight at 105 °C.

B.1.3.3 Clean-up of Extracts by Column Chromatography

Removal of polar material, including lipids was carried out using a silica gel column. The silica gel used was 70 to 230 mesh which was heated at 400 °C for at least 4 hours to remove impurities and residual moisture and then stored at 200 °C prior to use. The sample extract was added to the silica gel column, containing 5 g of adsorbent and eluted with 35 mL of DCM/pentane (1:2). The eluant was reduced in volume using the evaporator to approximately 2 mL, with activated copper powder (for removal of free sulphur), before being further reduced under a gentle stream of nitrogen to an appropriate volume and analysed by both gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS).

Instrument	Gas Chromatography [GC]	Gas Chromatography-Mass Spectrometry [GC-MS]
	HP 6890 Series GC with 7673 autoinjector	HP 7890 Series GC with autoinjector and 5977A MSD
Column	100 %-dimethylpolysiloxane bonded fused silica, 60 m, 0.25 µm film thickness, 0.32 mm internal diameter	(5 %phenyl)-methylpolysiloxane bonded fused silica, 60 m, 0.32 µm film thickness 0.25 mm internal diameter
Carrier Gas	Hydrogen (constant flow 3.5 mL /min)	Hydrogen (constant flow 1.4 mL/min)
Injector	On–column (2 µL injection)	Splitless, 280 °C, split flow 40 mL/min, vent time 1.5 min (1 µl injection)
Oven Temperature Programme	80 °C – 2 min 80 °C to 320 °C at 18 °C/min 320 °C – 13 min 320 °C to 350 °C at 30 °C/min	60 °C – 1 min 60 °C to 180 °C at 11 °C/min 180 °C to 260 °C at 6 °C/min 260 °C to 320 °C at 6 °C/min 330 °C – 7 min
Source/Detector Temperature	350 °C (FID)	230 °C
Electron Energy	-	70 eV
Selected Ion Monitoring (SIM)	-	9 groups - 6 ions per group
Dwell Time (per ion)	-	0.035 second

B.1.3.4 Total Hydrocarbons by Gas Chromatography–Flame Ionisation Detection (GC-FID)

The total hydrocarbon material present was quantified using response factors calculated from the analysis of mixed oil standard solutions over an appropriate range. The unresolved complex mixture (UCM) was determined by subtracting the area of all the resolved peaks from the total hydrocarbon area and applying the total hydrocarbon response factor.

B.1.3.5 n-Alkanes, Pristane and Phytane

Calibration was undertaken using a range of n-alkane standard solutions containing the even carbon number compounds between nC_{12} and nC_{36}, and a range of suitable internal standards. Individual response factors were calculated for each of the n-alkanes present in the calibration solution. Response factors for the non-calibrated n-alkanes (and pristane and phytane) were taken to be equivalent to closely eluting compounds.

The n-alkanes between nC_{12} and nC_{36} were reported, as were the ranges between nC_{12} and nC_{20} and nC_{21} to nC_{36}. Carbon preference index (CPI) values (the ratio of odd to even carbon numbered compounds) for the same ranges were also calculated. Pristane and phytane (and associated ratio) were also determined.

B.1.3.6 Polycyclic Aromatic Hydrocarbons (PAHs)

A full range of polycyclic aromatic hydrocarbons (PAHs) and alkylated PAH were quantified as specified by Department of Trade and Industry (DTI) regulations (DTI, 1993).

Calibration was undertaken using a range of PAH standard solutions, a number of alkylated PAH, dibenzothiophene and a range of suitable internal standards. Individual response factors were calculated for each of the compounds present in the calibration solution. Response factors for the non-calibrated alkylated PAH were taken to be equivalent to closely related compounds. The MRV of individual PAHs is 0.1 ng/g and 1 ng/g dry weight for alkylated PAHs.

B.1.4 Heavy and Trace Metals in Sediments

Analysis of sediment metals content was conducted by the National Laboratory Service.

Sediment samples were air dried at 30 °C and then sieved to the required size fraction (2000 µm). Samples were subjected to an aqua regia microwave digestion, with the exception of selenium which underwent an aqua regia block digest under reflux. This acid mixture allows a partial dissolution of metals from most soil and sediment types which allows the bioavailable metals content to be analysed. Arsenic, cadmium, chromium, copper, lead, nickel and zinc were analysed by inductively coupled plasma-mass spectrometry (ICP-MS). Aluminium, barium, iron and selenium were analysed by inductively coupled plasma-optical emission spectrometry (ICP-OES).

Mercury content was determined by sieving the sample to < 2000 µm followed by a microwave assisted aqua regia digest, acidic stannous chloride reduction and determination by cold vapour-atomic fluorescence spectroscopy (CV-AFS).

B.1.5 Macrofaunal Analysis

Macrofauna analysis was carried out by FGBML benthic laboratories which are members of the NMBAQC scheme of external quality assurance.

On return to the laboratory, the samples were removed from formalin and washed through 0.5 mm mesh sieves. The material retained was then processed to remove fauna. The animals were separated by hand from the retained sediment by using a combination of stereo microscopes for the fine sediments and in white trays for any coarser material. Processed sediment is stored in phenoxetol (2 %) or returned to the original formalin.

Following extraction, the animals were identified and enumerated by specialist taxonomists. Identification was to species level where possible. Specimens which, due to their immaturity, damage incurred during processing or lack of suitable taxonomic literature, cannot be identified to species level are identified at higher taxonomic levels as appropriate. After identification, samples were stored in 70 % industrial denatured alcohol (IDA) or a mixture of 70 % ethanol/1 % propylene glycol/29 % water. A minimum of 10 % of samples within the project were re-analysed (for extraction, species identification, enumeration and data entry) as per NMBAQC quality control guidelines (Worsfold, 2010). Species abundances were entered on file in a spreadsheet package or the Unicorn database, both of which store and sort entries into taxonomic order and provide output files for numerical analysis. Nomenclature follows that given on the World Register of Marine Species (http://www.marinespecies.org/). The taxonomic order is based on Species Directory codes (Howson and Picton, 1997) to give an idea of ‘evolutionary rank’. Once all the entries had been checked, the resulting quantitative data were subjected to various statistical techniques to investigate community structure. All quantitative analyses were performed on species abundances pooled from the two replicates at each station, thus the sample size was 0.2 m^2 at all stations.

Prior to statistical analysis, the macrofaunal abundance data was manipulated to avoid spurious enhancement of community statistics. This involved the removal of all parasitic (e.g. Copepoda) and damaged (e.g. Sipuncula (dam.)) taxa, as well as juvenile (e.g. Sipuncula (juv.)) specimens, as they are not considered to be a permanent part of the community. Some indeterminate species were also

rationalised at a higher taxonomic level with another taxon in the same genus to maintain these data in the dataset (e.g. *Spiophanes* with Spionidae (dam.)).

B.1.6 Sampling and Analysis Requirements – Sediments

Analyte	Volume per Sample [g]	Sample Container	Fixative/Storage	Analysing Laboratory	Method Code	Method Description	Accreditation	LOD	Holding Time
Al	200	Ziplock bags (double bagged)	Freeze	NLS	IHM 1043	ICP-OES	UKAS	20 µg/g	30 days
As					IHM 1041	ICP-MS		1 µg/g	
Ba					IHM 1043	ICP-OES		0.4 µg/g	
Cd					IHM 1041	ICP-MS		0.2 µg/g	
Cr					IHM 1041	ICP-MS	UKAS	2 µg/g	30 days
Cu					IHM 1041	ICP-MS		1 µg/g	
Fe					IHM 1043	ICP-OES		20 µg/g	
Ni					IHM 1041	ICP-MS		1 µg/g	
Pb					IHM 1041	ICP-MS		2 µg/g	
Zn					IHM 1041	ICP-MS		2.5 µg/g	
Se					IHM 914	ICP-OES		1 µg/g	
Hg					IHM 1042	CV-AFS	UKAS	0.01 µg/g	30 days
TOC	10	Ziplock bags	Freeze	Exova Jones	TM21/PM24	Combustion with NDIR	UKAS	0.02 %	30 days
PSD	200	Ziplock bags (double bagged)	Freeze	Fugro	BS 1377: 1990 Parts 1-3/ BS 13320:2009	Dry sieving/ laser diffraction	UKAS	0.01 %	5 years
THC	200	Amber glass	Freeze	Fugro	IHM	GC-FID	-	0.5 µg/g	181 days
n-Alkanes					IHM	GC-FID	-	0.5 ng/g	
PAH (EPA 16/alkylated)					IHM	GC-MS	-	0.1/1 ng/g	
Benthic macrofauna (0.5 mm)	Variable	1 L/5 L bucket	Formalin, ambient	Fugro	IHM	Microscopy	UKAS	NA	Indefinite

Notes:

Al = Aluminium; As = Arsenic; Ba = Barium; Cd = Cadmium; Cr = Chromium; Cu = Copper
Fe = Iron; Hg = Mercury; Ni = Nickel; Pb = Lead; Se = Selenium; Zn = Zinc
TOC = Total organic carbon
PSD = Particle size distribution
NDIR = Non-dispersive infrared detector
THC = Total hydrocarbon content
IHM = In house method
PAH = Polycyclic aromatic hydrocarbons
NA = Not applicable
GC-FID = Gas chromatography–flame ionisation detection
GC-MS = Gas chromatography-mass spectrometry
ICP-OES = Inductively coupled plasma-optical emission spectroscopy
ICP-MS = Inductively coupled plasma-mass spectrometry
CV-AFS = Cold vapour-atomic fluorescence spectroscopy
UKAS = United Kingdom Accreditation Service

B.2 LABORATORY ANALYSIS - WATERS

B.2.1 Total Suspended Solids (TSS)

Analysis of water samples for TSS content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 2540 D. Samples were filtered through a glass-fibre filter, which was then dried to a constant weight at 103 °C to 105 °C. The increase in the weight of the filter is representative of the TSS content of the water samples.

B.2.2 Total Organic Carbon (TOC)

Analysis of water samples for TOC content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 5310 C. Organic carbon is oxidised to CO_2 by persulfate in the presence of heat or ultraviolet light and the CO_2 is measured.

B.2.3 Nutrients (Nitrates, Nitrites and Total Kjeldhal Nitrogen)

Analysis of water samples for nitrates content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 4500-NO3 – E. Nitrates were obtained by using a spectrophotometric measurement in the UV range at 220 nm and 275 nm.

Analysis of water samples for nitrites content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 4500-NO2 – B. Nitrites were obtained through formation of a reddish purple azo dye produced at pH 2.0 to 2.5 by coupling diazotised sulfanilamide with N-(1-naphthyl)-ethylenediamine dihydrochloride (NED dihydrochloride).

Analysis of water samples for total Kjeldhal nitrogen (TKN) content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 4500-N-C. In the presence of H_2SO_4, potassium sulfate (K_2SO_4), and cupric sulfate ($CuSO_4$) catalyst, amino nitrogen of many organic materials is converted to ammonium. Free ammonia also is converted to ammonium. After addition of base, the ammonia is distilled from an alkaline medium and absorbed in boric or sulfuric acid. The ammonia may be determined colorimetrically, by ammonia-selective electrode, or by titration with a standard mineral acid.

B.2.4 Hydrocarbon Analysis

Analysis of water samples for hydrocarbon content was conducted by FGBML using the methods described in Section B1.3, although the following procedure was used in place of B.1.3.2:

B.2.4.1 Liquid-liquid Extraction Procedure

Water samples were thawed, weighed and poured into a 1 litre separating funnel. The empty sample bottle was then weighed. A solution containing an appropriate amount of the following internal standards was added to each sample using a microsyringe.

Aliphatic Standards	Aromatic Standards
Heptamethylnonane	D_8 naphthalene
D_{34} Hexadecane	D_{10} acenaphthene
D_{42} Eicosane	D_{10} phenanthrene
Squalane	D_{10} pyrene
	D_{12} chrysene
	D_{12} perylene

Approximately 50 mL of DCM was used to rinse the sample bottle and this was then poured into the separating funnel containing the sample and internal standard. The separating funnel was shaken thoroughly for approximately 30 seconds and the DCM layer run-off through a 100 mm diameter filter funnel containing a GF-C filter paper approximately half-filed with granular sodium sulphate into a clean 500 mL round-bottomed flask. This was repeated a further two times. The sodium sulphate in the filter funnel was then rinsed three times with approximately 30 mL of DCM.

The contents of the round-bottomed flask were then reduced in volume to approximately 2 mL using a rotary evaporator. The extract was transferred quantitatively into an 8 mL screw top vial, evaporated to approximately 1 mL under a gentle stream of nitrogen and approximately 2 mL of pentane was added to the vials. The clean-up and analysis procedures were then followed as for the sediment samples.

B.2.5 Metals

Analysis of water samples for metals content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 3030 F, SMEWW 3120 B. Samples were digested on a hot plate with the addition of concentrated nitric acid, then hydrochloric acid and water were added, and the sample was heated prior to adjusting the volume to 100 mL and analysing by ICP-OES.

B.2.6 Sampling and Analysis Requirements – Waters

Analyte	Volume per Sample [mL]	Sample Container	Fixative/Storage	Analysing Lab	Method Code	Method Description	Accreditation	MRV	Holding Time
Al	500	Plastic bottle	Nitric acid, refrigerate	Kaizen LAB	SMEWW 3030 F, 3120 B	ICP-OES	TT labs	50 µg/L	6 months
As								-	
Ba								50 µg/L	
Cd								0.40 µg/L	
Cr								8.0 µg/L	
Cu								8.0 µg/L	
Fe								200 µg/L	
Ni								5.0 µg/L	
Pb								3.0 µg/L	
Se								6.0 µg/L	
Zn								200 µg/L	
Hg								0.100 µg/L	30 days
TOC	2 × 40	Glass vials	Dihydrogen phosphate, refrigerate	Kaizen LAB	SMEWW 5310 C	Persulfate ultraviolet/ heated persulfate oxidation method	TT labs	-	7 days
TSS	1000	Plastic bottle	Refrigerate	Kaizen LAB	SMEWW 2540 D	Filtration, gravimetry (dried at 103 °C to 105 °C)	TT labs	-	7 days
THC	1000	Amber Glass	Freeze	Fugro	IHM	GC-FID	-	10 µg/L	152 days
n-Alkanes					IHM	GC-FID	-	-	
PAH (EPA 16/alkylated)					IHM	GC-MS	-	0.1/1 ng/L	
Spare	1000	Plastic bottle	Freeze	Fugro (spare)	NA	NA	NA	NA	NA

Notes:

Al = Aluminium; As = Arsenic; Ba = Barium; Cd = Cadmium; Cr = Chromium; Cu = Copper
Fe = Iron; Hg = Mercury; Ni = Nickel; Pb = Lead; Se = Selenium; Zn = Zinc
TOC = Total organic carbon
THC = Total hydrocarbon content
IHM = In house method
PAH = Polycyclic aromatic hydrocarbon
NA = Not applicable
GC-FID = Gas chromatography–flame ionisation detection
GC-MS = Gas chromatography-mass spectrometry
ICP-OES = Inductively coupled plasma-optical emission spectroscopy

B.3 STATISTICAL ANALYSIS

B.3.1 Correlations

Depth, crude granulometric data, chemical data and univariate indices of community structure were correlated using Spearman's Rank Correlation Coefficient. This is calculated as follows:

$$\rho = \frac{\sum(x-\overline{x})\,(y-\overline{y})}{\sqrt{\sum(x-\overline{x})^2\sum(y-\overline{y})^2}}$$

Where x and y are ranked vales for each variable.

The resultant test statistic (ρ) will range from -1 to 1, with -1 indicating a very strong negative correlation, 0 no correlation and 1 a very strong positive correlation. Significance levels were assigned from tabulated values for a two-tail test at 5 % and 1 % based on Fowler et al. (2013).

B.3.2 Univariate and Multivariate Analysis of Macrofauna Data

B.3.2.1 Primary Variables and Diversity Indices

A range of primary variables and derived indices were calculated that attempt to quantify the species richness, evenness and a combination of both. The primary variables (number of individuals and species) and diversity indices (Shannon-Wiener diversity, Brillouin's diversity, Simpson's diversity and Pielou's evenness) were calculated for both the samples and the pooled replicates for each station using the PRIMER v6 DIVERSE procedure.

Shannon Wiener Index (H' or more specifically H'Log$_2$)

The Shannon-Wiener index (or Shannon-Wiener information function) is essentially a measure of how difficult it would be to predict correctly the species of the next individual collected from the community under study. It is a measure of uncertainty and was originally developed to assess the information content of codes. Information content is a measure of uncertainty, so that the larger the value of the index, the greater the uncertainty. It is usually expressed as:

$$= -\sum_i P_i \,\mathrm{Log}(P_i)$$

Where pi is the proportion of the ith species. For practical application, the formula can be expanded to:

$$H_s = C\left(\log_{10} N - \frac{1}{N}\sum n_i \log_{10} n_i\right)$$

Where N = total number of individuals
ni = number of individuals of ith species
C = conversion factor $\log_{10} - \log_2$.

Two components of diversity are combined in the Shannon-Wiener index. These are species richness (i.e. numbers of species) and the equitability or evenness of distribution of individuals among the species. A greater number of species increases the index value as does more even distribution of

individuals amongst species. Theoretically, the Shannon-Wiener index should only be used on random samples drawn from a large community in which the total number of species is known. This is, of course, not usually possible and so the use of the index is always a compromise.

Simpsons (1-λ)

Simpson's index of diversity is derived from probability theory. It is simply a measure of the probability of picking two individuals from a community at random that are different species. The index is calculated from:

$$D = 1 - \sum_{i=1}^{s} (p_i)^2$$

Where pi is the proportion of the ith species. An expanded and more practicable formula is:

$$D = 1 - \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

Where ni = number of individuals of ith species
N = total number of individuals.

Simpson's index assigns relatively little weight to rare species, and more weight to the common ones. It ranges in value from 0 (low diversity) to a maximum of (1 to 1/s) where s = the number of species.

Brillouin's Index (Hb)

This index, like that of Shannon-Wiener, is concerned with information content. However, unlike the Shannon-Wiener index, which provides an estimate of the community diversity, Brillouin's index provides the actual diversity of the fully censused sample. It is not a statistical estimate but an actual measurement of the diversity of the sample unit. The formula, displayed below, contains factorials that can involve very large numbers in computation. In the past, this has been a serious drawback to the use of the index by practical ecologists. This is no longer the case with the advent of personal computers capable of high speed calculations.

The formula for Brillouin's index is:

$$H_b = \frac{1}{N} \log_e \frac{N!}{N_1! N_2! \ldots N_s!}$$

Where N = total number of individuals
Ni = number of individuals of the i^{th} species
S = total number of species in the collection.

As the index provides the exact diversity of the sample, it is most appropriate in surveys where it is not possible to define the limits of the population. Since this is nearly always the case when dealing with benthic communities, Brillouin's index has much to commend it in offshore pollution monitoring studies.

Pielou's Equitability (J)

Equitability refers to the evenness with which individuals are distributed amongst species. Equitability is clearly a component of species diversity and certainly enters into diversity indices such as H'Log$_2$, Hb, and λ.

Equitability can be assessed in several ways, the most commonly used approach being to calculate the theoretical diversity for a given species abundance list if all the species were equal in abundance. The equitability of the sample can then be defined as the ratio of the actual diversity to the theoretical maximum.

This is usually done using the Shannon-Wiener index (H'Log$_2$)

If all species are equally represented, then the equation can be written:

$$H'(max) = -S\left(\frac{1}{s} log2 \frac{1}{s}\right) = log_s S$$

The equitability ratio is therefore:

$$J = \frac{H_s}{log_2 S}$$

Where J = equitability measure (Pielou)
H' = calculated Shannon-Wiener diversity
S = total number of species.

Heip (1974) has suggested a modified form of Pielou's J that is essentially the antilog of H' divided by the antilog of H(max). To prevent equitability values at the extreme end of the range becoming nonsensical Heip took the precaution of subtracting 1 from the enumerator and denominator so that his index becomes:

$$Eh = \frac{2^H - 1}{s - 1}$$

Where 2H = the antilog of H'
S = the number of species.

The advantage of this measure is that it appears to provide more realistic equitability values in absolute terms; however, there is a curvilinear relationship between Eh and H' making it difficult to compare ranges of equitability. Although used by Government Laboratories, Heip's measure is not widely used elsewhere.

B.3.2.2 Multivariate Analysis

Macrofauna abundance data was analysed by multivariate techniques using the statistical package PRIMER v6. Approaches followed those outlined in Clarke and Gorley (2006). The main techniques used to interrogate the data are detailed below.

Pre-treatment and Transformations: prior to analysis data typically undergo transformation to down weight the effect of dominant data components in determining inter-sample similarities. These transformations vary in their effect through: no transform; square root (√); fourth root/double square root (√√); logarithmic, and; reduction to presence/absence. At the former end of the spectrum (no transform) all attention is focused on the dominant components of the dataset, and at the latter end (reduction to presence/absence) equal weighting is applied to all components (Clarke and Gorley, 2006). Macrofauna data is generally fourth root transformed for multivariate analysis. However, due to the small numbers of individuals in each taxon, square root transformation was used in this instance as detailed within the report.

Similarity Matrices: a triangular similarity matrix was produced from the square root transformed data, by calculating the similarity between every pair of replicate samples. The Bray-Curtis similarity coefficient was used for macrofaunal data (Bray and Curtis, 1957). This similarity measure is considered the most suitable as it maintains independence of joint absence (i.e. will not infer similarity between samples based on the absence of a certain parameter in them).

Hierarchical Agglomerative Clustering (CLUSTER) and Similarity Profile Testing (SIMPROF): the CLUSTER programme uses the similarity matrix to successively fuse samples into groups and groups into clusters according to their level of similarity. The end point of this process is a single cluster containing all the samples, which is displayed by means of a dendrogram with similarity displayed on one axis and samples on the other. Similarity profile permutation tests (SIMPROF) were also performed, to look for evidence of genuine statistically significant clusters, in samples that are a-priori unstructured (i.e. with no prior statistical design). By combining this significance testing with the CLUSTER function, dendrograms are produced indicating those clusters that are statistically significant.

Correlations with Environmental Variables: if more than one benthic assemblage was present in the macrofaunal data (i.e. there was structuring in the data), attempts were made to match the variation with reported environmental variables. This process can help identify relationships between the physical or chemical environment and the benthic communities present.

C. LOGS

C.1 SURVEY LOG

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
15/05/2019	18:24:03	GEOPC010DD	Video	SOL	1	879.2	487 687.9	873 555.9	487 652.4	873 544.8	37.2	Camera too light, added ~70 kg of weight
15/05/2019	18:26:58	GEOPC010DD	Still	GEOPC010DD_01	1	878.1	487 687.9	873 555.9	487 651.8	873 543.4	38.2	
15/05/2019	18:30:47	GEOPC010DD	Still	GEOPC010DD_02	2	878.7	487 687.9	873 555.9	487 666.8	873 552.7	21.3	
15/05/2019	18:32:30	GEOPC010DD	Still	GEOPC010DD_03	3	879.6	487 687.9	873 555.9	487 676.3	873 555.4	11.6	
15/05/2019	18:33:34	GEOPC010DD	Still	GEOPC010DD_04	4	879.2	487 687.9	873 555.9	487 673.1	873 558.1	15.0	
15/05/2019	18:33:46	GEOPC010DD	Still	GEOPC010DD_05	5	880.4	487 687.9	873 555.9	487 681.6	873 561.4	8.3	
15/05/2019	18:33:59	GEOPC010DD	Still	GEOPC010DD_06	6	880.3	487 687.9	873 555.9	487 683.7	873 559.8	5.7	
15/05/2019	18:34:14	GEOPC010DD	Still	GEOPC010DD_07	7	880.0	487 687.9	873 555.9	487 685.6	873 559.1	3.9	
15/05/2019	18:35:11	GEOPC010DD	Still	GEOPC010DD_08	8	880.1	487 687.9	873 555.9	487 690.8	873 563.3	8.0	
15/05/2019	18:34:44	GEOPC010DD	Still	GEOPC010DD_09	9	879.8	487 687.9	873 555.9	487 690.8	873 563.3	8.0	
15/05/2019	18:35:30	GEOPC010DD	Still	GEOPC010DD_10	10	880.0	487 687.9	873 555.9	487 693.6	873 564.1	9.9	
15/05/2019	18:35:51	GEOPC010DD	Still	GEOPC010DD_11	11	880.0	487 687.9	873 555.9	487 695.6	873 565.4	12.2	
15/05/2019	18:36:21	GEOPC010DD	Still	GEOPC010DD_12	12	880.5	487 687.9	873 555.9	487 698.4	873 568.2	16.1	
15/05/2019	18:36:32	GEOPC010DD	Still	GEOPC010DD_13	13	880.7	487 687.9	873 555.9	487 700.4	873 568.1	17.5	
15/05/2019	18:37:43	GEOPC010DD	Still	GEOPC010DD_14	14	880.8	487 687.9	873 555.9	487 709.0	873 571.7	26.4	
15/05/2019	18:37:55	GEOPC010DD	Still	GEOPC010DD_15	15	881.4	487 687.9	873 555.9	487 710.9	873 573.4	28.8	
15/05/2019	18:38:03	GEOPC010DD	Video	EOL	1	880.9	487 687.9	873 555.9	487 711.2	873 574.6	29.8	
17/05/2019	14:08:14	EBSHHDD_01	Video	SOL	1	1031.4	483 890.6	880 797.5	483 850.9	880 790.1	40.4	Photographs not acceptable, seabed not in view
17/05/2019	14:10:15	EBSHHDD_01	Still	EBSHH01DD_01	1	1031.7	483 890.6	880 797.5	483 854.2	880 794.4	36.5	
17/05/2019	14:12:16	EBSHHDD_01	Still	EBSHH01DD_02	2	1032.4	483 890.6	880 797.5	483 861.1	880 795.1	29.7	
17/05/2019	14:12:37	EBSHHDD_01	Still	EBSHH01DD_03	3	1032.1	483 890.6	880 797.5	483 862.6	880 795.9	28.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
17/05/2019	14:15:03	EBSHHDD_01	Still	EBSHH01DD_04	4	1032.1	483 890.6	880 797.5	483 878.5	880 795.6	12.3	
17/05/2019	14:15:49	EBSHHDD_01	Still	EBSHH01DD_05	5	1032.4	483 890.6	880 797.5	483 881.6	880 794.3	9.6	
17/05/2019	14:16:57	EBSHHDD_01	Still	EBSHH01DD_06	6	1035.5	483 890.6	880 797.5	483 890.4	880 794.9	2.6	
17/05/2019	14:19:27	EBSHHDD_01	Still	EBSHH01DD_07	7	1035.1	483 890.6	880 797.5	483 906.8	880 796.3	16.2	
17/05/2019	14:19:39	EBSHHDD_01	Still	EBSHH01DD_08	8	1035.7	483 890.6	880 797.5	483 908.4	880 796.0	17.9	
17/05/2019	14:19:56	EBSHHDD_01	Still	EBSHH01DD_09	9	1034.9	483 890.6	880 797.5	483 909.8	880 796.8	19.2	
17/05/2019	14:20:09	EBSHHDD_01	Still	EBSHH01DD_10	10	1034.5	483 890.6	880 797.5	483 911.9	880 796.8	21.3	
17/05/2019	14:20:25	EBSHHDD_01	Still	EBSHH01DD_11	11	1034.6	483 890.6	880 797.5	483 913.8	880 796.4	23.2	
17/05/2019	14:20:41	EBSHHDD_01	Still	EBSHH01DD_12	12	1034.3	483 890.6	880 797.5	483 915.7	880 796.5	25.1	
17/05/2019	14:20:56	EBSHHDD_01	Still	EBSHH01DD_13	13	1034.1	483 890.6	880 797.5	483 917.8	880 795.7	27.2	
17/05/2019	14:21:21	EBSHHDD_01	Still	EBSHH01DD_14	14	1036.2	483 890.6	880 797.5	483 921.3	880 796.6	30.8	
17/05/2019	14:21:57	EBSHHDD_01	Video	EOL	1	1031.4	483 890.6	880 797.5	483 925.7	880 796.7	35.1	
17/05/2019	16:39:27	EBSHHDD_01a	Video	SOL	1	1032.9	483 890.6	880 797.5	483 854.2	880 795.2	36.5	Weight removed from back of the camera
17/05/2019	16:39:40	EBSHHDD_01a	Still	EBSHH01DDa_01	1	1032.4	483 890.6	880 797.5	483 854.7	880 796.5	35.9	
17/05/2019	16:40:57	EBSHHDD_01a	Still	EBSHH01DDa_02	2	1033.3	483 890.6	880 797.5	483 857.5	880 797.2	33.1	
17/05/2019	16:41:29	EBSHHDD_01a	Still	EBSHH01DDa_03	3	1031.7	483 890.6	880 797.5	483 859.5	880 797.8	31.1	
17/05/2019	16:41:55	EBSHHDD_01a	Still	EBSHH01DDa_04	4	1032.9	483 890.6	880 797.5	483 861.0	880 798.6	29.7	
17/05/2019	16:42:32	EBSHHDD_01a	Still	EBSHH01DDa_05	5	1033.3	483 890.6	880 797.5	483 862.9	880 799.7	27.8	
17/05/2019	16:43:00	EBSHHDD_01a	Still	EBSHH01DDa_06	6	1034.2	483 890.6	880 797.5	483 863.6	880 799.7	27.1	
17/05/2019	16:43:37	EBSHHDD_01a	Still	EBSHH01DDa_07	7	1033.6	483 890.6	880 797.5	483 866.7	880 800.0	24.1	
17/05/2019	16:44:03	EBSHHDD_01a	Still	EBSHH01DDa_08	8	1034.6	483 890.6	880 797.5	483 866.9	880 801.0	23.9	
17/05/2019	16:44:21	EBSHHDD_01a	Still	EBSHH01DDa_09	9	1033.8	483 890.6	880 797.5	483 867.7	880 800.1	23.0	
17/05/2019	16:44:52	EBSHHDD_01a	Still	EBSHH01DDa_10	10	1034.5	483 890.6	880 797.5	483 872.0	880 800.2	18.8	
17/05/2019	16:45:27	EBSHHDD_01a	Still	EBSHH01DDa_11	11	1033.6	483 890.6	880 797.5	483 874.4	880 799.9	16.4	
17/05/2019	16:46:18	EBSHHDD_01a	Still	EBSHH01DDa_12	12	1033.1	483 890.6	880 797.5	483 879.6	880 801.2	11.6	
17/05/2019	16:46:38	EBSHHDD_01a	Still	EBSHH01DDa_13	13	1035.0	483 890.6	880 797.5	483 881.9	880 801.0	9.4	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
17/05/2019	16:47:27	EBSHHDD_01a	Still	EBSHH01DDa_14	14	1034.2	483 890.6	880 797.5	483 887.2	880 801.7	5.4	
17/05/2019	16:47:44	EBSHHDD_01a	Still	EBSHH01DDa_15	15	1035.3	483 890.6	880 797.5	483 889.2	880 802.1	4.8	
17/05/2019	16:48:09	EBSHHDD_01a	Still	EBSHH01DDa_16	16	1034.2	483 890.6	880 797.5	483 892.3	880 802.5	5.3	
17/05/2019	16:49:12	EBSHHDD_01a	Still	EBSHH01DDa_17	17	1034.6	483 890.6	880 797.5	483 900.3	880 803.9	11.6	
17/05/2019	16:49:34	EBSHHDD_01a	Still	EBSHH01DDa_18	18	1036.2	483 890.6	880 797.5	483 902.1	880 804.5	13.5	
17/05/2019	16:50:04	EBSHHDD_01a	Still	EBSHH01DDa_19	19	1036.3	483 890.6	880 797.5	483 904.9	880 804.6	15.9	
17/05/2019	16:51:42	EBSHHDD_01a	Video	EOL	1	1033.8	483 890.6	880 797.5	483 919.2	880 805.9	29.8	Camera spinning in the water column, photographs not accepted
17/05/2019	18:14:00	EBSHH_01	BC	FA/FB	1	1038.9	483 890.6	880 797.5	483 901.7	880 800.3	11.5	
17/05/2019	20:30:17	EBSHHDD_01b	Video	SOL	-	1033.6	483 890.6	880 797.5	483 845.0	880 804.7	46.2	Weight added to the back of the camera and to the front
17/05/2019	20:34:03	EBSHHDD_01b	Still	EBSHH01DDb_01	1	1033.4	483 890.6	880 797.5	483 851.2	880 805.5	40.3	
17/05/2019	20:34:28	EBSHHDD_01b	Still	EBSHH01DDb_02	2	1033.5	483 890.6	880 797.5	483 852.2	880 805.1	39.2	
17/05/2019	20:35:29	EBSHHDD_01b	Still	EBSHH01DDb_03	3	1034.6	483 890.6	880 797.5	483 856.1	880 803.9	35.1	
17/05/2019	20:35:42	EBSHHDD_01b	Still	EBSHH01DDb_04	4	1035.2	483 890.6	880 797.5	483 857.6	880 804.2	33.7	
17/05/2019	20:35:53	EBSHHDD_01b	Still	EBSHH01DDb_05	5	1033.5	483 890.6	880 797.5	483 858.1	880 803.7	33.1	
17/05/2019	20:36:02	EBSHHDD_01b	Still	EBSHH01DDb_06	6	1034.8	483 890.6	880 797.5	483 859.0	880 804.7	32.4	
17/05/2019	20:36:22	EBSHHDD_01b	Still	EBSHH01DDb_07	7	1034.9	483 890.6	880 797.5	483 860.3	880 804.4	31.0	
17/05/2019	20:36:41	EBSHHDD_01b	Still	EBSHH01DDb_08	8	1034.1	483 890.6	880 797.5	483 862.3	880 804.2	29.1	
17/05/2019	20:41:02	EBSHHDD_01b	Video	EOL	-	1034.7	483 890.6	880 797.5	483 887.9	880 801.7	5.0	Camera drop down aborted due to poor stills images
17/05/2019	21:56:41	EBSHH_01	BC	PC	2	1037.0	483 890.6	880 797.5	483 880.6	880 796.5	10.0	
18/05/2019	00:20:31	EBSHH_02	BC	PC, FA, FB	1	1098.1	488 361.4	878 558.8	488 359.2	878 553.6	5.7	
18/05/2019	02:23:14	EBSHH_03	BC	PC, FA, FB	1	1110.1	492 832.3	876 320.2	492 842.9	876 316.2	11.3	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	04:02:17	EBSHH_06	BC	PC, FA, FB	1	938.0	493 622.3	871 760.8	493 624.9	871 760.4	2.6	
18/05/2019	05:49:50	EBSHH_05	BC	PC, FA, FB	1	926.1	488 805.9	873 862.8	488 811.0	873 870.1	8.9	
18/05/2019	07:36:31	EBSHH_04	BC	PC, FA, FB	1	887.9	484 335.1	876 101.5	484 335.6	876 094.4	7.1	
18/05/2019	09:25:36	EBSHH_07	BC	PC, FA, FB	1	673.2	484 779.6	871 405.5	484 789.1	871 407.7	9.8	
18/05/2019	10:03:02	EBSHH_08	BC	PC, FA, FB	1	722.1	489 250.4	869 166.8	489 254.6	869 170.5	5.5	
18/05/2019	14:59:16	TR04	Video	SOL	1	99.5	489 761.0	852 259.0	489 648.0	852 133.1	169.2	
18/05/2019	15:01:23	TR04	Still	TR04_01	1	99.7	489 761.0	852 259.0	489 653.7	852 134.8	164.2	
18/05/2019	15:01:39	TR04	Still	TR04_02	2	99.1	489 761.0	852 259.0	489 655.7	852 136.5	161.5	
18/05/2019	15:01:51	TR04	Still	TR04_03	3	99.9	489 761.0	852 259.0	489 657.2	852 137.9	159.5	
18/05/2019	15:02:03	TR04	Still	TR04_04	4	100.4	489 761.0	852 259.0	489 658.6	852 138.8	157.9	
18/05/2019	15:02:09	TR04	Still	TR04_05	5	100.6	489 761.0	852 259.0	489 659.4	852 139.5	156.9	
18/05/2019	15:02:24	TR04	Still	TR04_06	6	99.7	489 761.0	852 259.0	489 660.8	852 140.5	155.2	
18/05/2019	15:02:43	TR04	Still	TR04_07	7	99.4	489 761.0	852 259.0	489 663.0	852 142.6	152.2	
18/05/2019	15:03:01	TR04	Still	TR04_08	8	100.5	489 761.0	852 259.0	489 664.6	852 144.2	149.9	
18/05/2019	15:03:41	TR04	Still	TR04_09	9	100.3	489 761.0	852 259.0	489 667.6	852 148.8	144.4	
18/05/2019	15:04:04	TR04	Still	TR04_10	10	101.1	489 761.0	852 259.0	489 669.7	852 151.5	141.1	
18/05/2019	15:04:18	TR04	Still	TR04_11	11	98.9	489 761.0	852 259.0	489 670.3	852 152.7	139.8	
18/05/2019	15:04:38	TR04	Still	TR04_12	12	100.7	489 761.0	852 259.0	489 671.9	852 155.5	136.6	
18/05/2019	15:04:50	TR04	Still	TR04_13	13	100.3	489 761.0	852 259.0	489 673.2	852 157.2	134.4	
18/05/2019	15:05:06	TR04	Still	TR04_14	14	101.1	489 761.0	852 259.0	489 674.3	852 158.9	132.4	
18/05/2019	15:05:27	TR04	Still	TR04_15	15	100.8	489 761.0	852 259.0	489 675.8	852 161.8	129.2	
18/05/2019	15:05:59	TR04	Still	TR04_16	16	101.6	489 761.0	852 259.0	489 678.5	852 165.9	124.4	
18/05/2019	15:06:45	TR04	Still	TR04_17	17	100.9	489 761.0	852 259.0	489 683.4	852 172.5	116.2	
18/05/2019	15:07:12	TR04	Still	TR04_18	18	101.3	489 761.0	852 259.0	489 686.9	852 175.5	111.6	
18/05/2019	15:07:25	TR04	Still	TR04_19	19	101.3	489 761.0	852 259.0	489 688.1	852 176.8	109.9	
18/05/2019	15:07:40	TR04	Still	TR04_20	20	101.1	489 761.0	852 259.0	489 689.8	852 179.3	106.8	
18/05/2019	15:07:55	TR04	Still	TR04_21	21	100.5	489 761.0	852 259.0	489 691.7	852 181.6	103.8	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	15:08:15	TR04	Still	TR04_22	22	101.0	489 761.0	852 259.0	489 694.6	852 184.2	100.0	
18/05/2019	15:08:48	TR04	Still	TR04_23	23	100.7	489 761.0	852 259.0	489 698.1	852 187.4	95.3	
18/05/2019	15:08:59	TR04	Still	TR04_24	24	101.7	489 761.0	852 259.0	489 699.0	852 188.4	93.9	
18/05/2019	15:09:40	TR04	Still	TR04_25	25	90.2	489 761.0	852 259.0	489 688.9	852 205.8	89.6	
18/05/2019	15:09:53	TR04	Still	TR04_26	26	101.1	489 761.0	852 259.0	489 705.0	852 196.5	83.9	
18/05/2019	15:10:16	TR04	Still	TR04_27	27	101.0	489 761.0	852 259.0	489 708.1	852 200.7	78.7	
18/05/2019	15:10:31	TR04	Still	TR04_28	28	100.7	489 761.0	852 259.0	489 709.9	852 203.1	75.7	
18/05/2019	15:10:46	TR04	Still	TR04_29	29	101.8	489 761.0	852 259.0	489 711.8	852 205.7	72.5	
18/05/2019	15:11:06	TR04	Still	TR04_30	30	100.6	489 761.0	852 259.0	489 714.0	852 208.8	68.7	
18/05/2019	15:11:37	TR04	Still	TR04_31	32	101.2	489 761.0	852 259.0	489 717.4	852 214.0	62.7	
18/05/2019	15:11:51	TR04	Still	TR04_32	33	101.7	489 761.0	852 259.0	489 718.6	852 215.7	60.6	
18/05/2019	15:12:35	TR04	Still	TR04_33	34	100.1	489 761.0	852 259.0	489 722.1	852 221.0	54.3	
18/05/2019	15:13:05	TR04	Still	TR04_34	35	101.5	489 761.0	852 259.0	489 725.3	852 223.7	50.2	
18/05/2019	15:13:32	TR04	Still	TR04_35	36	101.8	489 761.0	852 259.0	489 727.2	852 226.0	47.2	
18/05/2019	15:14:59	TR04	Still	TR04_36	37	101.8	489 761.0	852 259.0	489 733.6	852 233.2	37.6	
18/05/2019	15:15:24	TR04	Still	TR04_37	38	102.5	489 761.0	852 259.0	489 736.0	852 235.7	34.2	
18/05/2019	15:15:49	TR04	Still	TR04_38	39	102.5	489 761.0	852 259.0	489 738.1	852 237.6	31.3	
18/05/2019	15:17:42	TR04	Still	TR04_39	40	99.7	489 761.0	852 259.0	489 749.3	852 251.4	13.9	
18/05/2019	15:18:22	TR04	Still	TR04_40	41	100.9	489 761.0	852 259.0	489 753.6	852 256.7	7.8	
18/05/2019	15:18:41	TR04	Still	TR04_41	42	100.2	489 761.0	852 259.0	489 755.7	852 259.6	5.3	
18/05/2019	15:19:31	TR04	Still	TR04_42	45	95.6	489 761.0	852 259.0	489 761.4	852 269.7	10.7	
18/05/2019	15:20:07	TR04	Still	TR04_43	47	94.1	489 761.0	852 259.0	489 766.0	852 273.9	15.8	
18/05/2019	15:20:34	TR04	Still	TR04_44	48	94.7	489 761.0	852 259.0	489 769.1	852 277.7	20.4	
18/05/2019	15:21:29	TR04	Still	TR04_45	51	93.9	489 761.0	852 259.0	489 775.4	852 284.0	28.8	
18/05/2019	15:21:46	TR04	Still	TR04_46	52	92.9	489 761.0	852 259.0	489 776.9	852 285.4	30.8	
18/05/2019	15:21:58	TR04	Still	TR04_47	53	94.4	489 761.0	852 259.0	489 777.8	852 286.4	32.1	
18/05/2019	15:22:20	TR04	Still	TR04_48	54	94.0	489 761.0	852 259.0	489 780.1	852 289.5	35.9	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	15:22:34	TR04	Still	TR04_49	55	93.7	489 824.0	852 332.0	489 781.5	852 290.8	59.2	
18/05/2019	15:23:03	TR04	Still	TR04_50	57	94.3	489 824.0	852 332.0	489 784.9	852 293.7	54.8	
18/05/2019	15:24:15	TR04	Still	TR04_51	58	97.5	489 824.0	852 332.0	489 792.4	852 298.9	45.8	
18/05/2019	15:24:29	TR04	Still	TR04_52	59	96.8	489 824.0	852 332.0	489 793.9	852 300.0	43.9	
18/05/2019	15:24:49	TR04	Still	TR04_53	60	100.0	489 824.0	852 332.0	489 796.8	852 303.1	39.7	
18/05/2019	15:25:14	TR04	Still	TR04_54	61	99.3	489 824.0	852 332.0	489 799.1	852 305.8	36.1	
18/05/2019	15:25:24	TR04	Still	TR04_55	62	99.8	489 824.0	852 332.0	489 800.1	852 307.0	34.6	
18/05/2019	15:26:30	TR04	Still	TR04_56	63	96.1	489 824.0	852 332.0	489 803.4	852 314.3	27.1	
18/05/2019	15:26:46	TR04	Still	TR04_57	64	99.4	489 824.0	852 332.0	489 805.0	852 316.9	24.3	
18/05/2019	15:26:56	TR04	Still	TR04_58	65	100.8	489 824.0	852 332.0	489 806.5	852 319.1	21.7	
18/05/2019	15:27:23	TR04	Still	TR04_59	66	100.0	489 824.0	852 332.0	489 809.6	852 322.6	17.2	
18/05/2019	15:27:48	TR04	Still	TR04_60	67	100.1	489 824.0	852 332.0	489 812.8	852 326.4	12.5	
18/05/2019	15:28:01	TR04	Still	TR04_61	68	100.3	489 824.0	852 332.0	489 813.9	852 327.7	11.0	
18/05/2019	15:28:26	TR04	Still	TR04_62	69	100.1	489 824.0	852 332.0	489 816.0	852 329.7	8.3	
18/05/2019	15:29:07	TR04	Still	TR04_63	70	99.6	489 824.0	852 332.0	489 821.2	852 334.0	3.4	
18/05/2019	15:29:15	TR04	Video	EOL	1	99.4	489 824.0	852 332.0	489 821.7	852 334.2	3.2	
18/05/2019	16:37:16	TR05_part1	Video	SOL	1	99.2	486 554.7	853 954.2	486 551.3	853 954.9	3.4	
18/05/2019	16:38:34	TR05_part1	Still	TR05_01	1	101.6	486 554.7	853 954.2	486 554.7	853 954.2	0.0	
18/05/2019	16:39:57	TR05_part1	Still	TR05_02	2	100.0	486 554.7	853 954.2	486 562.5	853 948.3	9.8	
18/05/2019	16:40:21	TR05_part1	Still	TR05_03	3	101.1	486 554.7	853 954.2	486 564.7	853 945.9	13.0	
18/05/2019	16:40:31	TR05_part1	Still	TR05_04	4	101.3	486 554.7	853 954.2	486 566.5	853 944.8	15.1	
18/05/2019	16:40:47	TR05_part1	Still	TR05_05	5	100.8	486 554.7	853 954.2	486 569.0	853 943.1	18.2	
18/05/2019	16:40:59	TR05_part1	Still	TR05_06	6	99.3	486 554.7	853 954.2	486 570.0	853 941.5	19.9	
18/05/2019	16:41:27	TR05_part1	Still	TR05_07	7	100.0	486 554.7	853 954.2	486 571.8	853 940.2	22.1	
18/05/2019	16:41:52	TR05_part1	Still	TR05_08	8	100.5	486 554.7	853 954.2	486 575.2	853 938.6	25.8	
18/05/2019	16:42:08	TR05_part1	Still	TR05_09	9	103.1	486 554.7	853 954.2	486 578.7	853 937.4	29.4	
18/05/2019	16:42:26	TR05_part1	Still	TR05_10	10	102.4	486 554.7	853 954.2	486 581.4	853 936.5	32.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	16:42:53	TR05_part1	Still	TR05_11	11	102.0	486 554.7	853 954.2	486 585.7	853 934.5	36.8	
18/05/2019	16:43:08	TR05_part1	Still	TR05_12	12	102.7	486 554.7	853 954.2	486 587.3	853 933.8	38.5	
18/05/2019	16:44:11	TR05_part1	Video	EOL	1	100.7	486 554.7	853 954.2	486 592.7	853 927.6	46.4	Camera malfunction, vessel stopped and the system rebooted
18/05/2019	16:46:44	TR05_part2	Video	SOL	2	100.0	486 554.7	853 954.2	486 600.0	853 923.6	54.7	
18/05/2019	16:47:48	TR05_part2	Still	TR05_13	13	103.6	486 554.7	853 954.2	486 602.6	853 925.7	55.8	
18/05/2019	16:48:06	TR05_part2	Still	TR05_14	14	103.0	486 554.7	853 954.2	486 602.9	853 926.5	55.7	
18/05/2019	16:48:53	TR05_part2	Still	TR05_15	15	102.7	486 554.7	853 954.2	486 604.3	853 925.2	57.5	
18/05/2019	16:49:05	TR05_part2	Still	TR05_16	16	103.0	486 554.7	853 954.2	486 606.0	853 924.6	59.2	
18/05/2019	16:49:30	TR05_part2	Still	TR05_17	17	102.7	486 554.7	853 954.2	486 608.4	853 922.6	62.3	
18/05/2019	16:49:52	TR05_part2	Still	TR05_18	18	103.4	486 554.7	853 954.2	486 611.0	853 921.6	65.1	
18/05/2019	16:50:20	TR05_part2	Still	TR05_19	19	101.6	486 554.7	853 954.2	486 612.3	853 919.6	67.2	
18/05/2019	16:50:32	TR05_part2	Still	TR05_20	20	102.1	486 554.7	853 954.2	486 614.3	853 918.4	69.6	
18/05/2019	16:51:05	TR05_part2	Still	TR05_21	21	101.7	486 554.7	853 954.2	486 616.4	853 916.0	72.6	
18/05/2019	16:51:48	TR05_part2	Still	TR05_22	22	102.0	486 554.7	853 954.2	486 620.9	853 911.6	78.8	
18/05/2019	16:52:25	TR05_part2	Still	TR05_23	23	98.5	486 554.7	853 954.2	486 625.2	853 908.0	84.3	
18/05/2019	16:52:39	TR05_part2	Still	TR05_24	24	95.9	486 554.7	853 954.2	486 626.8	853 906.5	86.5	
18/05/2019	16:52:52	TR05_part2	Still	TR05_25	25	95.4	486 554.7	853 954.2	486 629.7	853 904.5	90.0	
18/05/2019	16:53:09	TR05_part2	Still	TR05_26	26	94.8	486 554.7	853 954.2	486 631.1	853 902.3	92.5	
18/05/2019	16:53:21	TR05_part2	Still	TR05_27	27	94.2	486 554.7	853 954.2	486 632.5	853 900.9	94.3	
18/05/2019	16:53:40	TR05_part2	Still	TR05_28	28	94.0	486 554.7	853 954.2	486 634.9	853 898.4	97.8	
18/05/2019	16:53:52	TR05_part2	Still	TR05_29	29	93.2	486 554.7	853 954.2	486 636.2	853 896.4	99.9	
18/05/2019	16:54:11	TR05_part2	Still	TR05_30	30	95.2	486 554.7	853 954.2	486 639.0	853 893.8	103.7	
18/05/2019	16:54:29	TR05_part2	Still	TR05_31	31	95.4	486 554.7	853 954.2	486 641.3	853 892.8	106.2	
18/05/2019	16:54:59	TR05_part2	Still	TR05_32	32	94.3	486 554.7	853 954.2	486 643.6	853 889.1	110.2	
18/05/2019	16:55:15	TR05_part2	Still	TR05_33	33	94.5	486 554.7	853 954.2	486 645.9	853 887.5	113.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	16:55:32	TR05_part2	Still	TR05_34	34	93.0	486 554.7	853 954.2	486 648.1	853 886.0	115.7	
18/05/2019	16:55:39	TR05_part2	Video	EOL	2	94.5	486 554.7	853 954.2	486 648.6	853 885.2	116.5	
18/05/2019	18:09:45	TR06_part1	Video	SOL	1	112.1	490 481.3	855 793.2	490 481.3	855 793.1	0.1	
18/05/2019	18:10:13	TR06_part1	Still	TR06_01	1	112.3	490 481.3	855 793.2	490 481.3	855 793.2	0.0	
18/05/2019	18:11:35	TR06_part1	Still	TR06_02	2	112.6	490 481.3	855 793.2	490 490.1	855 796.0	9.2	
18/05/2019	18:11:49	TR06_part1	Still	TR06_03	3	111.5	490 481.3	855 793.2	490 492.1	855 796.7	11.3	
18/05/2019	18:12:08	TR06_part1	Still	TR06_04	4	110.2	490 481.3	855 793.2	490 494.6	855 796.8	13.8	
18/05/2019	18:12:26	TR06_part1	Still	TR06_05	5	112.6	490 481.3	855 793.2	490 497.6	855 796.9	16.7	
18/05/2019	18:12:45	TR06_part1	Still	TR06_06	6	112.4	490 481.3	855 793.2	490 499.5	855 797.2	18.7	
18/05/2019	18:13:34	TR06_part1	Still	TR06_07	7	112.8	490 481.3	855 793.2	490 506.0	855 796.5	24.9	
18/05/2019	18:14:17	TR06_part1	Still	TR06_08	8	113.1	490 481.3	855 793.2	490 514.8	855 797.1	33.7	
18/05/2019	18:15:18	TR06_part1	Still	TR06_09	9	111.1	490 481.3	855 793.2	490 521.7	855 795.8	40.5	
18/05/2019	18:15:37	TR06_part1	Still	TR06_10	10	112.3	490 481.3	855 793.2	490 525.0	855 796.2	43.8	
18/05/2019	18:15:54	TR06_part1	Still	TR06_11	11	111.7	490 481.3	855 793.2	490 527.6	855 796.2	46.4	
18/05/2019	18:16:06	TR06_part1	Still	TR06_12	12	112.1	490 481.3	855 793.2	490 529.4	855 796.0	48.2	
18/05/2019	18:16:26	TR06_part1	Still	TR06_13	13	110.6	490 481.3	855 793.2	490 532.6	855 795.6	51.3	
18/05/2019	18:16:45	TR06_part1	Still	TR06_14	14	112.1	490 481.3	855 793.2	490 536.0	855 795.8	54.7	
18/05/2019	18:17:07	TR06_part1	Still	TR06_15	15	113.1	490 481.3	855 793.2	490 540.2	855 795.9	58.9	
18/05/2019	18:17:32	TR06_part1	Still	TR06_16	16	112.5	490 481.3	855 793.2	490 544.6	855 796.5	63.3	
18/05/2019	18:17:56	TR06_part1	Still	TR06_17	17	111.9	490 481.3	855 793.2	490 548.7	855 797.8	67.5	
18/05/2019	18:18:26	TR06_part1	Still	TR06_18	18	112.6	490 481.3	855 793.2	490 553.1	855 799.2	72.1	
18/05/2019	18:19:09	TR06_part1	Still	TR06_19	19	113.6	490 481.3	855 793.2	490 559.3	855 799.4	78.3	
18/05/2019	18:20:08	TR06_part1	Still	TR06_20	20	111.2	490 481.3	855 793.2	490 566.3	855 799.0	85.2	
18/05/2019	18:20:20	TR06_part1	Still	TR06_21	21	111.9	490 481.3	855 793.2	490 567.7	855 798.8	86.5	
18/05/2019	18:20:37	TR06_part1	Still	TR06_22	22	111.8	490 481.3	855 793.2	490 570.0	855 798.6	88.9	
18/05/2019	18:22:00	TR06_part1	Still	EOL	1	108.8	490 481.3	855 793.2	490 582.6	855 798.4	101.4	
18/05/2019	18:24:08	TR06_part2	Still	SOL	2	109.6	490 481.3	855 793.2	490 594.7	855 799.2	113.5	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	18:24:23	TR06_part2	Still	TR06_23	24	106.3	490 481.3	855 793.2	490 595.0	855 798.9	113.8	
18/05/2019	18:26:28	TR06_part2	Still	TR06_24	25	106.7	490 481.3	855 793.2	490 596.6	855 799.8	115.4	
18/05/2019	18:26:47	TR06_part2	Still	TR06_25	26	107.5	490 481.3	855 793.2	490 599.3	855 800.5	118.2	
18/05/2019	18:27:21	TR06_part2	Still	TR06_26	27	109.6	490 481.3	855 793.2	490 604.5	855 801.0	123.4	
18/05/2019	18:27:35	TR06_part2	Still	TR06_27	28	111.3	490 481.3	855 793.2	490 605.5	855 801.1	124.4	
18/05/2019	18:27:48	TR06_part2	Still	TR06_28	29	111.9	490 481.3	855 793.2	490 605.7	855 801.1	124.6	
18/05/2019	18:30:46	TR06_part2	Still	TR06_29	30	112.8	490 481.3	855 793.2	490 605.2	855 798.2	124.0	
18/05/2019	18:31:16	TR06_part2	Still	TR06_30	31	112.5	490 481.3	855 793.2	490 606.6	855 798.9	125.4	
18/05/2019	18:31:29	TR06_part2	Still	TR06_31	32	112.4	490 481.3	855 793.2	490 608.0	855 799.7	126.9	
18/05/2019	18:31:45	TR06_part2	Still	TR06_32	33	112.1	490 481.3	855 793.2	490 610.9	855 800.0	129.8	
18/05/2019	18:32:54	TR06_part2	Still	TR06_33	34	113.6	490 481.3	855 793.2	490 620.2	855 799.6	139.1	
18/05/2019	18:33:14	TR06_part2	Still	TR06_34	35	111.5	490 481.3	855 793.2	490 622.6	855 800.5	141.5	
18/05/2019	18:33:32	TR06_part2	Still	TR06_35	36	107.8	490 481.3	855 793.2	490 626.6	855 800.4	145.5	
18/05/2019	18:33:57	TR06_part2	Still	TR06_36	37	105.6	490 481.3	855 793.2	490 631.1	855 799.3	149.9	
18/05/2019	18:34:16	TR06_part2	Still	TR06_37	38	104.5	490 481.3	855 793.2	490 633.9	855 798.5	152.7	
18/05/2019	18:34:42	TR06_part2	Still	TR06_38	39	105.7	490 481.3	855 793.2	490 637.5	855 797.2	156.2	
18/05/2019	18:35:06	TR06_part2	Still	TR06_39	40	108.8	490 481.3	855 793.2	490 641.2	855 796.1	159.9	
18/05/2019	18:35:53	TR06_part2	Still	TR06_40	41	110.2	490 481.3	855 793.2	490 646.7	855 795.5	165.4	
18/05/2019	18:36:04	TR06_part2	Still	TR06_41	42	111.2	490 481.3	855 793.2	490 648.5	855 796.0	167.2	
18/05/2019	18:36:26	TR06_part2	Still	TR06_42	43	112.2	490 481.3	855 793.2	490 652.4	855 796.2	171.1	
18/05/2019	18:36:53	TR06_part2	Still	TR06_43	44	111.2	490 481.3	855 793.2	490 657.6	855 795.3	176.3	
18/05/2019	18:37:07	TR06_part2	Still	TR06_44	45	110.8	490 481.3	855 793.2	490 659.7	855 794.5	178.4	
18/05/2019	18:38:54	TR06_part2	Still	TR06_45		111.1	490 481.3	855 793.2	490 675.1	855 793.1	193.8	
18/05/2019	18:39:06	TR06_part2	Still	EOL	2	110.9	490 481.3	855 793.2	490 677.0	855 792.8	195.7	
18/05/2019	20:19:26	TR03	Video	SOL	1	103.7	486 938.8	856 841.0	486 939.4	856 840.3	1.0	
18/05/2019	20:19:50	TR03	Still	TR03_01	1	104.7	486 938.8	856 841.0	486 938.8	856 841.0	0.0	
18/05/2019	20:22:16	TR03	Still	TR03_02	2	102.7	486 938.8	856 841.0	486 951.4	856 847.5	14.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	20:23:36	TR03	Still	TR03_03	3	103.5	486 938.8	856 841.0	486 963.6	856 852.8	27.5	
18/05/2019	20:24:31	TR03	Still	TR03_04	4	103.6	486 938.8	856 841.0	486 971.1	856 855.3	35.3	
18/05/2019	20:24:50	TR03	Still	TR03_05	5	104.8	486 938.8	856 841.0	486 973.7	856 855.8	38.0	
18/05/2019	20:25:41	TR03	Still	TR03_06	6	104.4	486 938.8	856 841.0	486 981.3	856 855.5	44.9	
18/05/2019	20:26:04	TR03	Still	TR03_07	7	103.5	486 938.8	856 841.0	486 983.7	856 856.9	47.6	
18/05/2019	20:26:17	TR03	Still	TR03_08	8	103.3	486 938.8	856 841.0	486 985.1	856 857.5	49.1	
18/05/2019	20:26:44	TR03	Still	TR03_09	9	102.5	486 938.8	856 841.0	486 989.3	856 858.6	53.5	
18/05/2019	20:26:55	TR03	Still	TR03_10	10	103.9	486 938.8	856 841.0	486 990.7	856 859.4	55.1	
18/05/2019	20:27:48	TR03	Still	TR03_11	11	102.4	486 938.8	856 841.0	486 996.2	856 862.8	61.4	
18/05/2019	20:28:32	TR03	Still	TR03_12	12	103.3	486 938.8	856 841.0	487 003.0	856 864.3	68.3	
18/05/2019	20:29:04	TR03	Still	TR03_13	13	103.2	486 938.8	856 841.0	487 007.0	856 866.3	72.8	
18/05/2019	20:29:38	TR03	Still	TR03_14	14	103.7	486 938.8	856 841.0	487 012.1	856 867.6	78.0	
18/05/2019	20:30:30	TR03	Still	TR03_15	15	104.9	486 938.8	856 841.0	487 020.1	856 872.1	87.0	
18/05/2019	20:30:57	TR03	Still	TR03_16	16	104.1	486 938.8	856 841.0	487 024.3	856 874.6	91.9	
18/05/2019	20:31:30	TR03	Still	TR03_17	17	104.2	486 938.8	856 841.0	487 029.4	856 877.3	97.6	
18/05/2019	20:32:02	TR03	Still	TR03_18	18	105.6	486 938.8	856 841.0	487 033.7	856 880.0	102.6	
18/05/2019	20:32:15	TR03	Still	TR03_19	19	104.3	486 938.8	856 841.0	487 035.0	856 880.9	104.2	
18/05/2019	20:32:28	TR03	Still	TR03_20	20	105.3	486 938.8	856 841.0	487 037.4	856 882.8	107.1	
18/05/2019	20:33:19	TR03	Still	TR03_21	21	104.4	486 938.8	856 841.0	487 045.9	856 885.7	116.0	
18/05/2019	20:34:02	TR03	Still	TR03_22	22	102.6	486 938.8	856 841.0	487 051.1	856 886.8	121.3	
18/05/2019	20:34:44	TR03	Still	TR03_23	23	103.4	486 938.8	856 841.0	487 057.5	856 887.2	127.3	
18/05/2019	20:34:55	TR03	Still	TR03_24	24	103.9	486 938.8	856 841.0	487 058.9	856 888.3	129.1	
18/05/2019	20:35:11	TR03	Still	TR03_25	25	104.5	486 938.8	856 841.0	487 061.5	856 888.6	131.6	
18/05/2019	20:35:23	TR03	Still	TR03_26	26	104.5	486 938.8	856 841.0	487 063.1	856 889.8	133.5	
18/05/2019	20:35:44	TR03	Still	TR03_27	27	105.6	486 938.8	856 841.0	487 065.8	856 891.4	136.6	
18/05/2019	20:35:55	TR03	Still	TR03_28	28	103.7	486 938.8	856 841.0	487 067.5	856 892.3	138.5	
18/05/2019	20:36:14	TR03	Still	TR03_29	29	105.1	486 938.8	856 841.0	487 070.7	856 894.0	142.2	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	20:36:49	TR03	Still	TR03_30	30	103.6	486 938.8	856 841.0	487 075.9	856 895.2	147.4	
18/05/2019	20:37:07	TR03	Still	TR03_31	31	103.5	486 938.8	856 841.0	487 078.0	856 895.9	149.7	
18/05/2019	20:37:22	TR03	Still	TR03_32	32	103.9	486 938.8	856 841.0	487 080.2	856 896.7	152.0	
18/05/2019	20:37:32	TR03	Still	TR03_33	33	104.9	486 938.8	856 841.0	487 081.1	856 897.2	153.1	
18/05/2019	20:38:23	TR03	Still	TR03_34	34	103.9	486 938.8	856 841.0	487 088.7	856 899.6	161.0	
18/05/2019	20:38:37	TR03	Still	TR03_35	35	103.9	486 938.8	856 841.0	487 091.4	856 900.8	163.9	
18/05/2019	20:39:39	TR03	Still	TR03_36	36	104.1	486 938.8	856 841.0	487 101.1	856 904.0	174.1	
18/05/2019	20:40:08	TR03	Still	TR03_37	37	106.7	486 938.8	856 841.0	487 104.7	856 907.3	178.6	
18/05/2019	20:40:25	TR03	Still	TR03_38	38	106.6	486 938.8	856 841.0	487 106.5	856 908.7	180.8	
18/05/2019	20:40:42	TR03	Video	EOL	1	104.9	486 938.8	856 841.0	487 108.9	856 909.6	183.4	
18/5/2019	21:57:28	TR02_part1	Video	SOL	1	94.5	483 243.0	856 113.0	483 136.9	856 254.5	176.9	
18/5/2019	21:57:58	TR02_part1	Still	TR02_01	2	94.7	483 243.0	856 113.0	483 137.9	856 254.3	176.1	
18/5/2019	21:58:34	TR02_part1	Still	TR02_02	3	94.1	483 243.0	856 113.0	483 140.4	856 251.3	172.2	
18/5/2019	21:58:57	TR02_part1	Still	TR02_03	4	95.7	483 243.0	856 113.0	483 143.8	856 249.3	168.6	
18/5/2019	21:59:36	TR02_part1	Still	TR02_04	5	95.8	483 243.0	856 113.0	483 146.5	856 245.1	163.6	
18/5/2019	21:59:54	TR02_part1	Still	TR02_05	6	93.8	483 243.0	856 113.0	483 146.9	856 243.1	161.7	
18/5/2019	22:00:15	TR02_part1	Still	TR02_06	7	93.3	483 243.0	856 113.0	483 147.8	856 240.4	159.0	
18/5/2019	22:00:49	TR02_part1	Still	TR02_07	8	94.8	483 243.0	856 113.0	483 150.1	856 236.5	154.6	
18/5/2019	22:01:30	TR02_part1	Still	TR02_08	9	94.3	483 243.0	856 113.0	483 153.2	856 230.5	147.9	
18/5/2019	22:01:46	TR02_part1	Still	TR02_09	10	93.0	483 243.0	856 113.0	483 155.0	856 228.2	145.0	
18/5/2019	22:01:58	TR02_part1	Still	TR02_10	11	94.9	483 243.0	856 113.0	483 156.8	856 227.6	143.4	
18/5/2019	22:02:34	TR02_part1	Still	TR02_11	12	94.3	483 243.0	856 113.0	483 160.4	856 222.4	137.1	
18/5/2019	22:02:55	TR02_part1	Still	TR02_12	13	93.3	483 243.0	856 113.0	483 162.3	856 219.2	133.3	
18/5/2019	22:03:34	TR02_part1	Still	TR02_13	14	94.8	483 243.0	856 113.0	483 166.8	856 213.2	125.9	
18/5/2019	22:03:56	TR02_part1	Still	TR02_14	15	95.0	483 243.0	856 113.0	483 168.3	856 209.0	121.6	
18/5/2019	22:04:27	TR02_part1	Still	TR02_15	16	95.2	483 243.0	856 113.0	483 170.6	856 204.6	116.8	
18/5/2019	22:04:41	TR02_part1	Still	TR02_16	17	94.7	483 243.0	856 113.0	483 172.2	856 202.9	114.4	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/5/2019	22:05:02	TR02_part1	Still	TR02_17	18	95.5	483 243.0	856 113.0	483 173.6	856 200.2	111.4	
18/5/2019	22:05:27	TR02_part1	Still	TR02_18	19	96.3	483 243.0	856 113.0	483 175.5	856 196.5	107.4	
18/5/2019	22:06:10	TR02_part1	Still	TR02_19	20	97.5	483 243.0	856 113.0	483 179.5	856 191.2	100.7	
18/5/2019	22:07:21	TR02_part1	Still	TR02_20	21	98.7	483 243.0	856 113.0	483 185.7	856 183.1	90.6	
18/5/2019	22:07:50	TR02_part1	Still	TR02_21	22	100.6	483 243.0	856 113.0	483 189.8	856 178.6	84.5	
18/5/2019	22:08:09	TR02_part1	Still	TR02_22	23	100.7	483 243.0	856 113.0	483 191.8	856 175.3	80.7	
18/5/2019	22:08:28	TR02_part1	Still	TR02_23	24	101.5	483 243.0	856 113.0	483 193.1	856 173.0	78.0	
18/5/2019	22:08:41	TR02_part1	Still	TR02_24	25	100.5	483 243.0	856 113.0	483 194.5	856 171.4	75.9	
18/5/2019	22:08:52	TR02_part1	Still	TR02_25	26	99.9	483 243.0	856 113.0	483 195.3	856 170.8	74.9	
18/5/2019	22:09:13	TR02_part1	Still	TR02_26	27	99.0	483 243.0	856 113.0	483 197.5	856 168.2	71.5	
18/5/2019	22:09:34	TR02_part1	Still	TR02_27	28	99.8	483 243.0	856 113.0	483 200.5	856 165.1	67.2	
18/5/2019	22:10:02	TR02_part1	Still	TR02_28	29	98.1	483 243.0	856 113.0	483 204.7	856 162.8	62.8	
18/5/2019	22:10:21	TR02_part1	Still	TR02_29	30	98.9	483 243.0	856 113.0	483 207.2	856 160.6	59.6	
18/5/2019	22:11:39	TR02_part1	Still	TR02_30		97.4	483 243.0	856 113.0	483 215.8	856 154.3	49.4	
18/5/2019	22:12:02	TR02_part1	Still	TR02_31	31	97.1	483 243.0	856 113.0	483 217.8	856 151.2	45.7	
18/5/2019	22:12:34	TR02_part1	Still	TR02_32	32	95.6	483 243.0	856 113.0	483 221.8	856 149.7	42.4	
18/5/2019	22:13:00	TR02_part1	Still	TR02_33	33	95.0	483 243.0	856 113.0	483 224.6	856 147.3	38.9	
18/5/2019	22:14:14	TR02_part1	Video	EOL	1	95.8	483 243.0	856 113.0	483 230.1	856 139.4	29.4	
18/5/2019	22:17:35	TR02_part2	Video	SOL	2	94.3	483 243.0	856 113.0	483 232.7	856 135.9	25.1	
18/5/2019	22:17:50	TR02_part2	Still	TR02_34	36	94.8	483 243.0	856 113.0	483 231.9	856 136.8	26.3	
18/5/2019	22:18:22	TR02_part2	Still	TR02_35	37	94.4	483 243.0	856 113.0	483 231.9	856 136.6	26.1	
18/5/2019	22:18:46	TR02_part2	Still	TR02_36	38	94.0	483 243.0	856 113.0	483 233.5	856 135.0	24.0	
18/5/2019	22:19:22	TR02_part2	Still	TR02_37	39	94.5	483 243.0	856 113.0	483 236.1	856 130.4	18.7	
18/5/2019	22:19:43	TR02_part2	Still	TR02_38	40	95.1	483 243.0	856 113.0	483 238.1	856 129.2	16.9	
18/5/2019	22:21:36	TR02_part2	Still	TR02_39	41	98.0	483 243.0	856 113.0	483 251.7	856 118.6	10.3	
18/5/2019	22:22:12	TR02_part2	Still	TR02_40	42	97.5	483 243.0	856 113.0	483 252.2	856 114.6	9.4	
18/5/2019	22:22:39	TR02_part2	Still	TR02_41	43	97.8	483 243.0	856 113.0	483 253.4	856 110.3	10.7	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/5/2019	22:23:02	TR02_part2	Still	TR02_42		98.4	483 243.0	856 113.0	483 254.4	856 105.8	13.5	
18/5/2019	22:23:25	TR02_part2	Still	TR02_43	44	98.8	483 243.0	856 113.0	483 256.5	856 102.1	17.3	
18/5/2019	22:24:07	TR02_part2	Still	TR02_44		98.5	483 243.0	856 113.0	483 260.6	856 096.1	24.4	
18/5/2019	22:24:38	TR02_part2	Still	TR02_45	45	98.1	483 243.0	856 113.0	483 263.4	856 092.4	28.9	
18/5/2019	22:25:24	TR02_part2	Still	TR02_46	46	96.0	483 243.0	856 113.0	483 267.0	856 088.0	34.7	
18/5/2019	22:25:36	TR02_part2	Video	EOL	2	96.2	483 243.0	856 113.0	483 267.6	856 086.6	36.1	
18/05/2019	23:34:36	TR01_part1	Video	SOL	1	111.2	484 524.0	858 728.0	484 500.2	858 711.5	29.0	
18/05/2019	23:34:57	TR01_part1	Still	TR01_01	1	111.3	484 524.0	858 728.0	484 500.2	858 710.3	29.6	
18/05/2019	23:37:16	TR01_part1	Still	TR01_02	2	110.8	484 524.0	858 728.0	484 500.8	858 708.6	30.3	
18/05/2019	23:37:38	TR01_part1	Still	TR01_03	3	110.8	484 524.0	858 728.0	484 502.6	858 710.7	27.6	
18/05/2019	23:38:50	TR01_part1	Still	TR01_04	4	109.8	484 524.0	858 728.0	484 508.8	858 718.2	18.0	
18/05/2019	23:39:15	TR01_part1	Still	TR01_05	5	109.7	484 524.0	858 728.0	484 511.5	858 721.5	14.0	
18/05/2019	23:39:58	TR01_part1	Still	TR01_06	6	108.8	484 524.0	858 728.0	484 516.4	858 727.5	7.6	
18/05/2019	23:40:14	TR01_part1	Still	TR01_07	7	108.7	484 524.0	858 728.0	484 518.0	858 729.4	6.1	
18/05/2019	23:40:39	TR01_part1	Still	TR01_08	8	108.1	484 524.0	858 728.0	484 520.2	858 732.9	6.2	
18/05/2019	23:41:02	TR01_part1	Still	TR01_09	9	108.3	484 524.0	858 728.0	484 522.3	858 736.2	8.4	
18/05/2019	23:41:25	TR01_part1	Still	TR01_10	10	110.1	484 524.0	858 728.0	484 524.6	858 738.0	10.0	
18/05/2019	23:42:20	TR01_part1	Video	EOL	1	109.0	484 524.0	858 728.0	484 528.1	858 742.7	15.3	
18/05/2019	23:45:29	TR01_part2	Video	SOL	2	102.6	484 524.0	858 728.0	484 534.7	858 748.6	23.3	
18/05/2019	23:47:11	TR01_part2	Still	TR01_11	11	102.7	484 524.0	858 728.0	484 542.1	858 752.4	30.3	
18/05/2019	23:47:37	TR01_part2	Still	TR01_12	12	103.9	484 524.0	858 728.0	484 542.7	858 753.7	31.7	
18/05/2019	23:47:58	TR01_part2	Still	TR01_13	13	103.4	484 524.0	858 728.0	484 544.3	858 755.2	33.9	
18/05/2019	23:48:26	TR01_part2	Still	TR01_14	14	105.4	484 524.0	858 728.0	484 546.3	858 757.4	36.9	
18/05/2019	23:48:44	TR01_part2	Still	TR01_15	15	103.2	484 524.0	858 728.0	484 547.9	858 758.6	38.8	
18/05/2019	23:49:07	TR01_part2	Still	TR01_16	16	103.1	484 524.0	858 728.0	484 551.8	858 761.9	43.8	
18/05/2019	23:49:31	TR01_part2	Still	TR01_17	17	103.6	484 524.0	858 728.0	484 554.5	858 764.7	47.7	
18/05/2019	23:50:05	TR01_part2	Still	TR01_18	18	104.0	484 524.0	858 728.0	484 557.7	858 769.1	53.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	23:50:27	TR01_part2	Still	TR01_19	19	104.5	484 524.0	858 728.0	484 560.7	858 771.6	57.0	
18/05/2019	23:51:09	TR01_part2	Still	TR01_20	20	105.8	484 524.0	858 728.0	484 564.6	858 776.8	63.5	
18/05/2019	23:51:27	TR01_part2	Still	TR01_21	21	106.0	484 524.0	858 728.0	484 566.6	858 778.3	65.9	
18/05/2019	23:52:05	TR01_part2	Still	TR01_22	22	106.6	484 524.0	858 728.0	484 568.2	858 783.5	71.0	
18/05/2019	23:52:27	TR01_part2	Still	TR01_23	23	106.6	484 524.0	858 728.0	484 569.9	858 786.0	74.0	
18/05/2019	23:53:13	TR01_part2	Still	TR01_24	24	107.3	484 524.0	858 728.0	484 574.9	858 791.4	81.3	
18/05/2019	23:54:09	TR01_part2	Still	TR01_25	25	108.4	484 524.0	858 728.0	484 580.5	858 794.8	87.5	
18/05/2019	23:54:34	TR01_part2	Still	TR01_26	26	109.4	484 524.0	858 728.0	484 582.9	858 797.8	91.3	
18/05/2019	23:55:07	TR01_part2	Still	TR01_27	27	108.3	484 524.0	858 728.0	484 585.2	858 801.5	95.6	
18/05/2019	23:56:30	TR01_part2	Still	TR01_28	28	106.5	484 524.0	858 728.0	484 592.7	858 810.4	107.3	
18/05/2019	23:57:06	TR01_part2	Still	TR01_29	29	106.9	484 524.0	858 728.0	484 596.7	858 815.6	113.9	
18/05/2019	23:57:24	TR01_part2	Still	TR01_30	30	106.6	484 524.0	858 728.0	484 599.0	858 817.9	117.1	
18/05/2019	23:58:14	TR01_part2	Still	TR01_31	31	106.4	484 524.0	858 728.0	484 604.4	858 823.3	124.7	
18/05/2019	23:58:38	TR01_part2	Still	TR01_32	32	106.5	484 524.0	858 728.0	484 606.7	858 825.4	127.7	
18/05/2019	23:58:52	TR01_part2	Still	TR01_33	33	106.1	484 524.0	858 728.0	484 607.5	858 827.7	130.0	
18/05/2019	23:59:16	TR01_part2	Still	TR01_34	34	106.6	484 524.0	858 728.0	484 610.1	858 830.5	133.9	
18/05/2019	23:59:40	TR01_part2	Still	TR01_35	35	106.2	484 524.0	858 728.0	484 612.2	858 833.3	137.4	
19/05/2019	00:00:17	TR01_part2	Still	TR01_36	36	106.2	484 524.0	858 728.0	484 615.8	858 837.3	142.8	
19/05/2019	00:00:35	TR01_part2	Still	TR01_37	37	107.0	484 524.0	858 728.0	484 617.5	858 839.1	145.2	
19/05/2019	00:00:59	TR01_part2	Still	TR01_38	38	106.2	484 524.0	858 728.0	484 620.3	858 840.9	148.4	
19/05/2019	00:01:20	TR01_part2	Still	TR01_39	39	102.9	484 524.0	858 728.0	484 623.7	858 843.3	152.4	
19/05/2019	00:02:02	TR01_part2	Still	TR01_40	40	104.9	484 524.0	858 728.0	484 629.9	858 850.2	161.7	
19/05/2019	00:02:33	TR01_part2	Still	TR01_41	41	104.4	484 524.0	858 728.0	484 632.4	858 854.4	166.5	
19/05/2019	00:03:04	TR01_part2	Still	TR01_42	42	104.5	484 524.0	858 728.0	484 635.3	858 857.0	170.3	
19/05/2019	00:03:31	TR01_part2	Still	TR01_43	43	104.2	484 524.0	858 728.0	484 639.0	858 859.9	175.0	
19/05/2019	00:04:18	TR01_part2	Still	TR01_44	44	105.2	484 524.0	858 728.0	484 643.2	858 867.3	183.4	
19/05/2019	00:04:54	TR01_part2	Still	TR01_45	45	105.9	484 524.0	858 728.0	484 647.6	858 871.4	189.3	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	00:05:38	TR01_part2	Still	TR01_46	46	104.4	484 524.0	858 728.0	484 651.4	858 874.7	194.3	
19/05/2019	00:05:56	TR01_part2	Still	TR01_47	47	106.9	484 524.0	858 728.0	484 654.0	858 877.2	197.9	
19/05/2019	00:06:34	TR01_part2	Still	TR01_48	48	105.3	484 524.0	858 728.0	484 658.6	858 882.2	204.6	
19/05/2019	00:07:36	TR01_part2	Still	TR01_49	49	106.2	484 524.0	858 728.0	484 666.2	858 890.2	215.7	
19/05/2019	00:07:56	TR01_part2	Still	TR01_50	50	108.3	484 524.0	858 728.0	484 666.6	858 892.3	217.5	
19/05/2019	00:08:24	TR01_part2	Still	TR01_51	51	104.0	484 524.0	858 728.0	484 667.7	858 894.8	220.2	
19/05/2019	00:08:00	TR01_part2	Video	EOL	2	102.8	484 524.0	858 728.0	484 669.0	858 896.4	222.3	
19/05/2019	02:46:23	EBSHHDD_01c	Video	SOL	1	1033.5	483 865.5	880 797.2	483 849.5	880 792.5	16.8	
19/05/2019	02:48:51	EBSHHDD_01c	Still	EBSHH01DDc_01	1	1031.8	483 865.5	880 797.2	483 851.5	880 798.6	14.1	
19/05/2019	02:49:26	EBSHHDD_01c	Still	EBSHH01DDc_02	2	1032.6	483 865.5	880 797.2	483 851.3	880 799.4	14.4	
19/05/2019	02:50:13	EBSHHDD_01c	Still	EBSHH01DDc_03	3	1030.4	483 865.5	880 797.2	483 851.0	880 800.7	15.0	
19/05/2019	02:51:46	EBSHHDD_01c	Still	EBSHH01DDc_04	4	1033.4	483 865.5	880 797.2	483 851.8	880 801.3	14.4	
19/05/2019	02:52:33	EBSHHDD_01c	Still	EBSHH01DDc_05	5	1031.2	483 865.5	880 797.2	483 852.4	880 802.4	14.1	
19/05/2019	02:52:52	EBSHHDD_01c	Still	EBSHH01DDc_06	6	1032.0	483 865.5	880 797.2	483 852.8	880 802.4	13.7	
19/05/2019	02:53:26	EBSHHDD_01c	Still	EBSHH01DDc_07	7	1032.4	483 865.5	880 797.2	483 853.5	880 803.1	13.4	
19/05/2019	02:53:56	EBSHHDD_01c	Still	EBSHH01DDc_08	8	1033.3	483 865.5	880 797.2	483 854.8	880 803.6	12.5	
19/05/2019	02:55:48	EBSHHDD_01c	Still	EBSHH01DDc_09	9	1030.6	483 865.5	880 797.2	483 861.1	880 804.2	8.3	
19/05/2019	02:56:31	EBSHHDD_01c	Still	EBSHH01DDc_10	10	1032.4	483 865.5	880 797.2	483 864.9	880 803.2	6.0	
19/05/2019	02:57:41	EBSHHDD_01c	Still	EBSHH01DDc_11	11	1032.5	483 865.5	880 797.2	483 873.1	880 801.6	8.7	
19/05/2019	02:57:54	EBSHHDD_01c	Still	EBSHH01DDc_12	12	1032.5	483 865.5	880 797.2	483 874.6	880 802.1	10.3	
19/05/2019	02:58:32	EBSHHDD_01c	Still	EBSHH01DDc_13	13	1032.8	483 865.5	880 797.2	483 877.6	880 802.5	13.1	
19/05/2019	02:58:48	EBSHHDD_01c	Still	EBSHH01DDc_14	14	1033.6	483 865.5	880 797.2	483 880.5	880 802.6	15.9	
19/05/2019	02:59:10	EBSHHDD_01c	Still	EBSHH01DDc_15	15	1034.5	483 865.5	880 797.2	483 883.4	880 800.3	18.2	
19/05/2019	02:59:43	EBSHHDD_01c	Still	EBSHH01DDc_16	16	1032.6	483 865.5	880 797.2	483 886.6	880 801.9	21.6	
19/05/2019	03:00:20	EBSHHDD_01c	Still	EBSHH01DDc_17	17	1033.1	483 865.5	880 797.2	483 891.9	880 800.5	26.6	
19/05/2019	03:00:54	EBSHHDD_01c	Still	EBSHH01DDc_18	18	1033.1	483 865.5	880 797.2	483 895.2	880 801.1	29.9	
19/05/2019	03:01:58	EBSHHDD_01c	Still	EBSHH01DDc_19	19	1033.9	483 865.5	880 797.2	483 904.7	880 799.8	39.2	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	03:02:29	EBSHHDD_01c	Still	EBSHH01DDc_20	20	1034.6	483 865.5	880 797.2	483 908.3	880 799.7	42.8	
19/05/2019	03:02:55	EBSHHDD_01c	Still	EBSHH01DDc_21	21	1033.3	483 865.5	880 797.2	483 911.4	880 799.5	45.9	
19/05/2019	03:03:26	EBSHHDD_01c	Still	EBSHH01DDc_22	22	1034.4	483 865.5	880 797.2	483 913.5	880 799.7	48.0	
19/05/2019	03:04:17	EBSHHDD_01c	Still	EBSHH01DDc_23	23	1034.1	483 865.5	880 797.2	483 921.6	880 800.2	56.1	
19/05/2019	03:04:56	EBSHHDD_01c	Still	EBSHH01DDc_24	24	1037.1	483 865.5	880 797.2	483 927.7	880 800.1	62.3	
19/05/2019	03:05:35	EBSHHDD_01c	Still	EBSHH01DDc_25	25	1038.2	483 865.5	880 797.2	483 928.4	880 799.8	62.9	
19/05/2019	03:05:56	EBSHHDD_01c	Still	EBSHH01DDc_26	26	1036.5	483 865.5	880 797.2	483 933.1	880 804.3	67.9	
19/05/2019	03:05:36	EBSHHDD_01c	Video	EOL	1	1036.0	483 865.5	880 797.2	483 934.5	880 798.3	69.0	
19/05/2019	07:28:45	EBSHHDD_02	Video	SOL	1	1094.6	488 336.0	878 556.0	488 334.8	878 552.1	4.1	
19/05/2019	07:29:24	EBSHHDD_02	Video	EOL	1	1094.3	488 336.0	878 556.0	488 336.4	878 552.8	3.2	Winch power loss, camera recovered
19/05/2019	08:12:39	EBSHHDD_02	Video	SOL	2	1094.4	488 336.0	878 556.0	488 296.6	878 534.7	44.8	
19/05/2019	08:16:24	EBSHHDD_02	Still	EBSHH02DD_01	2	1092.5	488 336.0	878 556.0	488 300.5	878 541.2	38.5	
19/05/2019	08:18:46	EBSHHDD_02	Still	EBSHH02DD_02	3	1092.6	488 336.0	878 556.0	488 309.7	878 546.5	28.0	
19/05/2019	08:23:20	EBSHHDD_02	Still	EBSHH02DD_03	5	1094.5	488 339.9	878 556.3	488 336.8	878 561.0	5.6	
19/05/2019	08:23:35	EBSHHDD_02	Still	EBSHH02DD_04	6	1094.3	488 343.7	878 556.6	488 337.7	878 561.2	7.6	
19/05/2019	08:23:50	EBSHHDD_02	Still	EBSHH02DD_05	7	1094.3	488 347.6	878 556.9	488 339.0	878 560.9	9.5	
19/05/2019	08:23:59	EBSHHDD_02	Still	EBSHH02DD_06	8	1093.8	488 351.5	878 557.3	488 340.6	878 563.0	12.3	
19/05/2019	08:24:13	EBSHHDD_02	Still	EBSHH02DD_07	9	1094.6	488 355.3	878 557.6	488 342.5	878 562.8	13.9	
19/05/2019	08:24:43	EBSHHDD_02	Still	EBSHH02DD_08	10	1095.5	488 359.2	878 557.9	488 346.0	878 564.6	14.8	
19/05/2019	08:24:58	EBSHHDD_02	Still	EBSHH02DD_09	12	1095.8	488 366.9	878 558.5	488 348.7	878 565.4	19.5	
19/05/2019	08:25:13	EBSHHDD_02	Still	EBSHH02DD_10	13	1096.1	488 370.8	878 558.8	488 350.0	878 566.0	22.0	
19/05/2019	08:25:44	EBSHHDD_02	Still	EBSHH02DD_11	14	1093.4	488 374.6	878 559.2	488 352.8	878 567.7	23.4	
19/05/2019	08:26:05	EBSHHDD_02	Still	EBSHH02DD_12	16	1095.5	488 382.4	878 559.8	488 356.8	878 567.7	26.8	
19/05/2019	08:26:20	EBSHHDD_02	Still	EBSHH02DD_13	17	1095.3	488 386.2	878 560.1	488 358.4	878 568.9	29.2	
19/05/2019	08:26:47	EBSHHDD_02	Still	EBSHH02DD_14	18	1095.2	488 386.2	878 560.1	488 362.5	878 569.2	25.4	
19/05/2019	08:27:20	EBSHHDD_02	Still	EBSHH02DD_15	19	1095.0	488 386.2	878 560.1	488 366.8	878 570.5	22.0	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	08:27:35	EBSHHDD_02	Still	EBSHH02DD_16	20	1096.1	488 386.2	878 560.1	488 369.6	878 571.3	20.1	
19/05/2019	08:27:48	EBSHHDD_02	Still	EBSHH02DD_17	21	1095.9	488 386.2	878 560.1	488 370.9	878 571.8	19.3	
19/05/2019	08:28:07	EBSHHDD_02	Still	EBSHH02DD_18		1097.1	488 386.2	878 560.1	488 373.8	878 571.7	17.0	
19/05/2019	08:28:37	EBSHHDD_02	Still	EBSHH02DD_19		1097.0	488 386.2	878 560.1	488 377.6	878 572.7	15.3	
19/05/2019	08:28:51	EBSHHDD_02	Still	EBSHH02DD_20		1096.6	488 386.2	878 560.1	488 380.0	878 573.3	14.6	
19/05/2019	08:29:59	EBSHHDD_02	Still	EBSHH02DD_21		1097.3	488 386.2	878 560.1	488 388.9	878 575.4	15.5	
19/05/2019	08:30:27	EBSHHDD_02	Video	EOL	2	1096.9	488 386.2	878 560.1	488 392.2	878 576.4	17.3	
19/05/2019	19:33:00	EBSHHDD_03	Video	SOL	1	1106.5	492 832.3	876 320.2	492 803.4	876 326.1	29.5	
19/05/2019	19:33:31	EBSHHDD_03	Still	EBSHH03DD_01	1	1109.6	492 832.3	876 320.2	492 807.0	876 327.1	26.3	
19/05/2019	19:33:53	EBSHHDD_03	Still	EBSHH03DD_02	2	1108.1	492 832.3	876 320.2	492 809.4	876 326.5	23.8	
19/05/2019	19:35:05	EBSHHDD_03	Still	EBSHH03DD_03	3	1107.1	492 832.3	876 320.2	492 817.8	876 326.3	15.7	
19/05/2019	19:35:32	EBSHHDD_03	Still	EBSHH03DD_04	4	1109.4	492 832.3	876 320.2	492 821.4	876 327.7	13.3	
19/05/2019	19:37:06	EBSHHDD_03	Still	EBSHH03DD_05	5	1106.9	492 832.3	876 320.2	492 834.0	876 328.4	8.4	
19/05/2019	19:37:53	EBSHHDD_03	Still	EBSHH03DD_06	6	1108.8	492 832.3	876 320.2	492 840.4	876 330.1	12.8	
19/05/2019	19:38:15	EBSHHDD_03	Still	EBSHH03DD_07	7	1109.9	492 832.3	876 320.2	492 843.7	876 330.6	15.5	
19/05/2019	19:38:49	EBSHHDD_03	Still	EBSHH03DD_08	8	1110.4	492 832.3	876 320.2	492 847.8	876 329.7	18.2	
19/05/2019	19:39:02	EBSHHDD_03	Still	EBSHH03DD_09	9	1108.7	492 832.3	876 320.2	492 849.1	876 330.1	19.6	
19/05/2019	19:40:11	EBSHHDD_03	Still	EBSHH03DD_10	10	1109.2	492 832.3	876 320.2	492 858.2	876 331.8	28.4	
19/05/2019	19:40:44	EBSHHDD_03	Video	EOL	1	1107.2	492 832.3	876 320.2	492 863.4	876 332.1	33.4	
19/05/2019	21:17:42	EBSHHDD_03a	Video	SOL	1	1106.3	492 832.3	876 320.2	492 781.4	876 327.3	51.3	
19/05/2019	21:17:57	EBSHHDD_03a	Still	EBSHH03DDa_01	1	1107.3	492 832.3	876 320.2	492 783.0	876 327.5	49.9	
19/05/2019	21:18:18	EBSHHDD_03a	Still	EBSHH03DDa_02	2	1106.5	492 832.3	876 320.2	492 785.0	876 327.3	47.8	
19/05/2019	21:19:01	EBSHHDD_03a	Still	EBSHH03DDa_03	3	1108.0	492 832.3	876 320.2	492 788.9	876 327.0	43.9	
19/05/2019	21:19:51	EBSHHDD_03a	Still	EBSHH03DDa_04	4	1107.4	492 832.3	876 320.2	492 793.0	876 326.3	39.8	
19/05/2019	21:20:26	EBSHHDD_03a	Still	EBSHH03DDa_05	5	1105.7	492 832.3	876 320.2	492 796.8	876 325.9	36.0	
19/05/2019	21:22:02	EBSHHDD_03a	Still	EBSHH03DDa_06	6	1107.0	492 832.3	876 320.2	492 807.6	876 323.5	24.9	
19/05/2019	21:22:19	EBSHHDD_03a	Still	EBSHH03DDa_07	7	1107.0	492 832.3	876 320.2	492 809.3	876 323.8	23.3	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	21:22:34	EBSHHDD_03a	Still	EBSHH03DDa_08	8	1107.8	492 832.3	876 320.2	492 810.4	876 323.7	22.1	
19/05/2019	21:22:48	EBSHHDD_03a	Still	EBSHH03DDa_09	9	1107.1	492 832.3	876 320.2	492 811.9	876 323.2	20.6	
19/05/2019	21:23:28	EBSHHDD_03a	Still	EBSHH03DDa_10	10	1106.2	492 832.3	876 320.2	492 816.2	876 322.0	16.2	
19/05/2019	21:25:20	EBSHHDD_03a	Still	EBSHH03DDa_11	11	1104.2	492 832.3	876 320.2	492 827.3	876 320.0	5.0	
19/05/2019	21:25:34	EBSHHDD_03a	Still	EBSHH03DDa_12	12	1104.8	492 832.3	876 320.2	492 828.2	876 320.3	4.1	
19/05/2019	21:25:57	EBSHHDD_03a	Still	EBSHH03DDa_13	13	1105.1	492 832.3	876 320.2	492 829.4	876 320.3	2.9	
19/05/2019	21:26:32	EBSHHDD_03a	Still	EBSHH03DDa_14	14	1106.7	492 832.3	876 320.2	492 833.3	876 319.6	1.2	
19/05/2019	21:26:58	EBSHHDD_03a	Still	EBSHH03DDa_15	15	1105.4	492 832.3	876 320.2	492 835.6	876 319.3	3.4	
19/05/2019	21:27:18	EBSHHDD_03a	Still	EBSHH03DDa_16	16	1104.8	492 832.3	876 320.2	492 837.4	876 320.3	5.1	
19/05/2019	21:27:42	EBSHHDD_03a	Still	EBSHH03DDa_17	17	1105.2	492 832.3	876 320.2	492 839.1	876 319.3	6.9	
19/05/2019	21:28:06	EBSHHDD_03a	Still	EBSHH03DDa_18	18	1104.9	492 832.3	876 320.2	492 840.6	876 319.7	8.3	
19/05/2019	21:28:29	EBSHHDD_03a	Still	EBSHH03DDa_19	19	1106.6	492 832.3	876 320.2	492 842.6	876 319.1	10.4	
19/05/2019	21:29:00	EBSHHDD_03a	Still	EBSHH03DDa_20	20	1107.2	492 832.3	876 320.2	492 844.5	876 320.5	12.3	
19/05/2019	21:29:21	EBSHHDD_03a	Still	EBSHH03DDa_21	21	1106.5	492 832.3	876 320.2	492 845.9	876 319.7	13.6	
19/05/2019	21:30:12	EBSHHDD_03a	Still	EBSHH03DDa_22	22	1106.5	492 832.3	876 320.2	492 849.8	876 319.1	17.5	
19/05/2019	21:30:22	EBSHHDD_03a	Still	EBSHH03DDa_23	23	1107.5	492 832.3	876 320.2	492 849.5	876 319.5	17.3	
19/05/2019	21:30:48	EBSHHDD_03a	Still	EBSHH03DDa_24	24	1107.0	492 832.3	876 320.2	492 851.5	876 319.6	19.2	
19/05/2019	21:31:10	EBSHHDD_03a	Still	EBSHH03DDa_25	25	1107.8	492 832.3	876 320.2	492 853.3	876 318.6	21.1	
19/05/2019	21:31:26	EBSHHDD_03a	Still	EBSHH03DDa_26	26	1107.8	492 832.3	876 320.2	492 853.6	876 318.8	21.4	
19/05/2019	21:31:45	EBSHHDD_03a	Still	EBSHH03DDa_27	27	1107.7	492 832.3	876 320.2	492 854.9	876 318.4	22.7	
19/05/2019	21:31:56	EBSHHDD_03a	Still	EBSHH03DDa_28	28	1107.0	492 832.3	876 320.2	492 855.3	876 317.6	23.2	
19/05/2019	21:31:09	EBSHHDD_03a	Still	EBSHH03DDa_29	29	1106.7	492 832.3	876 320.2	492 855.8	876 317.6	23.6	
19/05/2019	21:32:19	EBSHHDD_03a	Still	EBSHH03DDa_30	30	1106.6	492 832.3	876 320.2	492 856.6	876 317.6	24.5	
19/05/2019	21:32:34	EBSHHDD_03a	Still	EBSHH03DDa_31	31	1108.0	492 832.3	876 320.2	492 857.1	876 317.8	25.0	
19/05/2019	21:32:44	EBSHHDD_03a	Video	EOL	1	1107.6	492 832.3	876 320.2	492 857.5	876 317.2	25.4	
19/05/2019	23:37:49	EBSHHDD_06	Video	SOL	1	930.0	493 622.3	871 760.8	493 580.4	871 748.3	43.7	
19/05/2019	23:38:39	EBSHHDD_06	Still	EBSHH06DD_01	1	932.0	493 622.3	871 760.8	493 580.6	871 750.2	43.0	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	23:39:03	EBSHHDD_06	Still	EBSHH06DD_02	2	931.5	493 622.3	871 760.8	493 580.5	871 749.3	43.4	
19/05/2019	23:40:23	EBSHHDD_06	Still	EBSHH06DD_03	3	932.0	493 622.3	871 760.8	493 581.3	871 750.2	42.3	
19/05/2019	23:42:33	EBSHHDD_06	Still	EOL	1	929.8	493 622.3	871 760.8	493 587.5	871 751.4	36.0	
19/05/2019	23:53:08	EBSHHDD_06	Still	SOL	2	932.4	493 622.3	871 760.8	493 594.3	871 751.6	29.5	
19/05/2019	23:53:58	EBSHHDD_06	Still	EBSHH06DD_04	4	933.3	493 622.3	871 760.8	493 594.8	871 752.5	28.8	
19/05/2019	23:54:52	EBSHHDD_06	Still	EOL	2	931.0	493 622.3	871 760.8	493 595.3	871 752.9	28.2	
20/05/2019	00:05:55	EBSHHDD_06	Still	SOL	3	932.5	493 622.3	871 760.8	493 608.0	871 754.2	15.8	
20/05/2019	00:06:07	EBSHHDD_06	Still	EBSHH06DD_05	5	931.6	493 622.3	871 760.8	493 608.1	871 754.2	15.7	
20/05/2019	00:06:48	EBSHHDD_06	Still	EBSHH06DD_06	6	931.7	493 622.3	871 760.8	493 608.0	871 754.5	15.7	
20/05/2019	00:07:39	EBSHHDD_06	Still	EBSHH06DD_07	7	931.6	493 622.3	871 760.8	493 607.9	871 754.5	15.7	
20/05/2019	00:08:25	EBSHHDD_06	Still	EBSHH06DD_08	8	932.6	493 622.3	871 760.8	493 607.5	871 754.5	16.1	
20/05/2019	00:08:53	EBSHHDD_06	Still	EBSHH06DD_09	9	932.3	493 622.3	871 760.8	493 607.8	871 754.7	15.7	
20/05/2019	00:09:20	EBSHHDD_06	Still	EBSHH06DD_10	10	931.8	493 622.3	871 760.8	493 607.4	871 755.3	15.9	
20/05/2019	00:10:07	EBSHHDD_06	Still	EBSHH06DD_11	11	932.6	493 622.3	871 760.8	493 607.9	871 754.9	15.6	
20/05/2019	00:10:29	EBSHHDD_06	Still	EBSHH06DD_12	12	932.7	493 622.3	871 760.8	493 608.4	871 756.5	14.5	
20/05/2019	00:11:08	EBSHHDD_06	Still	EBSHH06DD_13	13	932.8	493 622.3	871 760.8	493 610.2	871 757.0	12.7	
20/05/2019	00:12:00	EBSHHDD_06	Still	EBSHH06DD_14	14	931.8	493 622.3	871 760.8	493 611.5	871 757.5	11.3	
20/05/2019	00:12:29	EBSHHDD_06	Still	EBSHH06DD_15	15	932.2	493 622.3	871 760.8	493 613.2	871 757.1	9.8	
20/05/2019	00:13:43	EBSHHDD_06	Still	EBSHH06DD_16	16	932.9	493 622.3	871 760.8	493 615.5	871 757.2	7.8	
20/05/2019	00:14:11	EBSHHDD_06	Still	EBSHH06DD_17	17	932.7	493 622.3	871 760.8	493 616.5	871 757.8	6.5	
20/05/2019	00:14:46	EBSHHDD_06	Still	EBSHH06DD_18	18	932.2	493 622.3	871 760.8	493 615.6	871 757.5	7.5	
20/05/2019	00:15:55	EBSHHDD_06	Still	EBSHH06DD_19	19	933.0	493 622.3	871 760.8	493 617.6	871 757.3	5.9	
20/05/2019	00:17:20	EBSHHDD_06	Still	EBSHH06DD_20	20	932.6	493 622.3	871 760.8	493 620.6	871 757.6	3.6	
20/05/2019	00:17:52	EBSHHDD_06	Still	EBSHH06DD_21	21	932.6	493 622.3	871 760.8	493 622.5	871 759.7	1.1	
20/05/2019	00:18:34	EBSHHDD_06	Still	EBSHH06DD_22	22	937.0	493 622.3	871 760.8	493 639.9	871 865.6	106.2	
20/05/2019	00:18:52	EBSHHDD_06	Still	EBSHH06DD_23	23	932.8	493 622.3	871 760.8	493 625.9	871 759.1	4.0	
20/05/2019	00:19:22	EBSHHDD_06	Video	EOL	3	932.8	493 622.3	871 760.8	493 628.0	871 759.5	5.8	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	00:31:36	EBSHHDD_06	Video	SOL	4	785.0	493 622.3	871 760.8	493 644.6	871 767.6	23.3	
20/05/2019	00:32:22	EBSHHDD_06	Still	EBSHH06DD_24	24	640.3	493 622.3	871 760.8	493 625.9	871 775.2	14.8	
20/05/2019	00:33:35	EBSHHDD_06	Video	EOL	4	630.7	493 622.3	871 760.8	493 649.8	871 775.5	31.1	
20/05/2019	04:16:34	EBSHHDD_06a	Video	SOL	1	935.3	493 622.3	871 760.8	493 622.7	871 738.0	22.8	
20/05/2019	04:16:48	EBSHHDD_06a	Still	EBSHH06DDa_01	1	934.4	493 622.3	871 760.8	493 623.0	871 737.5	23.2	
20/05/2019	04:17:16	EBSHHDD_06a	Still	EBSHH06DDa_02	2	933.9	493 622.3	871 760.8	493 621.5	871 739.2	21.6	
20/05/2019	04:17:33	EBSHHDD_06a	Still	EBSHH06DDa_03	3	933.9	493 622.3	871 760.8	493 620.9	871 739.2	21.6	
20/05/2019	04:18:32	EBSHHDD_06a	Still	EBSHH06DDa_04	4	934.3	493 622.3	871 760.8	493 620.3	871 738.0	22.8	
20/05/2019	04:19:28	EBSHHDD_06a	Still	EBSHH06DDa_05	5	882.0	493 622.3	871 760.8	493 620.0	871 742.0	18.9	
20/05/2019	04:19:52	EBSHHDD_06a	Still	EBSHH06DDa_06	6	930.0	493 622.3	871 760.8	493 620.7	871 753.4	7.6	
20/05/2019	04:20:36	EBSHHDD_06a	Still	EBSHH06DDa_07	7	849.5	493 622.3	871 760.8	493 621.5	871 739.9	20.9	
20/05/2019	04:21:00	EBSHHDD_06a	Still	EBSHH06DDa_08	8	933.9	493 622.3	871 760.8	493 620.4	871 741.4	19.5	
20/05/2019	04:21:28	EBSHHDD_06a	Still	EBSHH06DDa_09	9	933.4	493 622.3	871 760.8	493 620.8	871 739.6	21.2	
20/05/2019	04:22:01	EBSHHDD_06a	Still	EBSHH06DDa_10	10	934.3	493 622.3	871 760.8	493 620.9	871 742.2	18.6	
20/05/2019	04:22:33	EBSHHDD_06a	Still	EBSHH06DDa_11	11	933.8	493 622.3	871 760.8	493 620.0	871 742.7	18.3	
20/05/2019	04:23:35	EBSHHDD_06a	Still	EBSHH06DDa_12	12	934.4	493 622.3	871 760.8	493 621.1	871 742.4	18.4	
20/05/2019	04:23:57	EBSHHDD_06a	Still	EBSHH06DDa_13	13	933.7	493 622.3	871 760.8	493 621.4	871 743.0	17.8	
20/05/2019	04:24:39	EBSHHDD_06a	Still	EBSHH06DDa_14	14	934.0	493 622.3	871 760.8	493 591.9	871 787.9	40.7	
20/05/2019	04:25:51	EBSHHDD_06a	Still	EBSHH06DDa_15	15	932.8	493 622.3	871 760.8	493 621.3	871 745.0	15.8	
20/05/2019	04:26:22	EBSHHDD_06a	Still	EBSHH06DDa_16	16	932.2	493 622.3	871 760.8	493 621.9	871 745.5	15.3	
20/05/2019	04:28:09	EBSHHDD_06a	Still	EBSHH06DDa_17	17	932.2	493 622.3	871 760.8	493 615.7	871 808.3	48.0	
20/05/2019	04:28:51	EBSHHDD_06a	Still	EBSHH06DDa_18	18	932.0	493 622.3	871 760.8	493 616.6	871 798.0	37.7	
20/05/2019	04:29:39	EBSHHDD_06a	Still	EBSHH06DDa_19	19	932.0	493 622.3	871 760.8	493 612.3	871 833.2	73.1	
20/05/2019	04:30:34	EBSHHDD_06a	Still	EBSHH06DDa_20	20	932.0	493 622.3	871 760.8	493 611.9	871 823.0	63.1	
20/05/2019	04:33:14	EBSHHDD_06a	Still	EBSHH06DDa_21	21	932.0	493 622.3	871 760.8	493 612.8	871 835.4	75.3	
20/05/2019	04:37:30	EBSHHDD_06a	Video	EOL	1	932.0	493 622.3	871 760.8	493 611.4	871 843.3	83.2	
20/05/2019	06:49:54	EBSHHDD_05	Video	SOL	1	920.5	488 805.9	873 862.8	488 753.3	873 859.9	52.7	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	06:49:56	EBSHHDD_05	Still	EBSHH05DD_01	1	920.1	488 805.9	873 862.8	488 753.4	873 860.5	52.6	
20/05/2019	06:50:54	EBSHHDD_05	Still	EBSHH05DD_02	2	917.7	488 805.9	873 862.8	488 753.9	873 861.9	52.0	
20/05/2019	06:51:42	EBSHHDD_05	Still	EBSHH05DD_03	3	917.5	488 805.9	873 862.8	488 753.3	873 863.7	52.7	
20/05/2019	06:56:16	EBSHHDD_05	Still	EBSHH05DD_04	4	918.3	488 805.9	873 862.8	488 761.4	873 871.7	45.4	
20/05/2019	07:00:30	EBSHHDD_05	Still	EBSHH05DD_05	5	920.2	488 805.9	873 862.8	488 787.4	873 878.7	24.4	
20/05/2019	07:00:51	EBSHHDD_05	Still	EBSHH05DD_06	6	920.7	488 805.9	873 862.8	488 790.1	873 879.9	23.2	
20/05/2019	07:01:16	EBSHHDD_05	Still	EBSHH05DD_07	7	921.2	488 805.9	873 862.8	488 793.7	873 879.2	20.5	
20/05/2019	07:01:51	EBSHHDD_05	Still	EBSHH05DD_08	8	921.6	488 805.9	873 862.8	488 797.9	873 880.1	19.0	
20/05/2019	07:02:13	EBSHHDD_05	Still	EBSHH05DD_09	9	921.9	488 805.9	873 862.8	488 802.2	873 880.9	18.5	
20/05/2019	07:02:31	EBSHHDD_05	Still	EBSHH05DD_10	10	921.8	488 805.9	873 862.8	488 805.1	873 881.2	18.4	
20/05/2019	07:02:53	EBSHHDD_05	Still	EBSHH05DD_11	11	922.9	488 805.9	873 862.8	488 807.2	873 881.5	18.7	
20/05/2019	07:03:31	EBSHHDD_05	Still	EBSHH05DD_12	12	921.7	488 805.9	873 862.8	488 811.6	873 881.2	19.2	
20/05/2019	07:04:07	EBSHHDD_05	Still	EBSHH05DD_13	13	923.7	488 805.9	873 862.8	488 817.3	873 882.2	22.5	
20/05/2019	07:04:42	EBSHHDD_05	Video	EOL	1	921.8	488 805.9	873 862.8	488 821.0	873 882.7	24.9	Vessel could not hold the position at this heading
20/05/2019	08:06:14	EBSHHDD_05a	Video	SOL	1	917.4	488 805.9	873 862.8	488 761.6	873 859.7	44.4	
20/05/2019	08:09:41	EBSHHDD_05a	Still	EBSHH05DDa_01	1	917.9	488 805.9	873 862.8	488 781.0	873 857.5	25.5	
20/05/2019	08:10:11	EBSHHDD_05a	Still	EBSHH05DDa_02	2	918.3	488 805.9	873 862.8	488 783.6	873 857.3	23.0	
20/05/2019	08:11:50	EBSHHDD_05a	Still	EBSHH05DDa_03	3	919.1	488 805.9	873 862.8	488 795.7	873 856.3	12.1	
20/05/2019	08:12:38	EBSHHDD_05a	Still	EBSHH05DDa_04	4	919.5	488 805.9	873 862.8	488 799.9	873 857.7	8.0	
20/05/2019	08:13:07	EBSHHDD_05a	Still	EBSHH05DDa_05	5	918.1	488 805.9	873 862.8	488 803.5	873 856.1	7.2	
20/05/2019	08:13:25	EBSHHDD_05a	Still	EBSHH05DDa_06	6	918.8	488 805.9	873 862.8	488 805.6	873 854.5	8.4	
20/05/2019	08:13:45	EBSHHDD_05a	Still	EBSHH05DDa_07	7	919.1	488 805.9	873 862.8	488 807.3	873 856.5	6.5	
20/05/2019	08:14:16	EBSHHDD_05a	Still	EBSHH05DDa_08	8	919.7	488 805.9	873 862.8	488 812.0	873 854.7	10.1	
20/05/2019	08:14:29	EBSHHDD_05a	Still	EBSHH05DDa_09	9	919.2	488 805.9	873 862.8	488 813.0	873 854.7	10.8	
20/05/2019	08:14:50	EBSHHDD_05a	Still	EBSHH05DDa_10	10	919.1	488 805.9	873 862.8	488 815.4	873 854.6	12.5	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	08:15:12	EBSHHDD_05a	Still	EBSHH05DDa_11	11	919.5	488 805.9	873 862.8	488 818.7	873 854.8	15.1	
20/05/2019	08:15:38	EBSHHDD_05a	Still	EBSHH05DDa_12	12	919.4	488 805.9	873 862.8	488 822.6	873 855.0	18.4	
20/05/2019	08:15:55	EBSHHDD_05a	Still	EBSHH05DDa_13	13	921.3	488 805.9	873 862.8	488 824.0	873 855.5	19.5	
20/05/2019	08:16:13	EBSHHDD_05a	Still	EBSHH05DDa_14	14	921.2	488 805.9	873 862.8	488 825.5	873 855.6	20.9	
20/05/2019	08:16:26	EBSHHDD_05a	Still	EBSHH05DDa_15	15	921.5	488 805.9	873 862.8	488 828.0	873 856.4	23.0	
20/05/2019	08:16:43	EBSHHDD_05a	Still	EBSHH05DDa_16	16	920.4	488 805.9	873 862.8	488 829.9	873 856.8	24.7	
20/05/2019	08:17:02	EBSHHDD_05a	Still	EBSHH05DDa_17	17	922.3	488 805.9	873 862.8	488 832.5	873 857.9	27.0	
20/05/2019	08:17:09	EBSHHDD_05a	Video	EOL	1	922.3	488 805.9	873 862.8	488 832.0	873 857.8	26.5	
20/05/2019	09:55:55	EBSHHDD_04	Video	SOL	1	879.8	484 335.1	876 101.5	484 267.2	876 107.1	68.1	
20/05/2019	09:56:35	EBSHHDD_04	Still	EBSHH04DD_01	1	880.4	484 335.1	876 101.5	484 269.0	876 106.9	66.3	
20/05/2019	09:56:59	EBSHHDD_04	Still	EBSHH04DD_02	2	880.7	484 335.1	876 101.5	484 269.7	876 106.3	65.5	
20/05/2019	09:57:52	EBSHHDD_04	Still	EBSHH04DD_03	3	880.6	484 335.1	876 101.5	484 274.2	876 105.7	61.0	
20/05/2019	09:58:43	EBSHHDD_04	Still	EBSHH04DD_04	4	880.3	484 335.1	876 101.5	484 278.6	876 105.4	56.6	
20/05/2019	09:59:30	EBSHHDD_04	Still	EBSHH04DD_05	5	881.4	484 335.1	876 101.5	484 283.3	876 104.0	51.9	
20/05/2019	09:59:52	EBSHHDD_04	Still	EBSHH04DD_06	6	882.2	484 335.1	876 101.5	484 285.3	876 103.6	49.8	
20/05/2019	10:00:53	EBSHHDD_04	Still	EBSHH04DD_07	7	881.8	484 335.1	876 101.5	484 292.0	876 101.9	43.1	
20/05/2019	10:03:15	EBSHHDD_04	Still	EBSHH04DD_08	8	881.2	484 335.1	876 101.5	484 307.9	876 100.3	27.2	
20/05/2019	10:03:43	EBSHHDD_04	Still	EBSHH04DD_09	9	882.4	484 335.1	876 101.5	484 311.8	876 099.7	23.3	
20/05/2019	10:04:04	EBSHHDD_04	Still	EBSHH04DD_10	10	882.4	484 335.1	876 101.5	484 314.3	876 099.8	20.8	
20/05/2019	10:04:23	EBSHHDD_04	Still	EBSHH04DD_11	11	882.2	484 335.1	876 101.5	484 316.6	876 099.7	18.6	
20/05/2019	10:04:40	EBSHHDD_04	Still	EBSHH04DD_12	12	882.1	484 335.1	876 101.5	484 319.1	876 100.1	16.1	
20/05/2019	10:04:58	EBSHHDD_04	Still	EBSHH04DD_13	13	883.2	484 335.1	876 101.5	484 321.2	876 099.0	14.1	
20/05/2019	10:05:14	EBSHHDD_04	Still	EBSHH04DD_14	14	882.0	484 335.1	876 101.5	484 322.0	876 099.8	13.2	
20/05/2019	10:05:56	EBSHHDD_04	Still	EBSHH04DD_15	15	882.7	484 335.1	876 101.5	484 324.5	876 098.6	11.0	
20/05/2019	10:05:56	EBSHHDD_04	Still	EBSHH04DD_16	16	882.7	484 335.1	876 101.5	484 324.5	876 098.6	11.0	
20/05/2019	10:06:19	EBSHHDD_04	Still	EBSHH04DD_17	17	883.0	484 335.1	876 101.5	484 328.6	876 097.4	7.7	
20/05/2019	10:07:08	EBSHHDD_04	Still	EBSHH04DD_18	18	882.6	484 335.1	876 101.5	484 334.3	876 097.8	3.8	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	10:07:49	EBSHHDD_04	Still	EBSHH04DD_19	19	883.6	484 335.1	876 101.5	484 339.3	876 099.4	4.7	
20/05/2019	10:08:35	EBSHHDD_04	Still	EBSHH04DD_20	20	882.5	484 335.1	876 101.5	484 343.7	876 101.4	8.6	
20/05/2019	10:08:53	EBSHHDD_04	Still	EBSHH04DD_21	21	883.9	484 335.1	876 101.5	484 345.1	876 101.1	10.0	
20/05/2019	10:09:19	EBSHHDD_04	Still	EBSHH04DD_22	22	883.6	484 335.1	876 101.5	484 348.6	876 102.9	13.6	
20/05/2019	10:09:41	EBSHHDD_04	Still	EBSHH04DD_23	23	883.8	484 335.1	876 101.5	484 350.6	876 102.6	15.6	
20/05/2019	10:09:56	EBSHHDD_04	Still	EBSHH04DD_24	24	883.7	484 335.1	876 101.5	484 351.3	876 102.0	16.2	
20/05/2019	10:10:44	EBSHHDD_04	Still	EBSHH04DD_25	25	882.6	484 335.1	876 101.5	484 357.1	876 103.7	22.1	
20/05/2019	10:11:08	EBSHHDD_04	Still	EBSHH04DD_26	26	883.8	484 335.1	876 101.5	484 359.1	876 102.8	24.0	
20/05/2019	10:11:16	EBSHHDD_04	Video	EOL	1	883.2	484 335.1	876 101.5	484 360.0	876 103.3	24.9	
20/05/2019	14:50:37	EBSHHDD_07	Video	SOL	1	662.8	484 779.6	871 405.5	484 808.0	871 414.8	29.9	
20/05/2019	14:51:22	EBSHHDD_07	Still	EBSHH07DD_01	1	662.8	484 779.6	871 405.5	484 724.8	871 373.6	63.4	
20/05/2019	14:51:49	EBSHHDD_07	Still	EBSHH07DD_02	2	662.9	484 779.6	871 405.5	484 726.3	871 374.2	61.8	
20/05/2019	14:52:37	EBSHHDD_07	Still	EBSHH07DD_03	3	661.2	484 779.6	871 405.5	484 730.3	871 377.7	56.6	
20/05/2019	14:53:10	EBSHHDD_07	Still	EBSHH07DD_04	4	662.7	484 779.6	871 405.5	484 732.6	871 379.0	53.9	
20/05/2019	14:53:59	EBSHHDD_07	Still	EBSHH07DD_05	5	662.0	484 779.6	871 405.5	484 737.5	871 379.7	49.3	
20/05/2019	14:54:41	EBSHHDD_07	Still	EBSHH07DD_06	6	662.5	484 779.6	871 405.5	484 741.6	871 380.5	45.5	
20/05/2019	14:54:54	EBSHHDD_07	Still	EBSHH07DD_07	7	663.7	484 779.6	871 405.5	484 742.4	871 380.9	44.6	
20/05/2019	14:56:20	EBSHHDD_07	Still	EBSHH07DD_08	8	663.1	484 779.6	871 405.5	484 750.5	871 385.6	35.3	
20/05/2019	14:57:38	EBSHHDD_07	Still	EBSHH07DD_09	9	663.5	484 779.6	871 405.5	484 758.6	871 389.1	26.6	
20/05/2019	14:57:53	EBSHHDD_07	Still	EBSHH07DD_10	10	665.1	484 779.6	871 405.5	484 761.0	871 389.8	24.4	
20/05/2019	14:58:11	EBSHHDD_07	Still	EBSHH07DD_11	11	664.1	484 779.6	871 405.5	484 763.2	871 391.2	21.8	
20/05/2019	14:58:28	EBSHHDD_07	Still	EBSHH07DD_12	12	665.7	484 779.6	871 405.5	484 764.6	871 391.6	20.4	
20/05/2019	14:58:45	EBSHHDD_07	Still	EBSHH07DD_13	13	664.1	484 779.6	871 405.5	484 767.0	871 392.4	18.2	
20/05/2019	14:59:09	EBSHHDD_07	Still	EBSHH07DD_14	14	666.7	484 779.6	871 405.5	484 768.9	871 393.8	15.8	
20/05/2019	14:59:29	EBSHHDD_07	Still	EBSHH07DD_15	15	667.1	484 779.6	871 405.5	484 771.5	871 394.5	13.6	
20/05/2019	14:59:44	EBSHHDD_07	Still	EBSHH07DD_16	16	667.4	484 779.6	871 405.5	484 772.9	871 395.1	12.3	
20/05/2019	15:00:12	EBSHHDD_07	Still	EBSHH07DD_17	17	667.0	484 779.6	871 405.5	484 775.1	871 396.6	10.0	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	15:01:15	EBSHHDD_07	Still	EBSHH07DD_18	18	668.6	484 779.6	871 405.5	484 781.9	871 400.1	5.9	
20/05/2019	15:01:50	EBSHHDD_07	Still	EBSHH07DD_19	19	667.7	484 779.6	871 405.5	484 785.5	871 402.7	6.6	
20/05/2019	15:03:00	EBSHHDD_07	Still	EBSHH07DD_20	20	668.7	484 779.6	871 405.5	484 791.3	871 405.7	11.7	
20/05/2019	15:03:22	EBSHHDD_07	Still	EBSHH07DD_21	21	668.5	484 779.6	871 405.5	484 793.6	871 407.2	14.1	
20/05/2019	15:03:39	EBSHHDD_07	Still	EBSHH07DD_22	22	665.2	484 779.6	871 405.5	484 795.9	871 408.0	16.5	
20/05/2019	15:04:37	EBSHHDD_07	Still	EBSHH07DD_23	23	669.4	484 779.6	871 405.5	484 800.0	871 410.0	20.9	
20/05/2019	15:05:05	EBSHHDD_07	Still	EBSHH07DD_24	24	669.8	484 779.6	871 405.5	484 801.9	871 411.6	23.2	
20/05/2019	15:05:23	EBSHHDD_07	Still	EBSHH07DD_25	25	669.9	484 779.6	871 405.5	484 803.3	871 412.7	24.8	
20/05/2019	15:06:19	EBSHHDD_07	Video	EOL	1	662.8	484 779.6	871 405.5	484 808.6	871 414.7	30.5	
20/05/2019	16:53:00	EBSHHDD_08	Video	SOL	1		489 250.4	869 166.8	489 191.7	869 161.8	59.0	
20/05/2019	16:53:07	EBSHHDD_08	Still	EBSHH08DD_01	1	715.7	489 250.4	869 166.8	489 192.0	869 161.7	58.6	
20/05/2019	16:59:46	EBSHHDD_08	Still	EBSHH08DD_02	2	717.1	489 250.4	869 166.8	489 217.6	869 161.4	33.3	
20/05/2019	17:00:24	EBSHHDD_08	Still	EBSHH08DD_03	3	716.1	489 250.4	869 166.8	489 221.3	869 160.0	30.0	
20/05/2019	17:00:45	EBSHHDD_08	Still	EBSHH08DD_04	4	717.2	489 250.4	869 166.8	489 223.6	869 160.3	27.6	
20/05/2019	17:00:58	EBSHHDD_08	Still	EBSHH08DD_05	5	716.3	489 250.4	869 166.8	489 225.5	869 160.9	25.6	
20/05/2019	17:01:42	EBSHHDD_08	Still	EBSHH08DD_06	6	717.5	489 250.4	869 166.8	489 230.0	869 160.5	21.4	
20/05/2019	17:01:58	EBSHHDD_08	Still	EBSHH08DD_07	7	716.7	489 250.4	869 166.8	489 230.8	869 160.2	20.7	
20/05/2019	17:02:15	EBSHHDD_08	Still	EBSHH08DD_08	8	717.2	489 250.4	869 166.8	489 232.0	869 159.8	19.7	
20/05/2019	17:03:35	EBSHHDD_08	Still	EBSHH08DD_09	9	717.5	489 250.4	869 166.8	489 238.1	869 159.9	14.2	
20/05/2019	17:04:10	EBSHHDD_08	Still	EBSHH08DD_10	10	719.3	489 250.4	869 166.8	489 241.4	869 161.8	10.3	
20/05/2019	17:04:18	EBSHHDD_08	Still	EBSHH08DD_11	11	719.6	489 250.4	869 166.8	489 241.5	869 162.4	10.0	
20/05/2019	17:05:40	EBSHHDD_08	Still	EBSHH08DD_12	12	716.5	489 250.4	869 166.8	489 250.6	869 164.0	2.9	
20/05/2019	17:06:40	EBSHHDD_08	Still	EBSHH08DD_13	13	718.3	489 250.4	869 166.8	489 256.4	869 166.4	6.0	
20/05/2019	17:06:55	EBSHHDD_08	Still	EBSHH08DD_14	14	719.3	489 250.4	869 166.8	489 259.0	869 167.6	8.6	
20/05/2019	17:07:20	EBSHHDD_08	Still	EBSHH08DD_15	15	719.5	489 250.4	869 166.8	489 260.1	869 168.3	9.8	
20/05/2019	17:08:01	EBSHHDD_08	Still	EBSHH08DD_16	16	717.7	489 250.4	869 166.8	489 263.1	869 168.8	12.9	
20/05/2019	17:08:18	EBSHHDD_08	Still	EBSHH08DD_17	17	719.0	489 250.4	869 166.8	489 263.5	869 169.5	13.4	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	17:08:31	EBSHHDD_08	Still	EBSHH08DD_18	18	719.7	489 250.4	869 166.8	489 264.1	869 170.1	14.1	
20/05/2019	17:09:59	EBSHHDD_08	Still	EBSHH08DD_19	19	719.3	489 250.4	869 166.8	489 268.1	869 169.3	17.8	
20/05/2019	17:10:11	EBSHHDD_08	Still	EBSHH08DD_20	20	720.3	489 250.4	869 166.8	489 270.5	869 172.2	20.8	
20/05/2019	17:10:22	EBSHHDD_08	Still	EBSHH08DD_21	21	719.7	489 250.4	869 166.8	489 272.3	869 171.9	22.4	
20/05/2019	17:10:37	EBSHHDD_08	Still	EBSHH08DD_22	22	719.9	489 250.4	869 166.8	489 272.8	869 171.6	22.9	
20/05/2019	17:11:27	EBSHHDD_08	Still	EBSHH08DD_23	23	719.2	489 250.4	869 166.8	489 275.0	869 173.0	25.3	
20/05/2019	17:11:58	EBSHHDD_08	Still	EBSHH08DD_24	24	720.1	489 250.4	869 166.8	489 275.7	869 173.5	26.1	
20/05/2019	17:12:11	EBSHHDD_08	Still	EBSHH08DD_25	25	722.3	489 250.4	869 166.8	489 277.3	869 174.8	28.1	
20/05/2019	17:14:08	EBSHHDD_08	Still	EBSHH08DD_26	26	714.3	489 250.4	869 166.8	489 282.9	869 174.0	33.2	
20/05/2019	17:14:31	EBSHHDD_08	Still	EBSHH08DD_27	27	720.7	489 250.4	869 166.8	489 283.3	869 175.2	33.9	
20/05/2019	17:15:03	EBSHHDD_08	Still	EBSHH08DD_28	28	720.4	489 250.4	869 166.8	489 283.4	869 175.3	34.1	
20/05/2019	17:15:45	EBSHHDD_08	Still	EBSHH08DD_29	29	722.5	489 250.4	869 166.8	489 285.8	869 175.9	36.5	
20/05/2019	17:16:41	EBSHHDD_08	Still	EBSHH08DD_30	30	721.9	489 250.4	869 166.8	489 288.1	869 176.8	39.0	
20/05/2019	17:16:52	EBSHHDD_08	Still	EBSHH08DD_31	31	722.6	489 250.4	869 166.8	489 291.4	869 178.5	42.6	
20/05/2019	17:17:00	EBSHHDD_08	Still	EBSHH08DD_32	32	722.4	489 250.4	869 166.8	489 291.4	869 178.1	42.5	
20/05/2019	17:17:41	EBSHHDD_08	Still	EBSHH08DD_33	33	720.7	489 250.4	869 166.8	489 295.0	869 178.7	46.1	
20/05/2019	17:18:08	EBSHHDD_08	Still	EBSHH08DD_34	34	721.6	489 250.4	869 166.8	489 296.9	869 179.6	48.2	
20/05/2019	17:18:19	EBSHHDD_08	Still	EBSHH08DD_35	35	721.4	489 250.4	869 166.8	489 297.7	869 180.0	49.1	
20/05/2019	17:18:35	EBSHHDD_08	Still	EBSHH08DD_36	36	722.8	489 250.4	869 166.8	489 297.3	869 180.3	48.8	
20/05/2019	17:19:09	EBSHHDD_08	Still	EBSHH08DD_37	37	721.6	489 250.4	869 166.8	489 298.6	869 181.4	50.3	
20/05/2019	17:19:26	EBSHHDD_08	Still	EBSHH08DD_38	38	722.2	489 250.4	869 166.8	489 301.3	869 181.9	53.1	
20/05/2019	17:19:46	EBSHHDD_08	Still	EBSHH08DD_39	39	723.6	489 250.4	869 166.8	489 301.6	869 181.0	53.1	
20/05/2019	17:20:10	EBSHHDD_08	Video	EOL	1	723.6	489 250.4	869 166.8	489 301.6	869 181.5	53.2	
20/05/2019	19:34:00	EBSWS_08 (Surface)	WS	BIOA1, BIOA2, WS	1	5.0	489 250.4	869 166.8	489 251.3	869 172.1	5.4	
20/05/2019	19:58:00	EBSWS_08 (Surface)	WS	BIOB1, BIOB2	2	5.0	489 250.4	869 166.8	489 252.2	869 171.6	5.1	
20/05/2019	20:17:00	EBSWS_08 (Surface)	WS	BIOC1, BIOC2	3	5.0	489 250.4	869 166.8	489 252.1	869 170.3	3.8	
20/05/2019	20:42:00	EBSWS_08 (Surface)	WS	Spare	4	5.0	489 250.4	869 166.8	489 252.1	869 175.0	8.3	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	23:12:00	EBSWS_08 (Bottom)	WS/WP	BIOA1, BIOA2, WS, WP	1	711.4	489 250.4	869 166.8	489 264.4	869 157.1	17.1	
20/05/2019	00:35:00	EBSWS_08 (Bottom)	WS	BIOB1, BIOB2	2	715.8	489 250.4	869 166.8	489 257.7	869 163.3	8.1	
20/05/2019	01:31:00	EBSWS_08 (Bottom)	WS/WP	BIOC1, BIOC2, WP	3	716.8	489 250.4	869 166.8	489 262.3	869 162.4	12.7	
20/05/2019	01:46:00	EBSWS_08 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	202.8	489 250.4	869 166.8	489 255.1	869 174.8	9.3	
20/05/2019	02:38:00	EBSWS_08 (Mid)	WS	BIOC1, BIOC2	2	201.3	489 250.4	869 166.8	489 261.6	869 164.2	11.5	
21/05/2019	04:23:00	EBSWS_07 (Bottom)	WS/WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	662.4	484 779.6	871 405.5	484 797.9	871 391.3	23.2	
21/05/2019	05:28:00	EBSWS_07 (Bottom)	WS	BIOC1, BIOC2,	2	662.5	484 779.6	871 405.5	484 794.3	871 392.2	19.9	
21/05/2019	06:24:00	EBSWS_07 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	198.0	484 779.6	871 405.5	484 780.5	871 401.0	4.6	
21/05/2019	07:05:00	EBSWS_07 (Mid)	WS	BIOC1, BIOC2	2	199.8	484 779.6	871 405.5	484 778.1	871 401.9	3.9	
21/05/2019	07:35:00	EBSWS_07 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	484 779.6	871 405.5	484 779.9	871 406.7	1.2	
21/05/2019	07:57:00	EBSWS0_7 (Surface)	WS	BIOC1, BIOC2	2	5.0	484 779.6	871 405.5	484 779.1	871 394.9	10.6	
21/05/2019	09:44:00	EBSWS_04 (Bottom)	WS/WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	880.3	484 335.1	876 101.5	484 336.8	876 100.8	1.8	
21/05/2019	11:45:00	EBSWS_04 (Bottom)	WS/WP	BIOC1, BIOC2, WP	2	895.3	484 335.1	876 101.5	484 332.0	876 108.9	8.0	
21/05/2019	12:56:00	EBSWS_04 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	237.4	484 335.1	876 101.5	484 334.2	876 106.9	5.5	
21/05/2019	13:37:00	EBSWS_04 (Mid)	WS	BIOC1, BIOC2	2	239.2	484 335.1	876 101.5	484 340.9	876 104.6	6.6	
21/05/2019	13:57:00	EBSWS_04 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	484 335.1	876 101.5	484 336.4	876 108.0	6.7	
21/05/2019	14:23:00	EBSWS_04 (Surface)	WS	BIOC1, BIOC2	2	5.0	484 335.1	876 101.5	484 335.0	876 107.3	5.8	
21/05/2019	16:01:00	EBSWS_05 (Bottom)	WP	WP	1	918.2	488 805.9	873 862.8	488 820.3	873 846.7	21.6	Niskins not triggered
21/05/2019	18:32:00	EBSWS_05 (Bottom)	WP	WP	2	915.7	488 805.9	873 862.8	488 814.9	873 854.3	12.4	Niskins not triggered
21/05/2019	19:53:00	EBSWS_05 (Bottom)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	3	918.4	488 805.9	873 862.8	488 806.8	873 865.4	2.7	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
21/05/2019	20:37:00	EBSWS_05 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	488 805.9	873 862.8	488 797.4	873 860.8	8.8	
21/05/2019	20:59:00	EBSWS_05 (Surface)	WS	BIOC1, BIOC2	2	5.0	488 805.9	873 862.8	488 797.5	873 862.0	8.5	
21/05/2019	21:34:00	EBSWS_05 (Bottom)	WS	BIOC1, BIOC2	4	918.4	488 805.9	873 862.8	488 815.9	873 852.7	14.2	
21/05/2019	22:17:00	EBSWS_05 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	204.2	488 805.9	873 862.8	488 799.8	873 869.1	8.8	
21/05/2019	22:46:00	EBSWS_05 (Mid)	WS	BIOC1, BIOC2	2	203.0	488 805.9	873 862.8	488 802.4	873 862.1	3.7	
21/05/2019	00:21:00	EBSWS_06 (Bottom)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	931.0	493 622.3	871 760.8	493 645.0	871 752.0	24.3	
21/05/2019	01:24:00	EBSWS_06 (Bottom)	WS	BIOC1, BIOC2, WP	2	932.8	493 622.3	871 760.8	493 629.8	871 745.7	16.8	
21/05/2019	02:03:00	EBSWS_06 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	199.1	493 622.3	871 760.8	493 626.6	871 769.1	9.4	
21/05/2019	02:32:00	EBSWS_06 (Mid)	WS	BIOC1, BIOC2	2	201.0	493 622.3	871 760.8	493 626.7	871 762.8	4.8	
21/05/2019	02:50:00	EBSWS_06 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	493 622.3	871 760.8	493 623.3	871 765.8	5.1	
21/05/2019	03:10:00	EBSWS_06 (Surface)	WS	BIOC1, BIOC2	2	5.0	493 622.3	871 760.8	493 623.6	871 767.1	6.4	
22/05/2019	04:33:00	EBSWS_03 (Bottom)	WS/WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	1100.0	492 832.3	876 320.2	492 838.1	876 298.4	22.5	
22/05/2019	05:50:00	EBSWS_03 (Bottom)	WS/WP	BIOC1, BIOC2, WP	2	1101.0	492 832.3	876 320.2	492 829.9	876 310.3	10.2	
22/05/2019	06:35:00	EBSWS_03 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	200.4	492 832.3	876 320.2	492 833.5	876 319.9	1.3	
22/05/2019	07:05:00	EBSWS_03 (Mid)	WS	BIOC1, BIOC2	2	203.1	492 832.3	876 320.2	492 834.1	876 319.4	2.0	
22/05/2019	07:21:00	EBSWS_03 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	492 832.3	876 320.2	492 832.5	876 320.2	0.2	
22/05/2019	07:39:00	EBSWS_03 (Surface)	WS	BIOC1, BIOC2	2	5.0	492 832.3	876 320.2	492 831.7	876 321.6	1.6	
22/05/2019	08:58:00	EBSWS_02 (Bottom)	WS/WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	1089.6	488 361.4	878 558.8	488 357.6	878 569.3	11.1	
22/05/2019	10:11:00	EBSWS_02 (Bottom)	WS/WP	BIOC1, BIOC2, WP	2	1089.6	488 361.4	878 558.8	488 359.9	878 565.3	6.6	

Geodetic Parameters: WGS84 UTM Zone 21 N											
Date	Time [UTC]	Transect/Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
22/05/2019	11:03:00	EBSWS_02 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	204.9	488 361.4	878 558.8	488 359.3	878 562.1	3.9	
22/05/2019	11:29:00	_	WS	DNA C1, C1	2	198.2	488 361.4	878 558.8	488 358.7	878 561.2	3.6	
22/05/2019	11:53:00	EBSWS_02 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	488 361.4	878 558.8	488 356.8	878 557.8	4.8	
22/05/2019	12:06:00	EBSWS_02 (Surface)	WS	BIOC1, BIOC2	2	5.0	488 361.4	878 558.8	488 356.4	878 560.4	5.2	
22/05/2019	13:24:00	EBSWS_01 (Bottom)	WS/WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	1027.2	483 890.6	880 797.5	483 877.2	880 811.0	19.0	
22/05/2019	14:37:00	EBSWS_01 (Bottom)	WS/WP	BIOC1, BIOC2, WP	2	1029.5	483 890.6	880 797.5	483 888.0	880 797.3	2.6	
22/05/2019	15:18:00	EBSWS_01 (Mid)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	201.8	483 890.6	880 797.5	483 895.6	880 798.9	5.2	
22/05/2019	15:49:00	EBSWS_01 (Mid)	WS	BIOC1, BIOC2	2	201.7	483 890.6	880 797.5	483 895.9	880 799.0	5.5	
22/05/2019	16:04:00	EBSWS_01 (Surface)	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	483 890.6	880 797.5	483 889.8	880 797.8	0.8	
22/05/2019	16:27:00	EBSWS_01 (Surface)	WS	BIOC1, BIOC2	2	5.0	483 890.6	880 797.5	483 890.6	880 799.7	2.2	

Notes:
UTC = Coordinated Universal Time
BSL = Below sea level
SOL = Start of line
EOL = End of line
FA/FB = Faunal sample FA/FB
BC = Box corer
BIO = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample
WS = Physico-chemical water sample
WP = Water profile

C.2 GRAB LOG

Date	Time [UTC]	Station	Sample Rep	Fix No.	Sample Depth	Temp [°C]	Redox [mV]	pH	Sediment Description (including stratigraphy)				Comments (fauna, smell, bioturbation, debris)
									Depth [cm]	Sediment Type	Sediment Description	Munsell Colour	
17/05/2019	18:14:00	EBSHH_01	FA, FB		32	17	246	7.30	2	M	Mud	2.5 Y 4/4	
17/05/2019	18:14:00	EBSHH_01				16	241	7.31	5	M			
17/05/2019	18:14:00	EBSHH_01				14	251	7.37	10	M			
17/05/2019	21:56:41	EBSHH_01	PC, BIO		41	23	346	7.30	2	M	Mud	2.5 Y 4/4	
17/05/2019	21:56:41	EBSHH_01				21	341	7.30	5	M			
17/05/2019	21:56:41	EBSHH_01				16	341	7.30	10	M			
18/05/2019	00:20:31	EBSHH_02	PC, FA, FB, BIO		40	21	384	7.36	2	M	Mud	2.5 Y 4/4	
18/05/2019	00:20:31	EBSHH_02				17	377	7.36	5	M			
18/05/2019	00:20:31	EBSHH_02				12	377	7.36	10	M			
18/05/2019	02:23:14	EBSHH_03	PC, FA, FB, BIO		42	20	353	7.40	2	M	Mud	2.5 Y 4/4	Bioturbation- gas smell
18/05/2019	02:23:14	EBSHH_03				17	352	7.40	5	M			
18/05/2019	02:23:14	EBSHH_03				11	353	7.40	10	M			
18/05/2019	04:02:17	EBSHH_06	PC, FA, FB, BIO		38	18	365	7.27	2	M	Mud	2.5 Y 4/4	
18/05/2019	04:02:17	EBSHH_06				13	365	7.27	5	M			
18/05/2019	04:02:17	EBSHH_06				17.6	365	7.27	10	M			
18/05/2019	05:49:50	EBSHH_05	PC, FA, FB, BIO		45	14	324	7.35	2	M	Mud	2.5 Y 5/4	3 cm to 4 cm of brown mud, below clay
18/05/2019	05:49:50	EBSHH_05				12	324	7.35	5	M			
18/05/2019	05:49:50	EBSHH_05				12	324	7.35	10	M			
18/05/2019	07:36:31	EBSHH_04	PC, FA, FB, BIO		45	16.6	306	7.33	2	M	Mud	2.5 Y 5/4	3 cm to 4 cm of brown mud, below clay
18/05/2019	07:36:31	EBSHH_04				16	306	7.32	5	M			
18/05/2019	07:36:31	EBSHH_04				16	206	7.33	10	M			
18/05/2019	09:25:36	EBSHH_07	PC, FA, FB, BIO		33	15	334	7.44	2	M	Mud	2.5 Y 5/4	3 cm to 4 cm brown mud
18/05/2019	09:25:36	EBSHH_07				18.9	334	7.44	5	M			Followed by grey clay
18/05/2019	09:25:36	EBSHH_07				19	334	7.44	10	M			
18/05/2019	10:03:02	EBSHH_08	PC, FA, FB, BIO		49	16	344	7.45	2	M	Mud	5 Y 5/3	3 cm to 4 cm mud followed by clay

Date	Time [UTC]	Station	Sample Rep	Fix No.	Sample Depth	Temp [˚C]	Redox [mV]	pH	Sediment Description (including stratigraphy)				Comments (fauna, smell, bioturbation, debris)
									Depth [cm]	Sediment Type	Sediment Description	Munsell Colour	
18/05/2019	10:03:02	EBSHH_08				12	344	7.42	5	M			
18/05/2019	10:03:02	EBSHH_08				12	344	7.42	10	M			

Notes:
UTC = Coordinated Universal Time
FA/FB = Faunal sample A/B
BIO = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample

C.3 VIDEO AND PHOTOGRAPHIC LOG

Geodetic Datum: WGS84 UTM Zone 21 N

Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna/Bioturbation/Debris
					Easting [m]	Northing [m]				
15/05/2019	190199 GEOPC010DD	190199 GEOPC010DD	SOL	18:25:30	487 652.4	0 873 544.8	66	GEOPC010DD_01-GEOPC010DD_15	Mud	Shrimp (Caridea), carnivorous sponge (*Chondrocladia* sp.), sea cucumber (Holothuroidea), xenophyophore (Xenophyophoroidea), faunal tubes and numerous faunal burrows
			EOL	18:38:03	487 711.2	0 873 574.6				
17/05/2019	190199 EBSHHDD_01	190199 EBSHH_01DD	SOL	14:08:14	483 850.9	0 880 790.1	75	EBSHH01DD_01-EBSHH01DD_14	Mud	Starfish (Asteroidea), faunal tubes and burrows
			EOL	14:21:57	483 925.7	0 880 796.7				
17/05/2019	190199 EBSHHDD_01a	190199 EBSHH_01DDa	SOL	16:39:27	483 854.2	0 880 795.2	66	EBSHH01DDa_01-EBSHH01DDa_19	Mud	Unidentified fish (Pisces), shrimp (Caridea), faunal tubes and burrows
			EOL	16:51:42	483 919.2	0 880 805.9				
17/05/2019	190199 EBSHHDD_01b	190199 EBSHH_01DDb	SOL	20:30:17	483 843.4	0 880 804.1	45	EBSHH01DDb_01-EBSHH01DDb_08	Mud	Starfish (Asteroidea), faunal tubes and burrows
			EOL	20:41:02	483 887.9	0 880 801.7				
18/05/2019	190199 TR04	190199 TR04	SOL	14:59:16	489 648.0	0 852 133.1	56	TR04_01-TR04_17	Gravelly muddy sand with shell fragments and occasional small (< 25 m²) patches of exposed, elevated bedrock. Occasional carbonate	Starfish (Asteroidea), possible soft coral (Alcyonacea). Numerous faunal burrows
			EOL	15:07:08	489 686.1	0 852 174.7				
			SOL	15:07:08	489 686.1	0 852 174.7	14	TR04_18-TR04_22	Exposed, elevated bedrock/carbonate with gravelly muddy sand	Coralline algae (Corallinales), sponge (Porifera), sea fan (Gorgoniidae), sea whip (Octocorallia), faunal turf (Bryozoa/Hydrozoa/Porifera), black coral (Antipatharia including *Tanacetipathes* sp.), unidentified fish (Pisces). Faunal tubes. Numerous faunal burrows
			EOL	15:08:22	489 695.3	0 852 184.6				
			SOL	15:08:22	489 695.3	0 852 184.6	26	TR04_23-TR04_28	Gravelly muddy sand with shell fragments	No visible fauna. Numerous faunal burrows
			EOL	15:10:42	489 711.3	0 852 205.0				
			SOL	15:10:42	489 711.3	0 852 205.0	18	TR04_29-TR04_32	Exposed, elevated bedrock/carbonate interspersed with gravelly muddy sand	Coralline algae (Corallinales), sponge (Porifera), sea fan (Gorgoniidae), sea whip (Octocorallia), black coral (*Stichopathes* sp.). Numerous faunal burrows
			EOL	15:12:21	489 721.3	0 852 220.1				
			SOL	15:12:21	489 721.3	0 852 220.1	59	TR04_32-TR04_41	Gravelly, muddy sand with shell fragments	No visible fauna. Numerous faunal burrows
			EOL	15:19:12	489 759.2	0 852 265.7				

Geodetic Datum: WGS84 UTM Zone 21 N										
Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna/Bioturbation/Debris
					Easting [m]	Northing [m]				
18/05/2019	190199 TR04 Continued	190199 TR04	SOL	15:19:12	489 759.2	0 852 265.7	54	TR04_41-TR04_53	Exposed, elevated bedrock/carbonate interspersed with gravelly muddy sand. Bedrock ledge approximately 8 m high present at 489 759.63 mE, 0 852 266.52 mN	Coralline algae (Corallinales), sponge (Porifera), sea fan (Gorgoniidae), sea whip (Octocorallia), brittlestar (Ophiuroidea), black coral (Antipatharia including *Stichopathes* sp. and *Tanacetipathes* sp.), damsel fish (Pomacentridae), unidentified fish (Pisces), possible anemone (Actiniaria), lobster (Palinuridae), possible stony coral (Scleractinia), faunal turf (Bryozoa/Hydrozoa/Porifera). Numerous faunal burrows
			EOL	15:25:05	489 797.8	0 852 303.6				
			SOL	15:25:05	489 797.8	0 852 303.6	8	TR04_54-TR04_55	Gravelly, muddy sand with shell fragments	No visible fauna. Numerous faunal burrows
			EOL	15:25:51	489 801.9	0 852 310.9				
			SOL	15:25:51	489 801.9	0 852 310.9	10	TR04_56-TR04_58	Exposed, elevated bedrock/carbonate interspersed with gravelly muddy sand	Coralline algae (Corallinales), sponge (Porifera), black coral (Antipatharia including *Tanacetipathes* sp.), unidentified fish (Pisces), faunal turf (Bryozoa/Hydrozoa/Porifera)
			EOL	15:27:03	489 806.6	0 852 319.2				
			SOL	15:27:03	489 806.6	0 852 319.2	21	TR04_59-TR04_63	Gravelly, muddy sand with shell fragments	Unidentified fish (Pisces), black coral (*Stichopathes* sp.). Numerous faunal burrows
			EOL	15:29:15	489 821.7	0 852 334.2				
18/05/2019	190199 TR05	190199 TR05_part1 and 190199 TR05_part2	SOL	16:37:16	486 551.3	0 853 954.9	22	TR05_01-TR05_06	Gravelly, muddy sand	Pencil urchin (Cidaridae), sponge (Porifera). Faunal burrows
			EOL	16:40:57	486 569.5	0 853 941.8				
			SOL	16:40:57	486 569.5	0 853 941.8	97	TR05_07-TR05_34	Exposed, elevated bedrock/carbonate interspersed with gravelly muddy sand and shell debris. Bedrock ledge approximately 5 m high present at 486 625.16 mE, 0 853 908.00 mN	Coralline algae (Corallinales), sponge (Porifera), sea fan (Gorgoniidae), sea whip (Octocorallia), black coral (Antipatharia including *Stichopathes* sp. and *Tanacetipathes* sp.), squirrelfish (Holocentridae), unidentified fish (Pisces), brittlestar associated with sea fans and black corals (Ophiuroidea), crinoid (Crinoidea), sea urchin (Echinoidea), faunal turf (Bryozoa/Hyrdrozoan/Porifera), soft coral (Alcyoniidae), starfish (Asteroidea). Numerous faunal burrows
			EOL	16:55:39	486 648.6	0 853 885.2				

Geodetic Datum: WGS84 UTM Zone 21 N										
Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna/Bioturbation/Debris
					Easting [m]	Northing [m]				
18/05/2019	190199 TR06	190199 TR06_part1 and 190199 TR06_part2	SOL	18:09:45	490 481.3	0 855 793.1	97	TR06_01-TR06_22	Gravelly, muddy sand with shell fragments and occasional carbonate rubble	Sea urchin (Echinoidea), feather starfish (Crinoidea), sea pen (Pennatulacea), black coral (Antipatharia including *Stichopathes* sp.), flatfish (Pleuronectiformes), unidentified fish (Pisces), jack fish (*Seriola* sp.), coralline algae (Corallinales). Bacterial mat. Numerous faunal burrows
				18:21:25	490 578.2	0 855 798.1				
				18:21:25	490 578.2	0 855 798.1	64	TR06_23-TR06_39	Exposed, elevated bedrock/carbonate interspersed with gravelly muddy sand and shell fragments. Occasional boulders and cobbles. Bedrock ledges present at 490 594.95 mE, 0 855 798.84 mN and 490 633.32 mE, 0 855 798.44 mN	Coralline algae (Corallinales), sponge (Porifera), black coral (Antipatharia including *Stichopathes* sp., *Tanacetipathes* sp.), sea fan (Gorgoniidae), jack fish (*Seriola* sp.), damselfish (Pomacentridae), unidentified fish (Pisces), faunal turf (Bryozoa/Hydrozoa/Porifera), anemones (Actiniaria), starfish (Asteroidea), brittlestar (Ophiuroidea), stony coral (Scleractinia). Bacterial mats. Anthropogenic debris (disguarded fishing line)
				18:35:16	490 642.2	0 855 795.8				
				18:35:26	490 643.5	0 855 796.5	34	TR06_40-TR06_45	Gravelly, muddy sand with shell fragment	Unidentified fish (Pisces), jack fish (*Seriola* sp.). Small faunal holes in honeycomb formation
			EOL	18:39:06	490 677.0	0 855 792.8				
18/05/2019	190199 TR03	190199 TR03	SOL	20:19:26	486 939.4	0 856 840.3	183	TR03_01 - TR03_38	Patches of exposed/elevated bedrock/carbonate interspersed with gravelly muddy sand and shell debris	Coralline algae (Corallinales), sponge (Porifera), sea fan (Gorgoniidae), sea whip (Octocorallia), black coral (Antipatharia including *Antipathes furcata* and *Stichopathes* sp.), fish (Pisces including possible Scaridae), brittlestar (Ophiuroidea) associated with sea fans and black corals, (Ophiuroidea), stony coral (Scleractinia), soft coral (Alcyonacea), basket star (Phrynophiurida), shrimp aggregation (Caridea), faunal turf (Hydrozoa/Bryozoa/Porifera), sea fan (Gorgoniidae), branching stony coral (Scleractinia), starfish (Asteroidea). Faunal burrows. Anthropogenic debris (disguarded fishing line)
			EOL	20:40:42	487 108.9	0 856 909.6				

Geodetic Datum: WGS84 UTM Zone 21 N										
Date	**Transect/ Station**	**Video File**	**Point on Line**	**Time [UTC]**	**Video Coordinates**		**Length [m]**	**Still Nos.**	**Sediment Description**	**Fauna/Bioturbation/Debris**
18/05/2019	190199 TR02	190199 TR02_part 1 and 190199 TR02_part 2	SOL	21:57:28	483 136.9	0 856 254.5	86	TR02_01-TR02_19	Exposed, elevated bedrock interspersed with gravelly muddy sand. Occasional cobbles and pebbles. Bedrock ledge approx. 5 m high present at 483 184.79 mE, 0 856 185.36 mN	Sea whip (Octocorallia), black coral (Antipatharia incldluing Stichopathes sp.), Coralline algae (Corallinales), sponge (Porifera), sea fan (Gorgoniidae), stony coral (Scleractinia), unidentified fish (Pisces), damsel fish (Pomacentridae), faunal turf (Hydrozoa/Bryozoa/Porifera), starfish (Asteroidea), brittlestar (Ophiuroidea) associated with sea fans, possible sea urchin (Echinoidea). Bioturbation, numerous faunal burrows
				22:07:17	483 185.3	0 856 183.9				
				22:07:17	483 185.3	0 856 183.9	31	TR02_20-TR02_28	Sandy mud	Crocodile fish (Platycephalidae), black coral (*Tanacetipathes* sp.). Numerous faunal burrows
				22:10:14	483 206.2	0 856 161.3				
				22:10:14	483 206.2	0 856 161.3	62	TR02_29-TR02_38	Exposed, elevated bedrock/carbonate interspersed with gravelly muddy sand. Occasional cobbles and pebbles	Coralline algae (Corallinales), sponge (Porifera), black coral including bottlebrush black coral (Antipatharia including *Antipathes furcata*, *Tanacetipathes* sp. and *Stichopathes* sp.), possible sea fan (possible Gorgoniidae), sea whip (Octocorallia), stony coral (Scleractinia), soft coral (Alcyonacea), damsel fish (Pomacentridae), faunal turf (Hydrozoa/Bryozoa/Porifera), tube dwelling worms (Sabellidae/Serpulidae), brittlestar (Ophiuroidea), basket star (Phrynophiurida)
				22:21:27	483 251.8	0 856 119.4				
				22:21:27	483 251.8	0 856 119.4	36	TR02_39-TR02_46	Sandy mud with occasional small patch of exposed bedrock/carbonate, occasionally elevated	Starfish (Asteroidea), coralline algae (Corallinales), sponge (Porifera), fauna turf (Bryozoa/Hydrozoa/Porifera), black coral (Antipatharia including *Stichopathes* sp. and *Tanacetipathes* sp.), sea whip (Octocorallia), sea fan (Gorgoniidae), branching stony coral (Scleractinia), fish (Pisces). Numerous faunal burrows
			EOL	22:25:36	483 267.6	0 856 086.6				

Geodetic Datum: WGS84 UTM Zone 21 N										
Date	**Transect/ Station**	**Video File**	**Point on Line**	**Time [UTC]**	**Video Coordinates**		**Length [m]**	**Still Nos.**	**Sediment Description**	**Fauna/Bioturbation/Debris**
18/05/2019	190199 TR01	190199 TR01_part1	SOL	23:34:36	484 500.2	0 858 711.5	61	TR01_01-TR01_11	Exposed, bedrock/carbonate, elevated in places, interspersed with gravelly, muddy sand	Coralline algae (Corallinales), sponge (Porifera), black coral (Antipatharia including *Stichopathes* sp.), faunal turf (Hydrozoa/Bryozoa/encrusting Porifera), encrusting worm tubes (Serpulidae), possible scorpionfish (Scorpaeniformes), unidentified fish (Pisces), brittlestar (Ophiuroidea), possible crinoid (Crinoidea), sea urchin (Diadematidae). Numerous faunal burrows
				23:47:49	484 543.5	0 858 754.3				
		190199 TR01_part2		23:47:49	484 543.5	0 858 754.3	34	TR01_12-TR01_21	Elevated exposed bedrock/carbonate with ledges interspersed with small gravelly, muddy sand patches	Faunal turf (Hydrozoa/Bryozoa/encrusting Porifera), coralline algae (Corallinales), sponge (Porifera), soft coral (Alcyonacea), black coral (Antipatharia including *Stichopathes* sp. and *Tanacetipathes* sp.), sea fan (Gorgoniidae), encrusting worm tubes (Serpulidae). Numerous faunal burrows
				23:51:35	484 567.2	0 858 779.3				
				23:51:35	484 567.2	0 858 779.3	43	TR01_13-TR01_28	Muddy sand covering elevated bedrock/carbonate	Shrimp (Caridea), sea pen (Pennatulacea), black coral (*Stichopathes* sp.). Numerous faunal burrows
				23:56:50	484 594.7	0 858 812.7				
				23:56:50	484 594.7	0 858 812.7	78	TR01_29-TR01_44	Elevated exposed bedrock/carbonate and boulders interspersed with muddy sand	Black coral (Antipatharia including *Stichopathes* sp. and *Tanacetipathes* sp.), coralline algae (Corallinales), sponge (Porifera), faunal turf (Hydrozoa/Bryozoa/Porifera), sea pen (Pennatulacea), sea whip (Octocorallia), soft coral (Alcyonacea), stony coral (Scleractinia), unidentified fish (Pisces), ascidian (Ascidiacea), brittlestar (Ophiuroidea), possible sea urchin (Echinoidea), sea fan (Gorgoniidae), orange cup-like sponge (Porifera), tube dwelling worm (Polychaeta possible Sabellidae). Numerous faunal burrows. Anthropogenic debris (disguarded thin rope)
				00:04:46	484 646.7	0 858 870.5				
			EOL	00:08:36	484 669.3	0 858 897.4	35	TR01_45-TR01_51	Muddy sand with patches of exposed, elevated bedrock	Black coral including bottlebrush black coral (Antipatharia), Encrusting pink and yellow sponge (Porifera), faunal turf (Hydrozoa/Bryozoa/Porifera), unidentified fish (Pisces), sea whip (Octocorallia). Holes arranged in honeycomb formation in the soft sediment

Geodetic Datum: WGS84 UTM Zone 21 N										
Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna/Bioturbation/Debris
19/05/2019	190199 EBSHHDD_01c	190199 EBSHH_01DDc	SOL	02:46:23	483 849.5	0 880 792.5	85	EBSHH01DDc_01-EBSHH01DDc_26	Mud	Unidentified fish (Pisces), possible soft coral (Alcyonacea), brittlestar (Ophiuroidea). Faunal tubes and burrows.
			EOL	03:05:37	483 934.5	0 880 799.0				
19/05/2019	190199 EBSHHDD_02	190199 EBSHH_02DD_part1 and 190199 EBSHH_02DD_part2	SOL	07:28:46	488 334.8	0 878 552.1	2	EBSHH02DD_01-EBSHH02DD_21	Mud	Eeltail fish (Halosauridae), sea cucumber (Holothuroidea), faunal burrows
				08:12:19	488 336.4	0 878 552.8				
				08:18:51	488 296.6	0 878 534.7	104			
			EOL	08:30:27	488 392.2	0 878 576.4				
19/05/2019	190199 EBSHHDD_03	190199 EBSHH_03DD	SOL	19:33:00	492 803.0	0 876 326.8	61	EBSHH03DD_01-EBSHH03DD_10	Mud	Sea pen (Pennatulacea), xenophyophore (Xenophyophoroidea). Faunal tubes and burrows
			EOL	19:40:44	492 863.4	0 876 332.1				
19/05/2019	190199 EBSHHDD_03a	190199 EBSHH_03DDa	SOL	21:17:42	492 781.4	0 876 327.3	77	EBSHH03DDa_01-EBSHH03DDa_31	Mud	Small unidentified fish (Pisces), sea cucumber (Holothuroidea), sea pen (Pennatulacea). Faunal tubes and burrows
			EOL	21:32:44	492 857.4	0 876 317.2				
19/05/2019	190199 EBSHH DD _06	190199 EBSHH_06DD_part1, 190199 EBSHH_06DD_part2, 190199 EBSHH_06DD_part3 and 190199 EBSHH_06DD_part4	SOL	23:37:49	493 580.4	0 871 748.3	74	EBSHH06DD_01-EBSHH06DD_24	Mud	Sea pen (Pennatulacea), Sea cucumber (Holothuroidea), shrimp (Caridea). Faunal tubes, tracks and burrows
			EOL	00:33:35	493 649.8	0 871 775.5				
20/05/2019	190199 EBSHHDD_06a	190199 EBSHH_06DDa	SOL	04:16:34	493 622.7	0 871 738.0	106	EBSHH06DDa_01-EBSHH06DDa_21	Mud	Sea pen (Pennatulacea), feather star (Crinoidea), sea cucumber (Holothuroidea). Faunal tubes, tracks and burrows
			EOL	04:37:30	493 611.4	0 871 843.3				
20/05/2019	190199 EBSHH DD _05	190199 EBSHH_05DD	SOL	06:49:54	488 753.3	0 873 859.9	71	EBSHH05DD_01-EBSHH05DD_13	Mud	Burrowing anemone (Cerianthidae), feather star (Crinoidea), unidentified fish (Pisces). Faunal tubes and burrows
			EOL	07:04:42	488 821.0	0 873 882.7				
20/05/2019	190199 EBSHHDD_05a	190199 EBSHH_05DDa	SOL	08:06:14	488 761.6	0 873 859.7	70	EBSHH05DDa_01-EBSHH05DDa_17	Mud	Burrowing anemone (Cerianthidae). Faunal tubes and burrows
			EOL	08:17:09	488 832.0	0 873 857.8				
20/05/2019	190199 EBSHHDD_04	190199 EBSHH_04DD	SOL	09:55:55	484 267.2	0 876 107.1	93	EBSHH04DD_01-EBSHH04DD_26	Mud	Burrowing anemone (Cerianthidae), shrimp (Caridea), unidentified fish (Pisces). Faunal tubes and burrows
			EOL	10:11:16	484 360.0	0 876 103.3				
20/05/2019	190199 EBSHHDD_07	190199 EBSHH_07DD	SOL	14:50:37	484 722.1	0 871 373.5	96	EBSHH07DD_01-EBSHH07DD_25	Mud	Sea cucumber (Holothuroidea). Faunal tubes and burrows
			EOL	15:06:19	484 808.6	0 871 414.7				
20/05/2019	190199 EBSHHDD_08	190199 EBSHH_08DD	SOL	16:53:00	489 191.7	0 869 161.8	112	EBSHH07DD_01-EBSHH07DD_39	Mud	Sea cucumber (Holothuroidea), burrowing anemone (Cerianthidae), shrimp (Caridea), unidentified fish (Pisces). Faunal tubes and burrows
			EOL	17:20:10	489 301.6	0 869 181.5				

D. SEDIMENT PARTICLE SIZE AND GRAB SAMPLE PHOTOGRAPHS

STATION EBSHH_01

Easting: 483 901.7 mE **Depth:** 1038.9 m BSL
Northing: 880 800.3 mN **Sediment Type:** Sandy mud

Easting: 483 901.7 mE **Depth:** 1038.9 m BSL
Northing: 880 800.3 mN **Sediment Type:** Sandy mud

Easting: 483 901.7 mE **Depth:** 1038.9 m BSL
Northing: 880 800.3 mN **Sediment Type:** Sandy mud

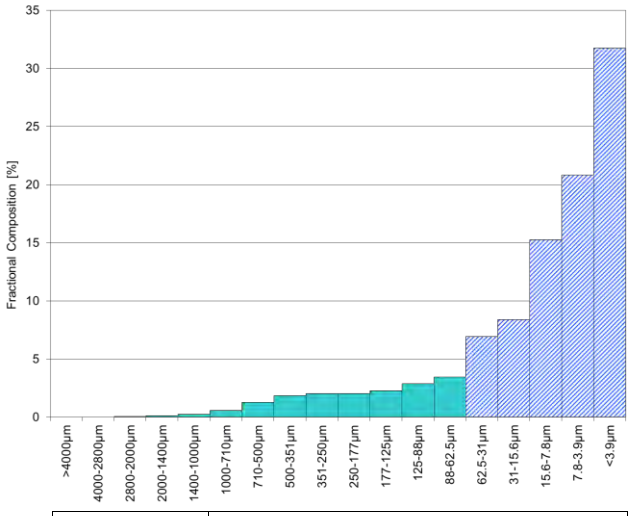
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.08	0.08
1400	-0.49	0.12	0.20
1000	0.00	0.24	0.44
707	0.49	0.58	1.02
500	1.00	1.28	2.30
354	1.51	1.84	4.14
250	2.00	2.04	6.18
177	2.50	2.03	8.22
125	3.00	2.27	10.49
88.0	3.51	2.88	13.37
62.5	4.00	3.45	16.82
31.2	5.01	6.94	23.76
15.6	6.00	8.38	32.14
7.81	7.00	15.26	47.40
3.91	8.00	20.83	68.23
< 3.91	> 8.00	31.77	100
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.47	Very poorly sorted
Skewness [phi]	-0.66	Coarse skewed
Mean [µm]	10.6	Fine silt
Mean [phi]	6.64	
Gravel [%]	0.08	Sandy mud
Sand [%]	16.74	
Mud [%]	83.18	

PARTICLE SIZE DISTRIBUTION



mm		µm								
Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_02

Easting: 488 359.2 mE **Depth:** 1098.1 m BSL
Northing: 878 553.6 mN **Sediment Type:** Sandy mud

Easting: 488 359.2 mE **Depth:** 1098.1 m BSL
Northing: 878 553.6 mN **Sediment Type:** Sandy mud

Easting: 488 359.2 mE **Depth:** 1098.1 m BSL
Northing: 878 553.6 mN **Sediment Type:** Sandy mud

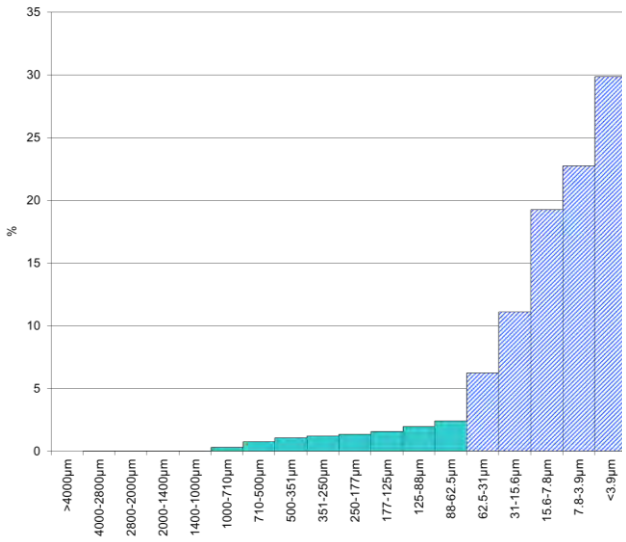
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.02	0.02
2000	-1.00	0.01	0.02
1400	-0.49	0.00	0.03
1000	0.00	0.04	0.07
707	0.49	0.32	0.38
500	1.00	0.76	1.14
354	1.51	1.07	2.21
250	2.00	1.23	3.44
177	2.50	1.34	4.78
125	3.00	1.59	6.37
88.0	3.51	1.99	8.36
62.5	4.00	2.42	10.78
31.2	5.01	6.25	17.03
15.6	6.00	11.12	28.15
7.81	7.00	19.27	47.42
3.91	8.00	22.74	70.15
< 3.91	> 8.00	29.85	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.13	Very poorly sorted
Skewness [phi]	-0.68	Coarse skewed
Mean [µm]	8.72	Fine silt
Mean [phi]	6.84	
Gravel [%]	0.02	Sandy mud
Sand [%]	10.76	
Mud [%]	89.22	

PARTICLE SIZE DISTRIBUTION

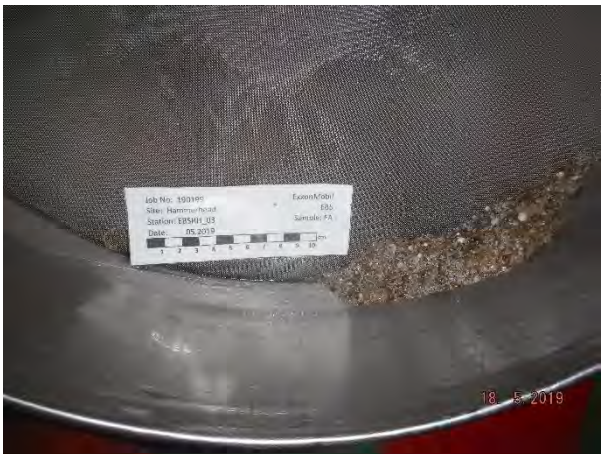


mm			µm								
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_03

Easting: 492 842.9 mE **Depth:** 1101.1 m BSL
Northing: 876 316.2 mN **Sediment Type:** Sandy mud

Easting: 492 842.9 mE **Depth:** 1101.1 m BSL
Northing: 876 316.2 mN **Sediment Type:** Sandy mud



Easting: 492 842.9 mE **Depth:** 1101.1 m BSL
Northing: 876 316.2 mN **Sediment Type:** Sandy mud

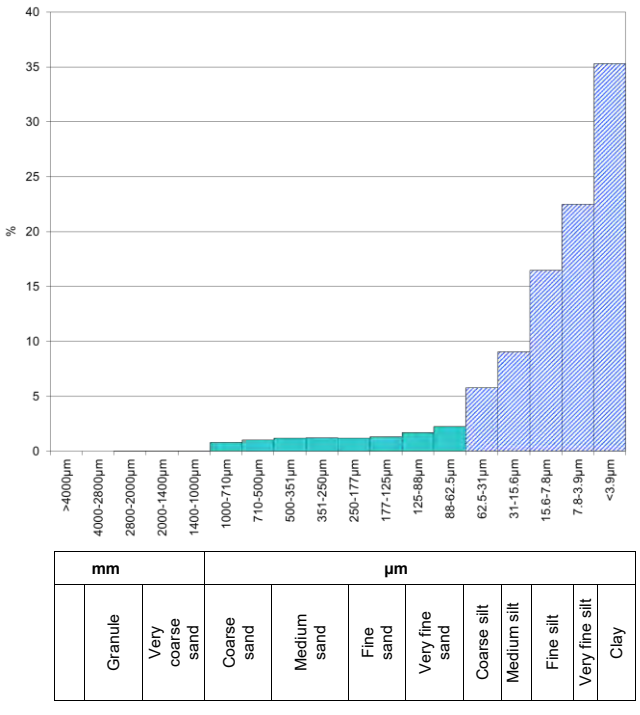
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.05	0.05
1400	-0.49	0.04	0.09
1000	0.00	0.05	0.14
707	0.49	0.82	0.95
500	1.00	1.03	1.98
354	1.51	1.19	3.17
250	2.00	1.23	4.40
177	2.50	1.19	5.59
125	3.00	1.31	6.91
88.0	3.51	1.71	8.62
62.5	4.00	2.25	10.86
31.2	5.01	5.80	16.66
15.6	6.00	9.06	25.72
7.81	7.00	16.49	42.21
3.91	8.00	22.50	64.70
< 3.91	> 8.00	35.30	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.26	Very poorly sorted
Skewness [phi]	-0.83	Coarse skewed
Mean [µm]	7.80	Fine silt
Mean [phi]	7.00	
Gravel [%]	0.05	Sandy mud
Sand [%]	10.81	
Mud [%]	89.14	

PARTICLE SIZE DISTRIBUTION

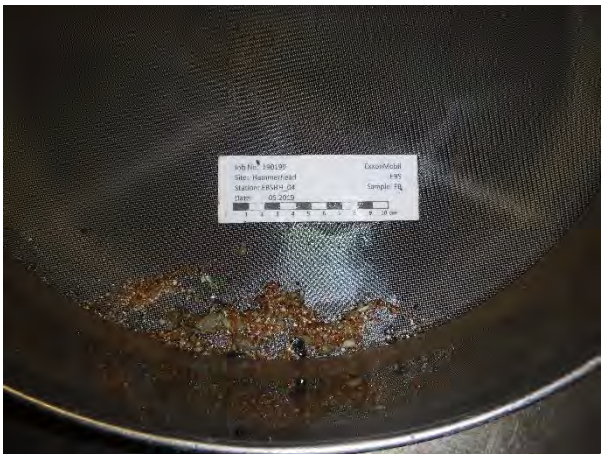


mm			µm								
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_04

Easting: 484 335.6 mE **Depth:** 887.9 m BSL
Northing: 876 094.4 mN **Sediment Type:** Mud

Easting: 484 335.6 mE **Depth:** 887.9 m BSL
Northing: 876 094.4 mN **Sediment Type:** Mud



Easting: 484 335.6 mE **Depth:** 887.9 m BSL
Northing: 876 094.4 mN **Sediment Type:** Mud

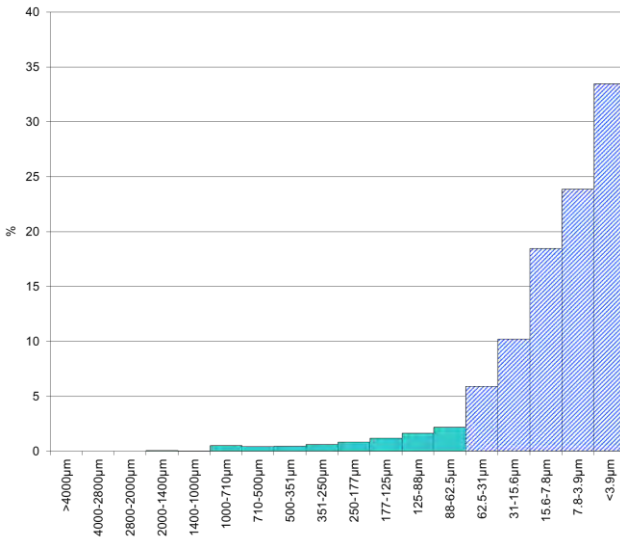
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.49	0.07	0.07
1000	0.00	0.03	0.10
707	0.49	0.52	0.62
500	1.00	0.44	1.06
354	1.51	0.45	1.51
250	2.00	0.63	2.14
177	2.50	0.86	3.00
125	3.00	1.19	4.19
88.0	3.51	1.66	5.85
62.5	4.00	2.19	8.03
31.2	5.01	5.93	13.96
15.6	6.00	10.23	24.19
7.81	7.00	18.48	42.67
3.91	8.00	23.86	66.53
< 3.91	> 8.00	33.47	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.02	Poorly sorted
Skewness [phi]	-0.73	Coarse skewed
Mean [µm]	7.38	Very fine silt
Mean [phi]	7.08	
Gravel [%]	0.00	Mud
Sand [%]	8.03	
Mud [%]	89.14	

PARTICLE SIZE DISTRIBUTION



mm		µm								
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_05

Easting: 488 811.0 mE **Depth:** 926.1 m BSL
Northing: 873 870.1 mN **Sediment Type:** Mud

Easting: 488 811.0 mE **Depth:** 926.1 m BSL
Northing: 873 870.1 mN **Sediment Type:** Mud

Easting: 488 811.0 mE **Depth:** 926.1 m BSL
Northing: 873 870.1 mN **Sediment Type:** Mud

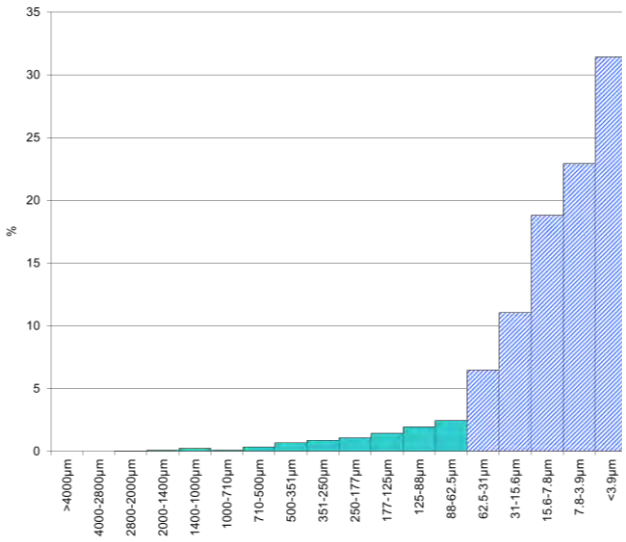
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.03	0.03
1400	-0.49	0.08	0.11
1000	0.00	0.22	0.33
707	0.49	0.10	0.43
500	1.00	0.35	0.77
354	1.51	0.68	1.45
250	2.00	0.87	2.32
177	2.50	1.08	3.40
125	3.00	1.45	4.85
88.0	3.51	1.95	6.80
62.5	4.00	2.46	9.27
31.2	5.01	6.48	15.75
15.6	6.00	11.05	26.80
7.81	7.00	18.82	45.61
3.91	8.00	22.95	68.56
< 3.91	> 8.00	31.44	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.06	Very poorly sorted
Skewness [phi]	-0.65	Coarse skewed
Mean [µm]	8.04	Fine silt
Mean [phi]	6.96	
Gravel [%]	0.03	Mud
Sand [%]	9.24	
Mud [%]	90.73	

PARTICLE SIZE DISTRIBUTION



mm			µm							
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_06

Easting: 493 624.9 mE **Depth:** 938.0 m BSL
Northing: 871 760.4 mN **Sediment Type:** Sandy mud

Easting: 493 624.9 mE **Depth:** 938.0 m BSL
Northing: 871 760.4 mN **Sediment Type:** Sandy mud

Easting: 493 624.9 mE **Depth:** 938.0 m BSL
Northing: 871 760.4 mN **Sediment Type:** Sandy mud

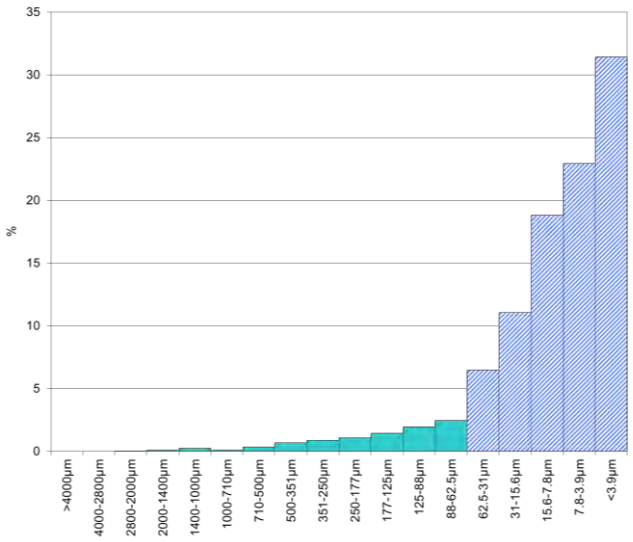
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.49	0.08	0.08
1000	0.00	0.14	0.22
707	0.49	0.38	0.60
500	1.00	0.66	1.26
354	1.51	0.97	2.23
250	2.00	1.28	3.51
177	2.50	1.52	5.03
125	3.00	1.81	6.84
88.0	3.51	2.28	9.12
62.5	4.00	2.76	11.88
31.2	5.01	6.36	18.23
15.6	6.00	9.39	27.62
7.81	7.00	17.06	44.69
3.91	8.00	22.51	67.20
< 3.91	> 8.00	32.80	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.22	Very poorly sorted
Skewness [phi]	-0.71	Coarse skewed
Mean [µm]	8.37	Fine silt
Mean [phi]	6.90	
Gravel [%]	0.00	Sandy mud
Sand [%]	11.88	
Mud [%]	88.12	

PARTICLE SIZE DISTRIBUTION



mm			µm								
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_07

Easting: 484 789.1 mE **Depth:** 673.2 m BSL
Northing: 871 407.7 mN **Sediment Type:** Sandy mud

Easting: 484 789.1 mE **Depth:** 673.2 m BSL
Northing: 871 407.7 mN **Sediment Type:** Sandy mud

Easting: 484 789.1 mE **Depth:** 673.2 m BSL
Northing: 871 407.7 mN **Sediment Type:** Sandy mud

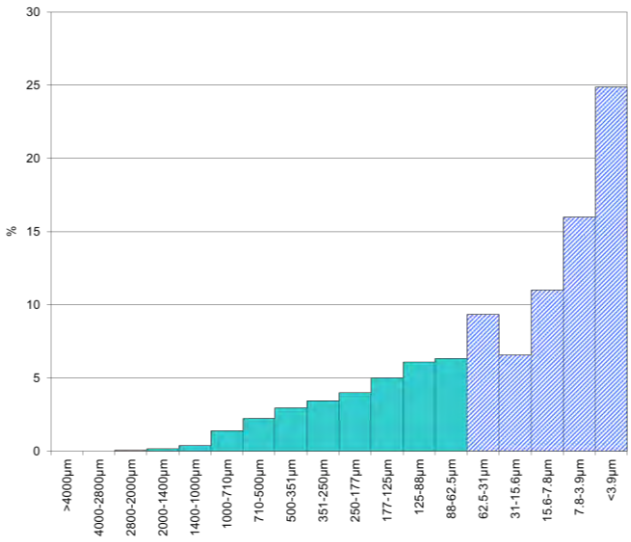
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.09	0.09
1400	-0.49	0.17	0.26
1000	0.00	0.39	0.65
707	0.49	1.40	2.05
500	1.00	2.24	4.29
354	1.51	2.96	7.25
250	2.00	3.45	10.70
177	2.50	4.01	14.71
125	3.00	5.01	19.72
88.0	3.51	6.09	25.81
62.5	4.00	6.35	32.16
31.2	5.01	9.35	41.52
15.6	6.00	6.57	48.09
7.81	7.00	11.01	59.10
3.91	8.00	16.01	75.11
< 3.91	> 8.00	24.89	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.78	Very poorly sorted
Skewness [phi]	-0.18	Coarse skewed
Mean [µm]	18.57	Medium silt
Mean [phi]	5.75	
Gravel [%]	0.09	Sandy mud
Sand [%]	32.07	
Mud [%]	67.84	

PARTICLE SIZE DISTRIBUTION



mm			µm								
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSHH_08

Easting: 489 254.6 mE **Depth:** 722.1 m BSL
Northing: 869 170.5 mN **Sediment Type:** Sandy mud

Easting: 489 254.6 mE **Depth:** 722.1 m BSL
Northing: 869 170.5 mN **Sediment Type:** Sandy mud

Easting: 489 254.6 mE **Depth:** 722.1 m BSL
Northing: 869 170.5 mN **Sediment Type:** Sandy mud

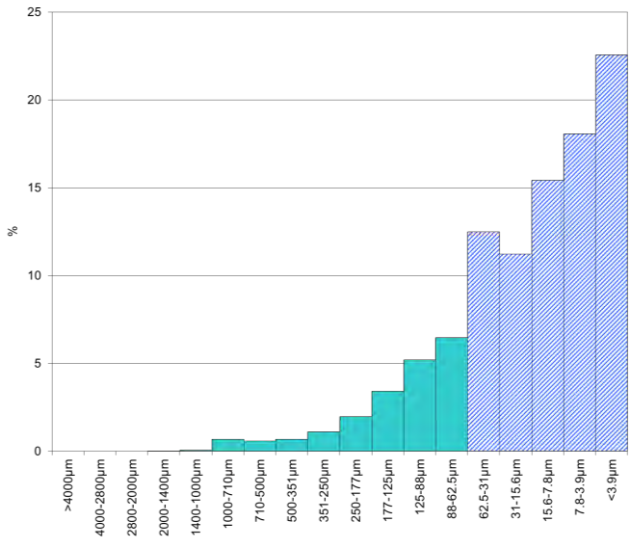
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.49	0.02	0.02
1000	0.00	0.07	0.09
707	0.49	0.69	0.78
500	1.00	0.58	1.36
354	1.51	0.69	2.05
250	2.00	1.10	3.15
177	2.50	1.96	5.12
125	3.00	3.43	8.54
88.0	3.51	5.20	13.74
62.5	4.00	6.47	20.21
31.2	5.01	12.50	32.71
15.6	6.00	11.23	43.94
7.81	7.00	15.43	59.37
3.91	8.00	18.07	77.43
< 3.91	> 8.00	22.57	100.00
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.27	Very poorly sorted
Skewness [phi]	-0.21	Coarse skewed
Mean [µm]	13.90	Fine silt
Mean [phi]	6.17	
Gravel [%]	0.00	Sandy mud
Sand [%]	20.21	
Mud [%]	79.79	

PARTICLE SIZE DISTRIBUTION

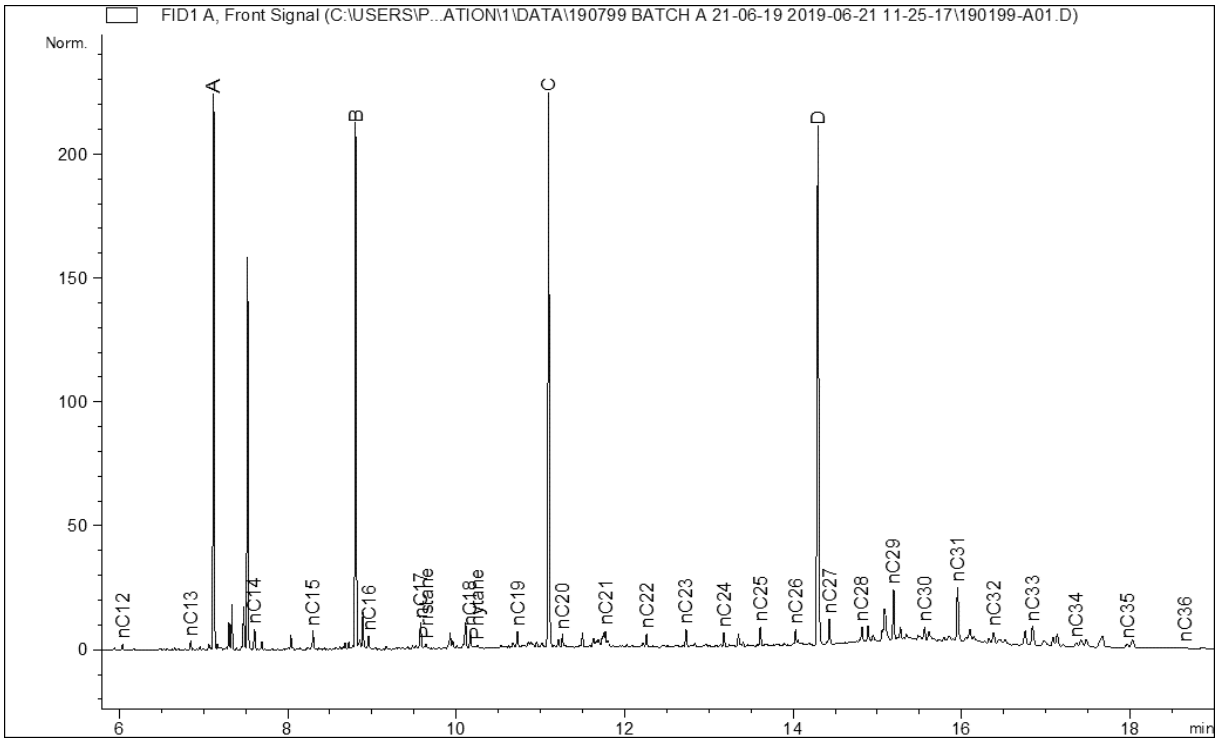


mm		µm							
Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

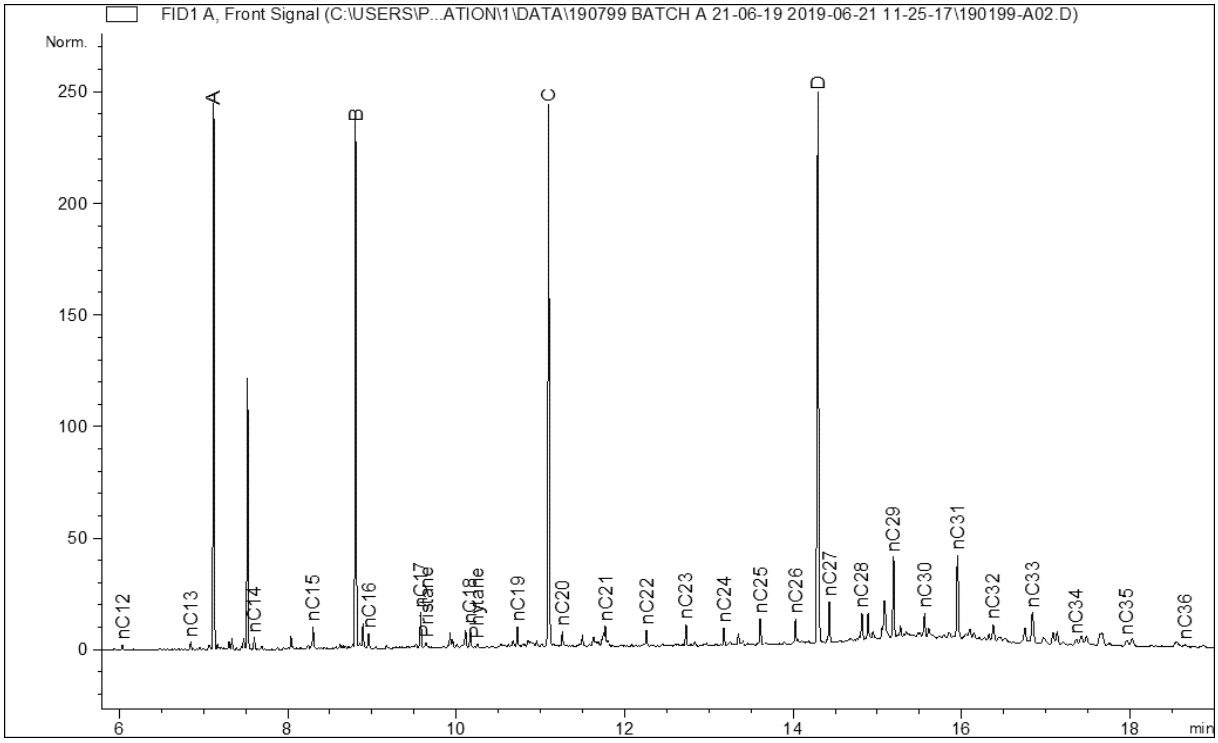
E. HYDROCARBON ANALYSIS

E.1 GAS CHROMATOGRAPHY TRACES

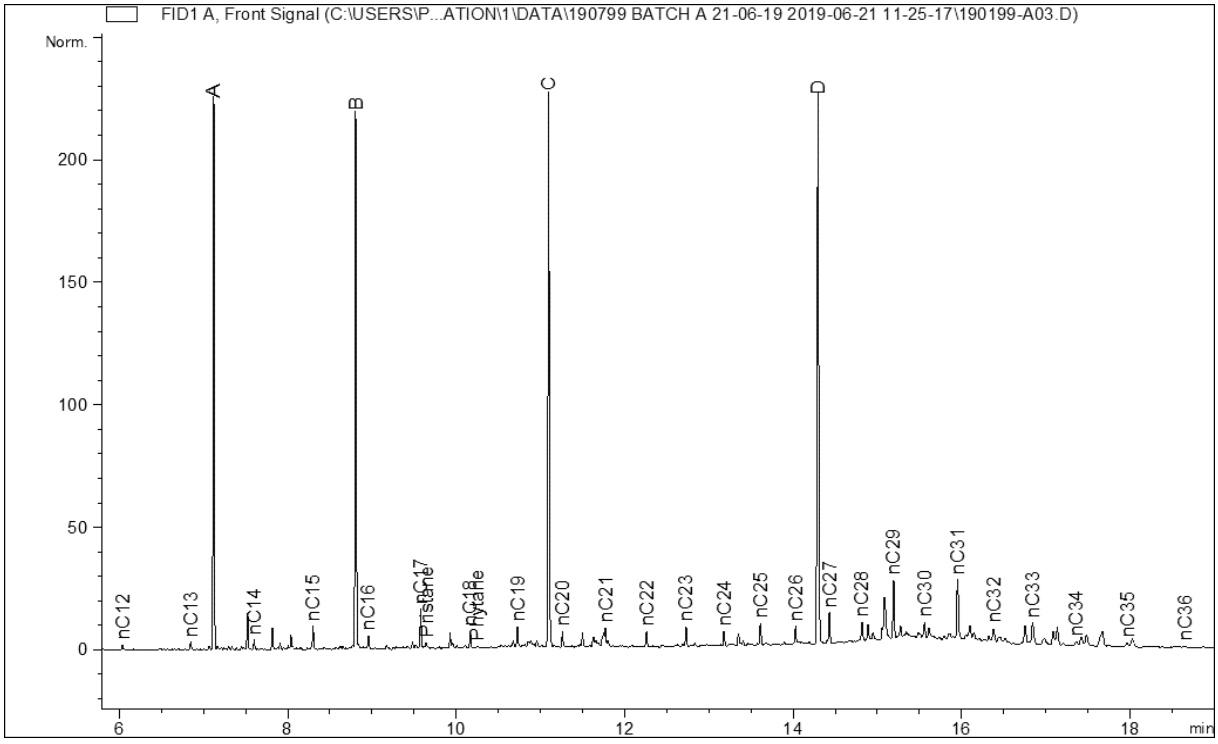
E.1.1 Sediment



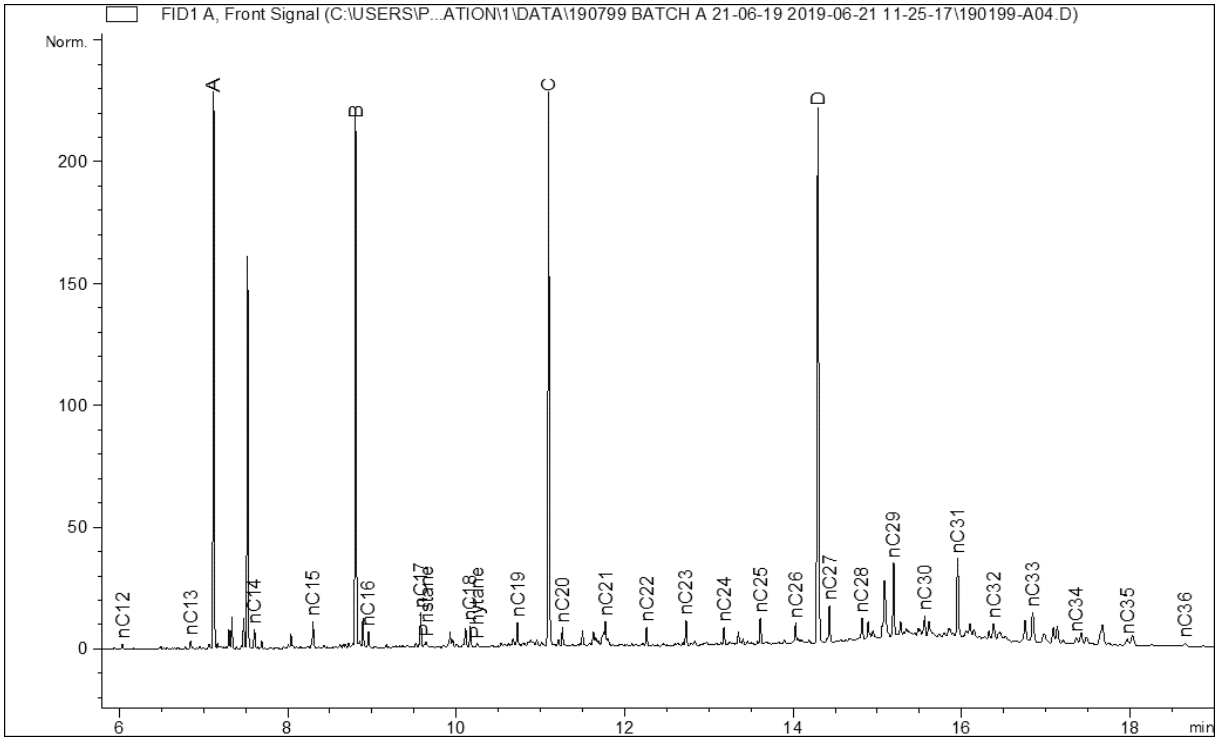
Station EBSHH_01



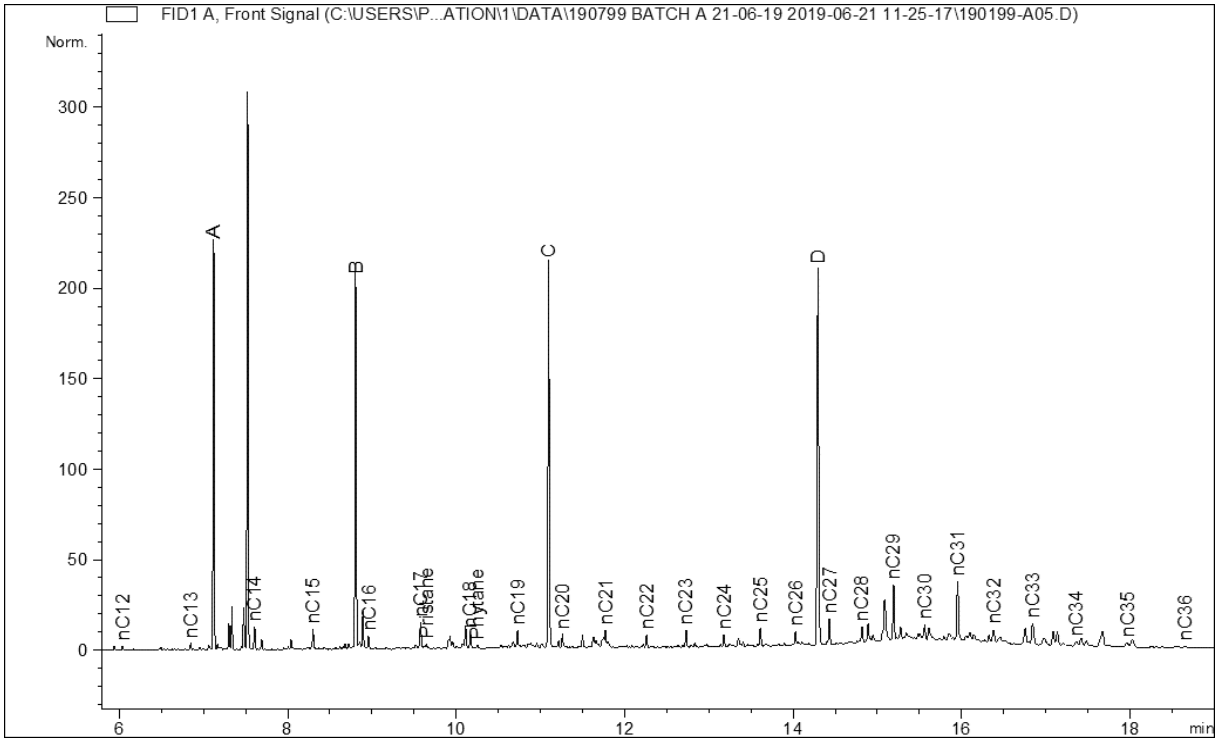
Station EBSHH_02



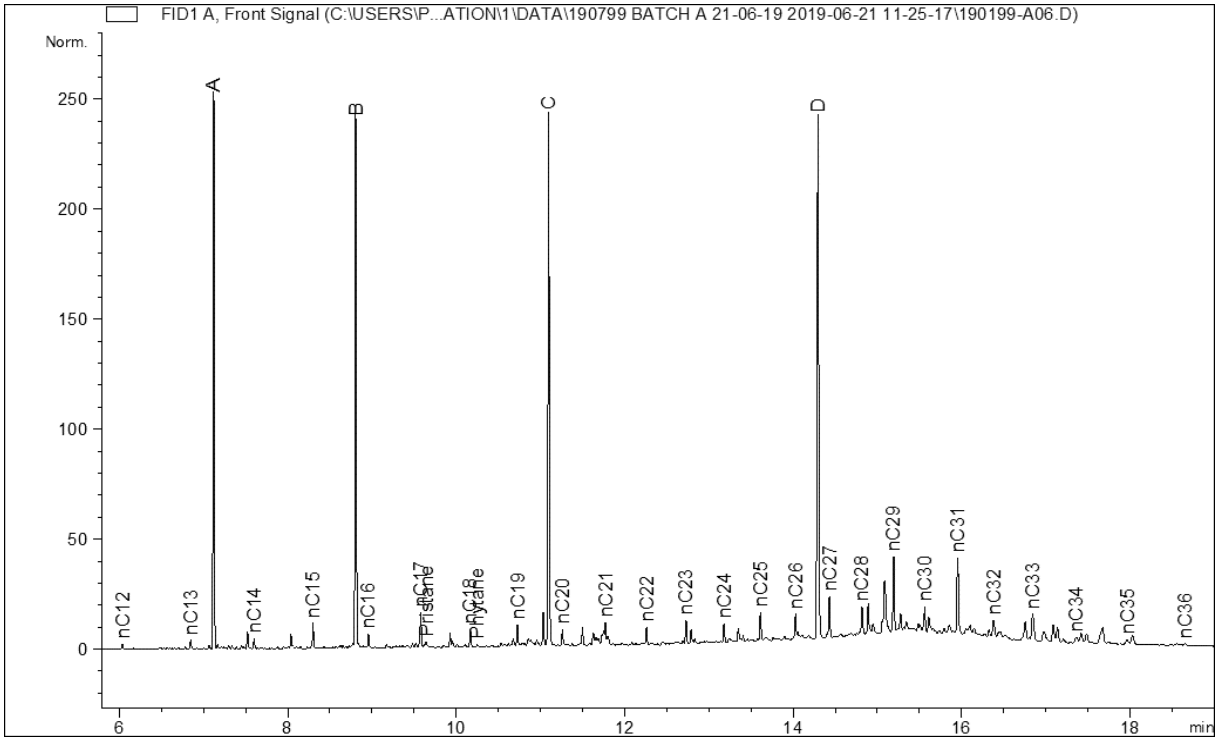
Station EBSHH_03



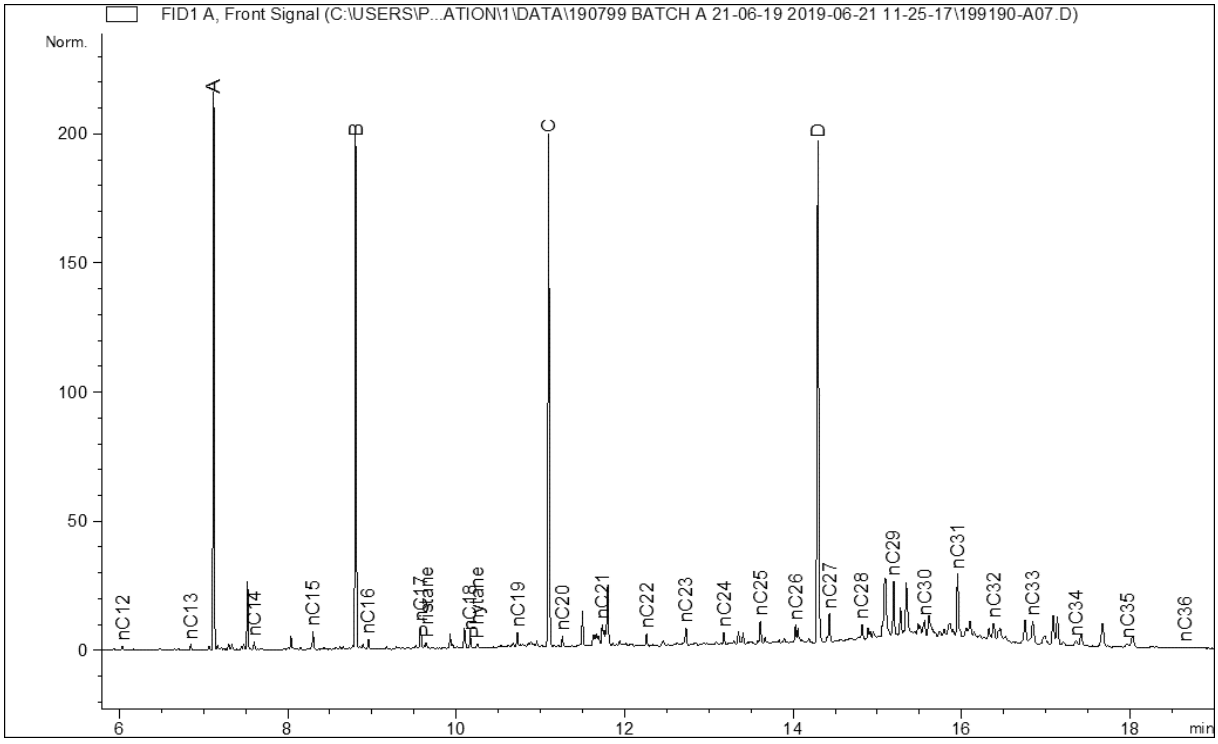
Station EBSHH_04



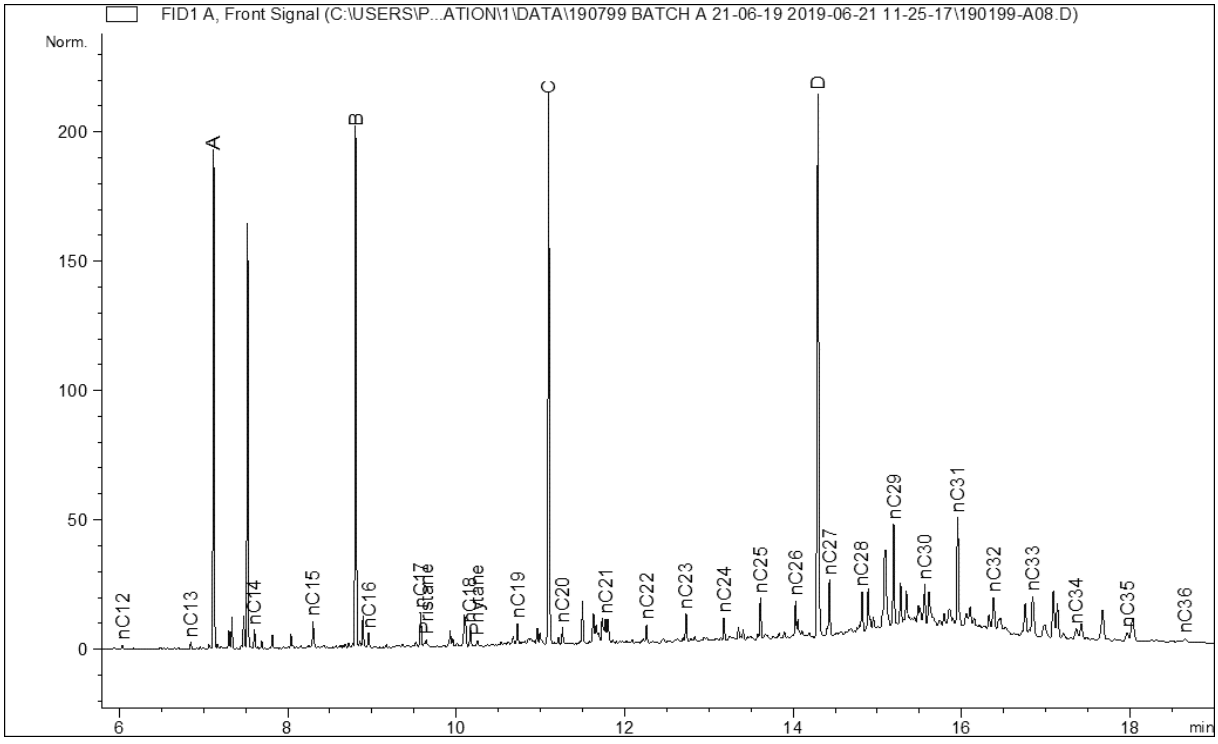
Station EBSHH_05



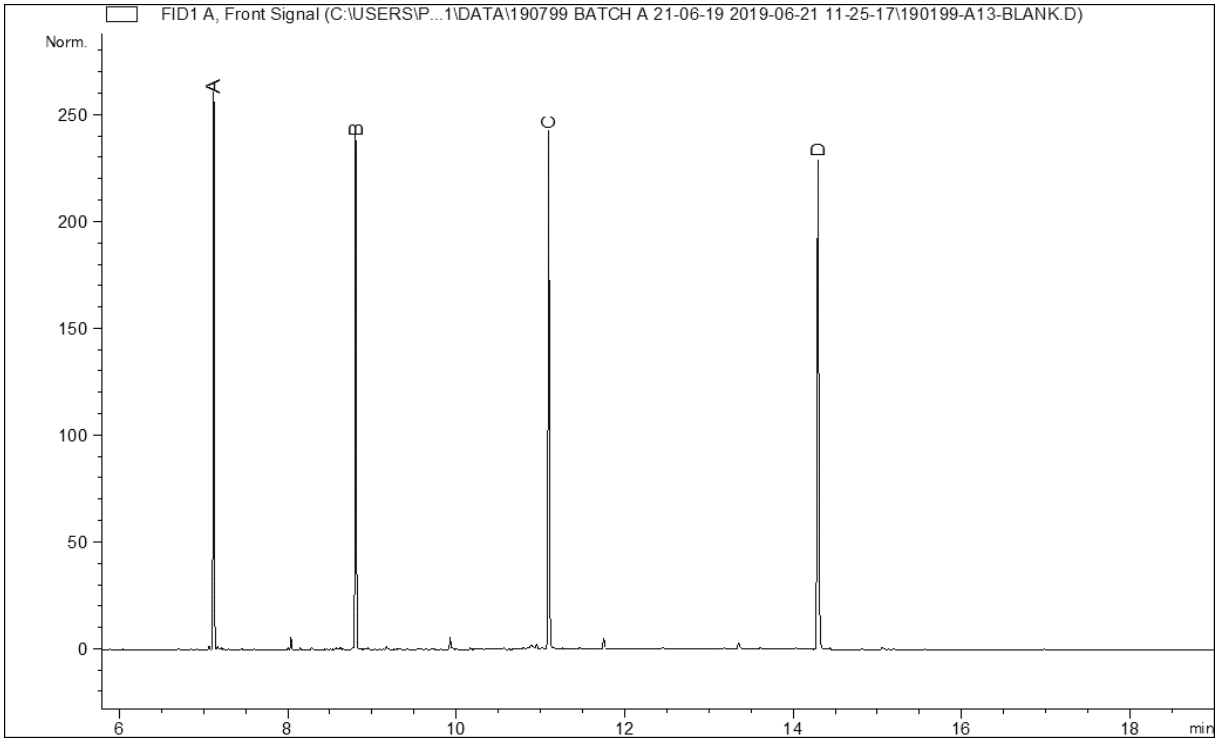
Station EBSHH_06



Station EBSHH_07

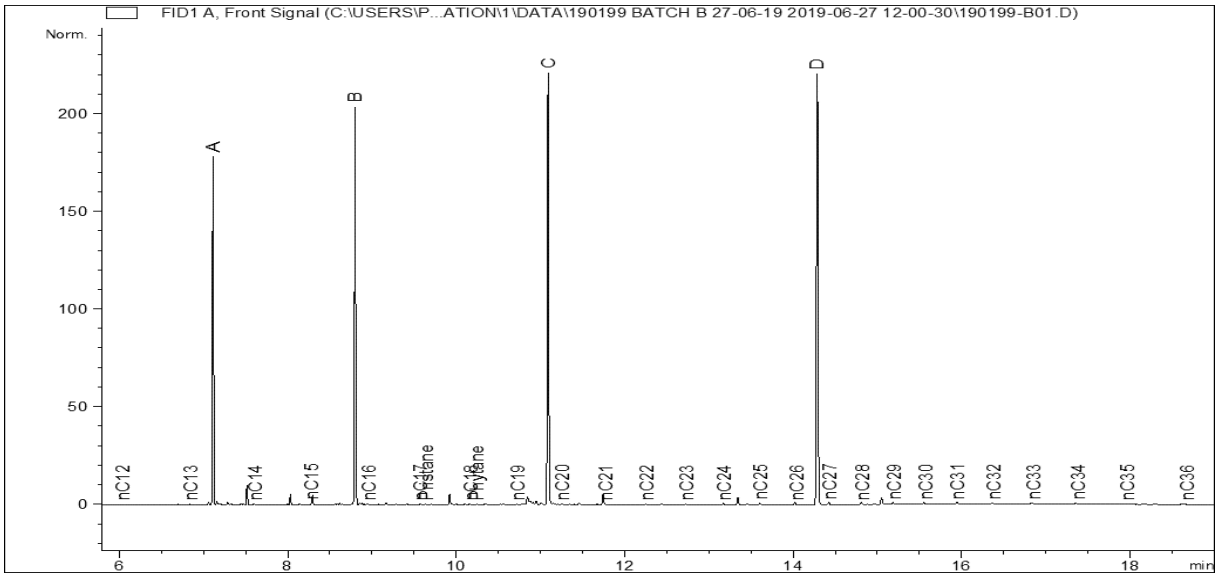


Station EBSHH_08

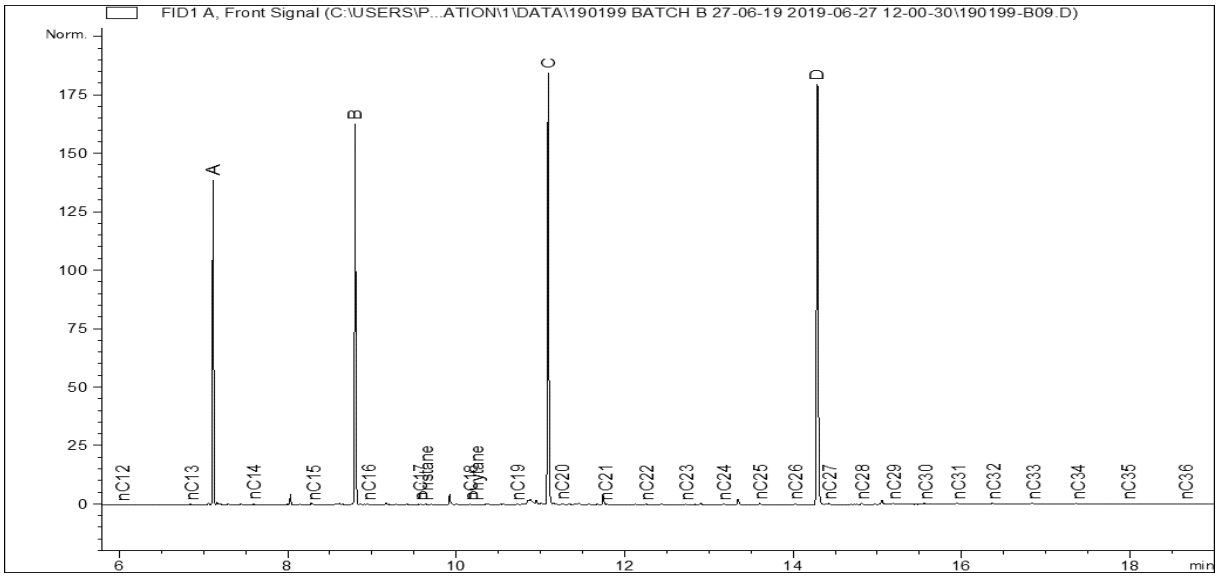

FID1 A, Front Signal (C:\USERS\P...1\DATA\190799 BATCH A 21-06-19 2019-06-21 11-25-17\190199-A13-BLANK.D)
Norm.
250
200
150
100
50
0
A
B
C
D
6
8
10
12
14
16
18
min

Blank

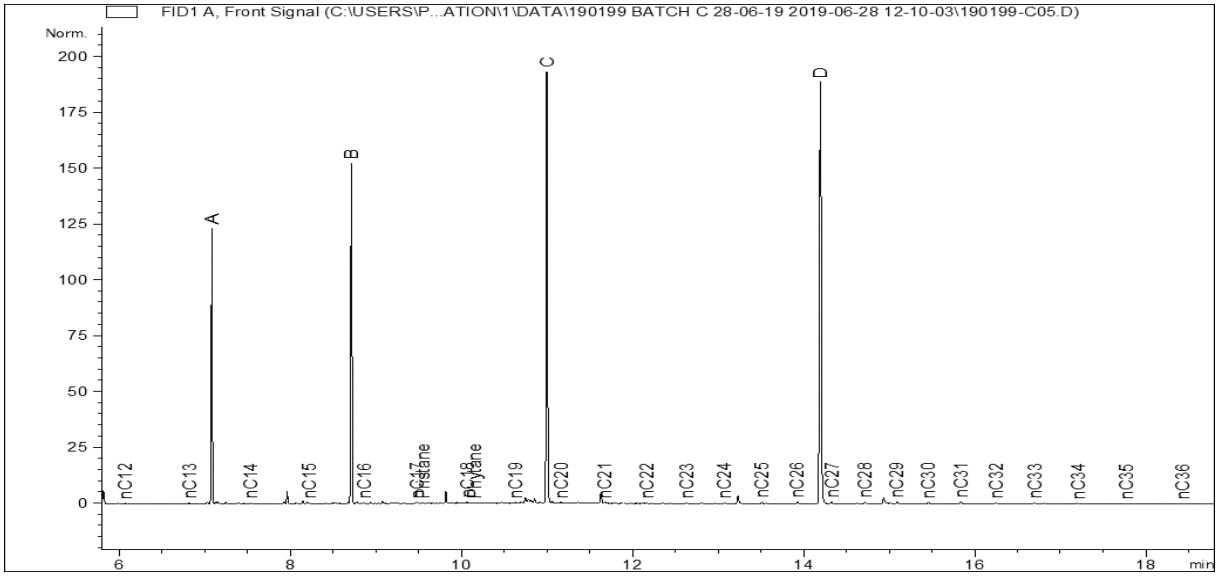
E.1.2 Water Samples



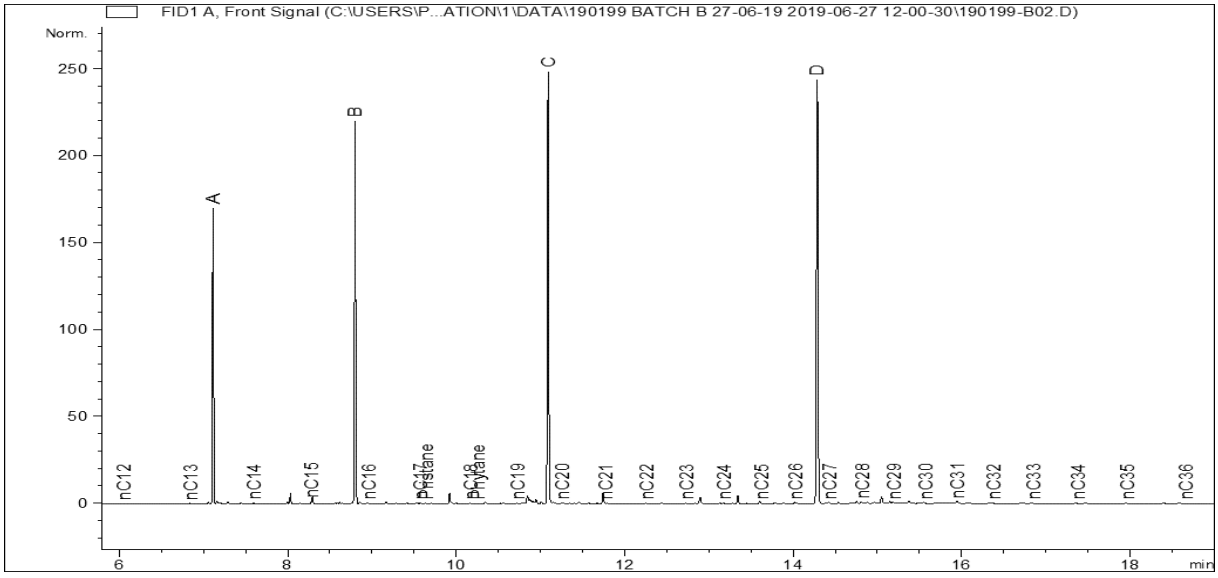
Station EBSHHW_01 (Surface)



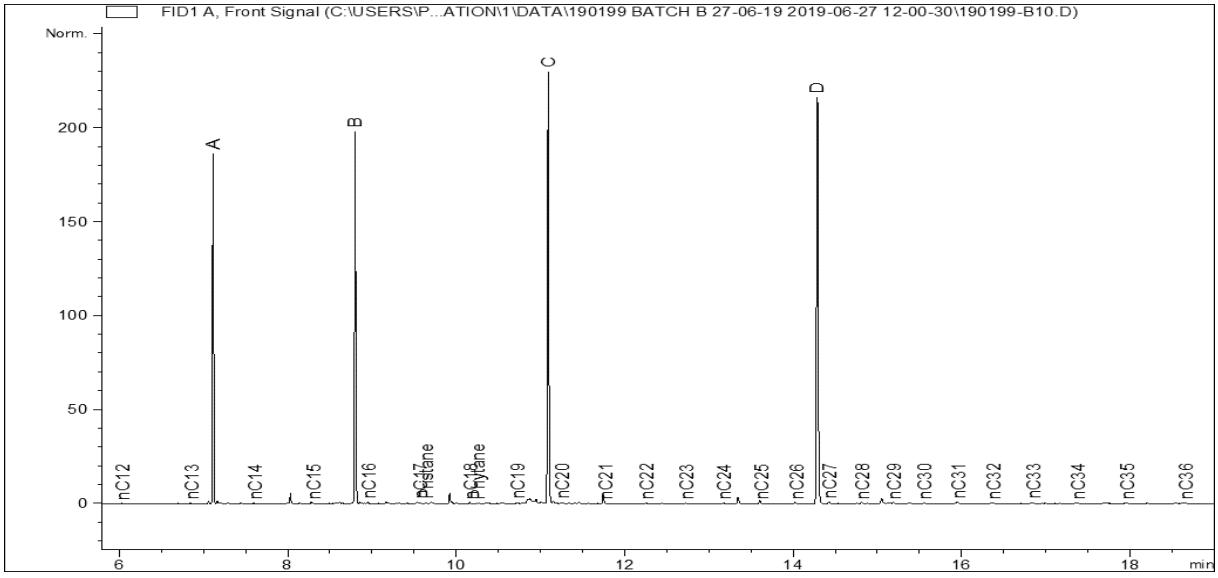
Station EBSHHW_01 (Mid)



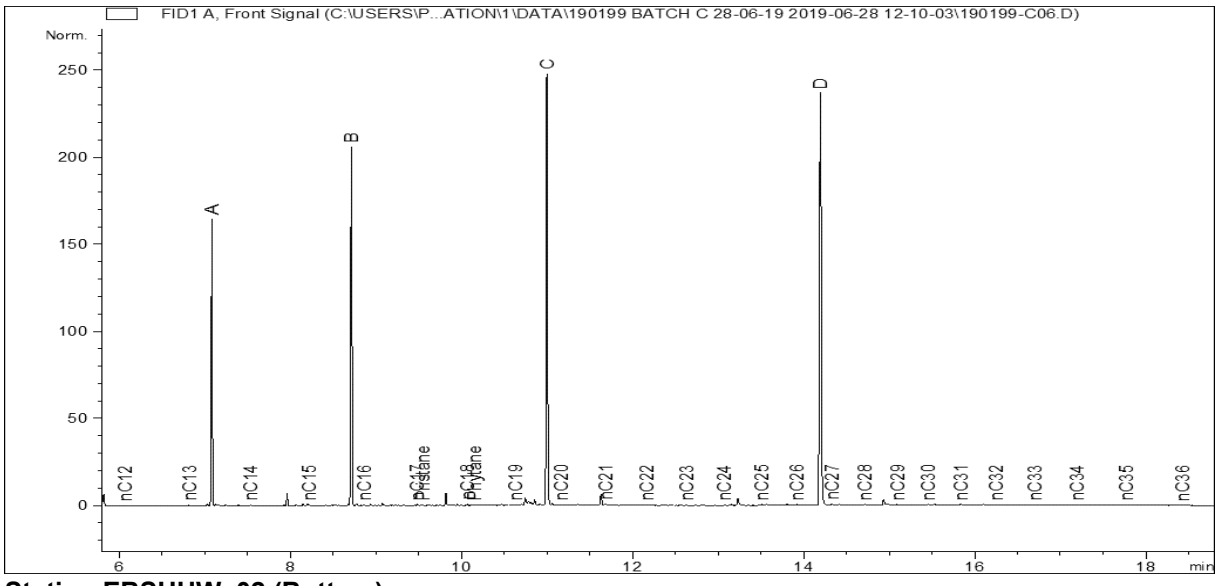
Station EBSHHW_01 (Bottom)



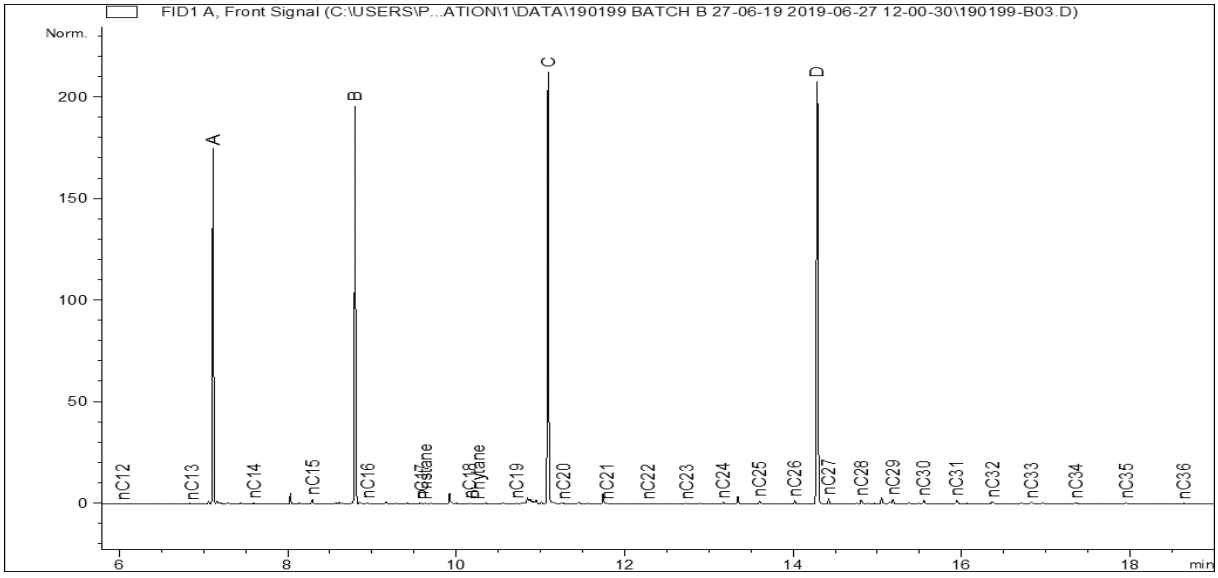
Station EBSHHW_02 (Surface)



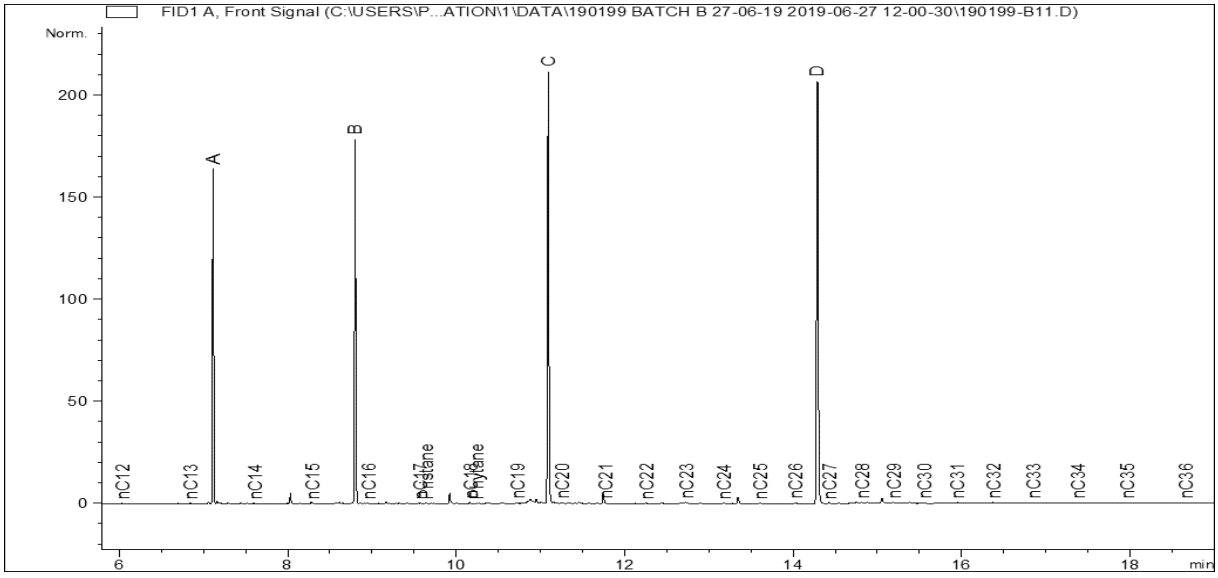
Station EBSHHW_02 (Mid)



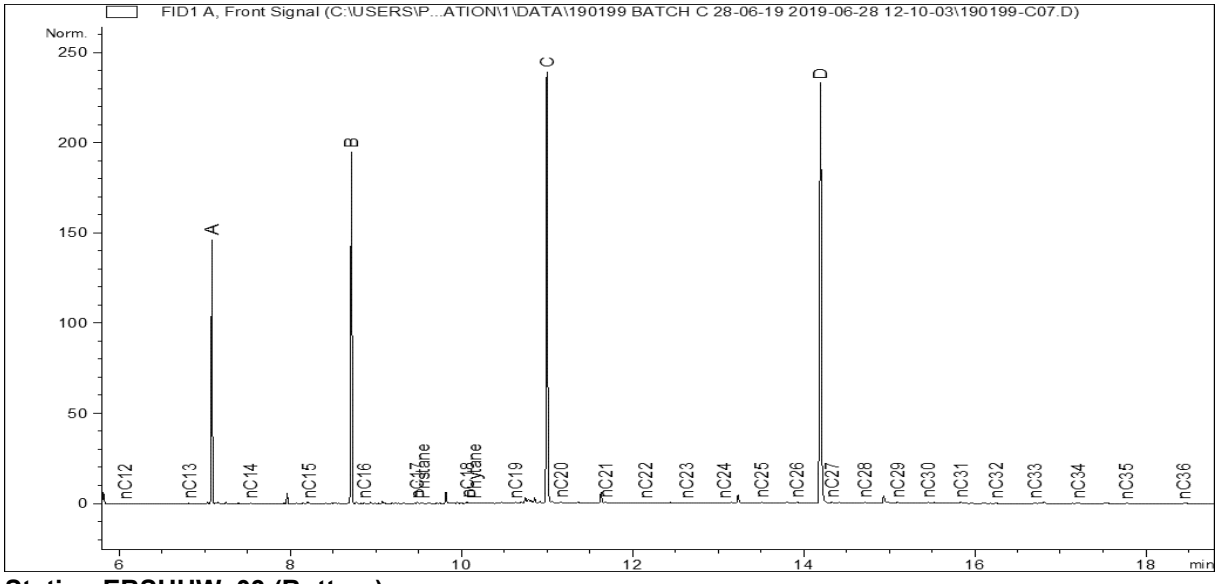
Station EBSHHW_02 (Bottom)



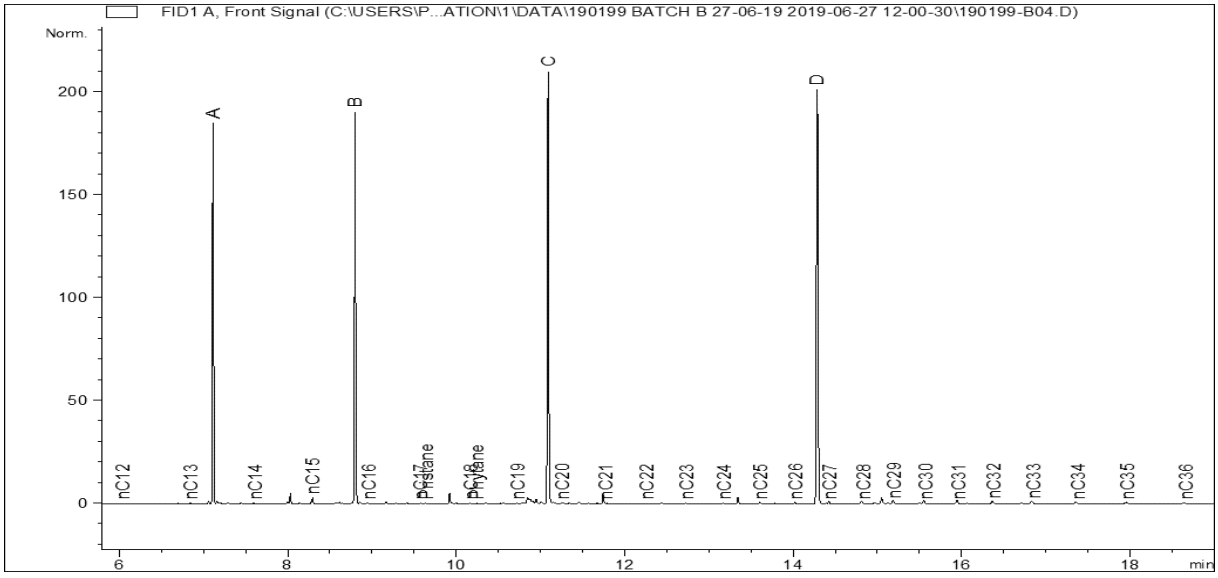
Station EBSHHW_03 (Surface)



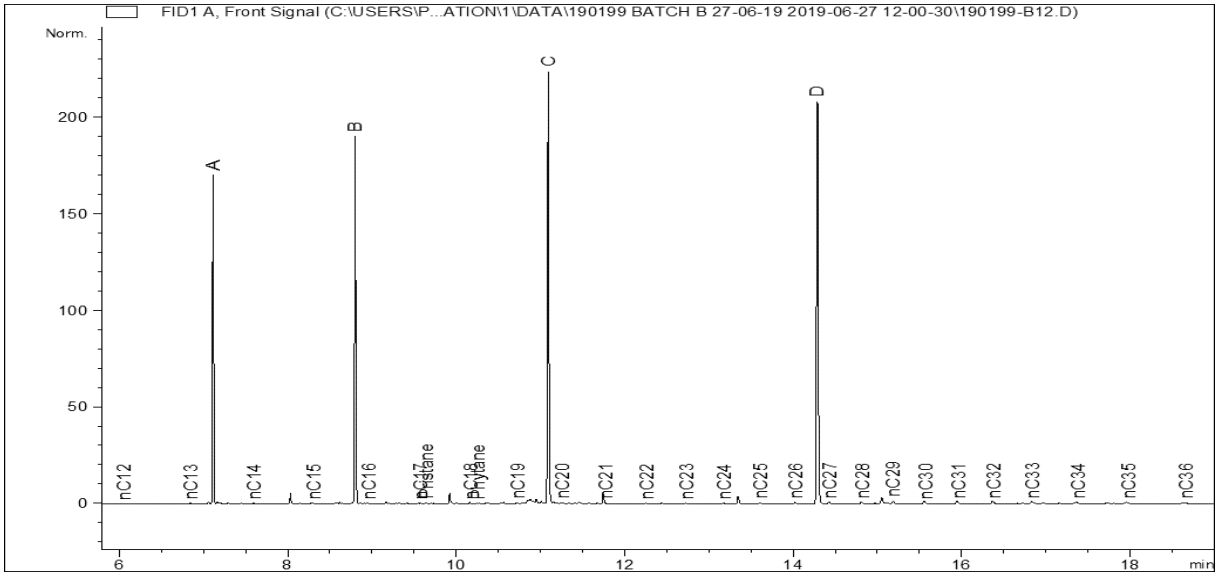
Station EBSHHW_03 (Mid)



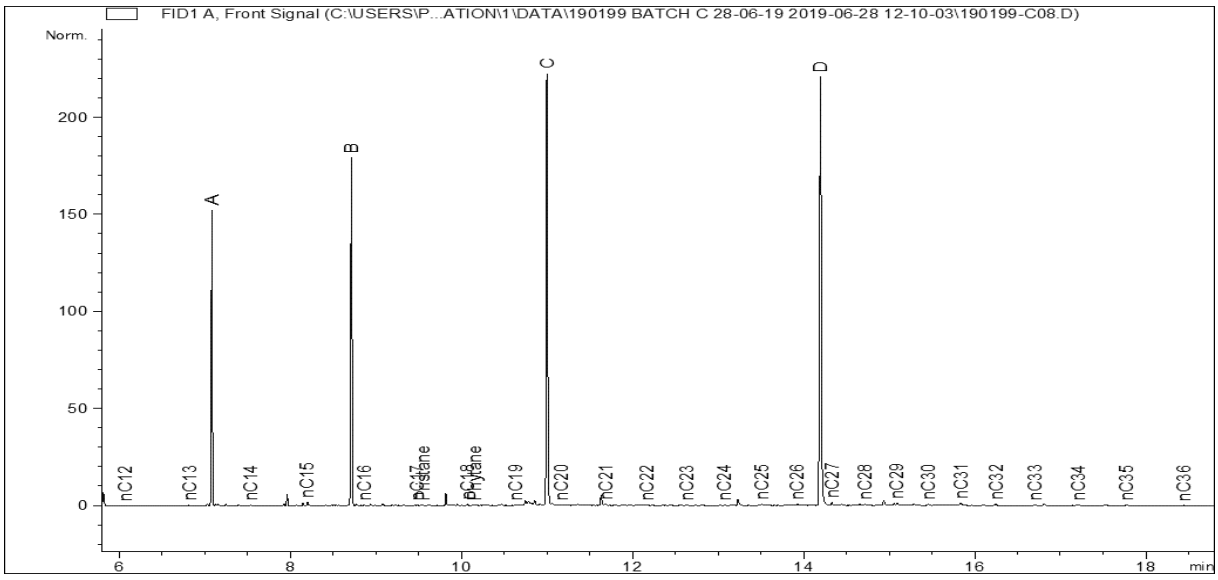
Station EBSHHW_03 (Bottom)



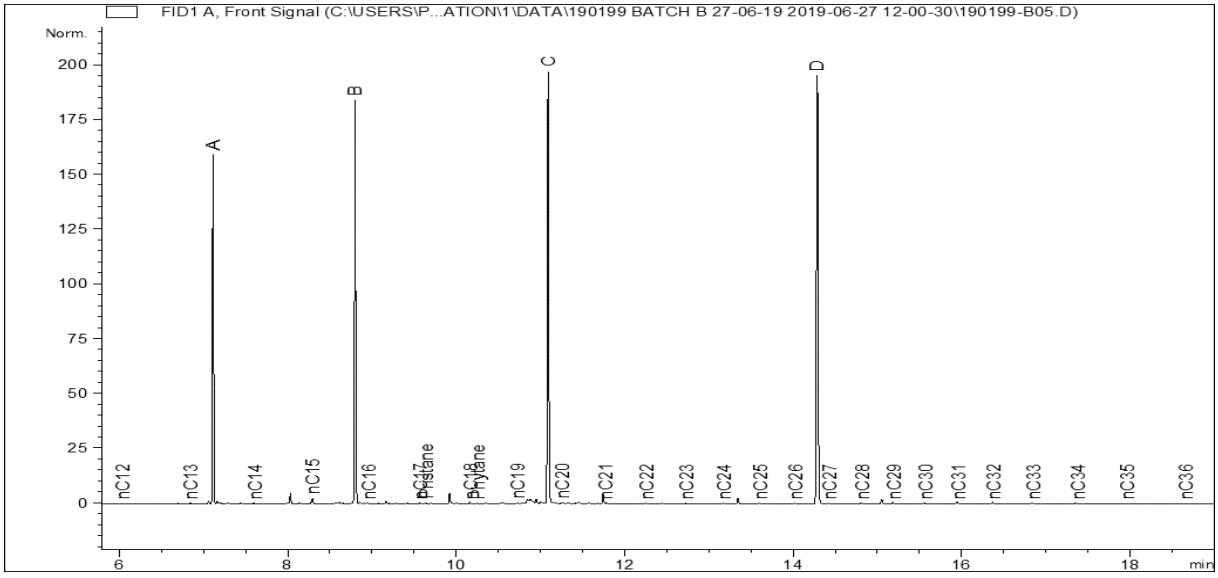
Station EBSHHW_04 (Surface)



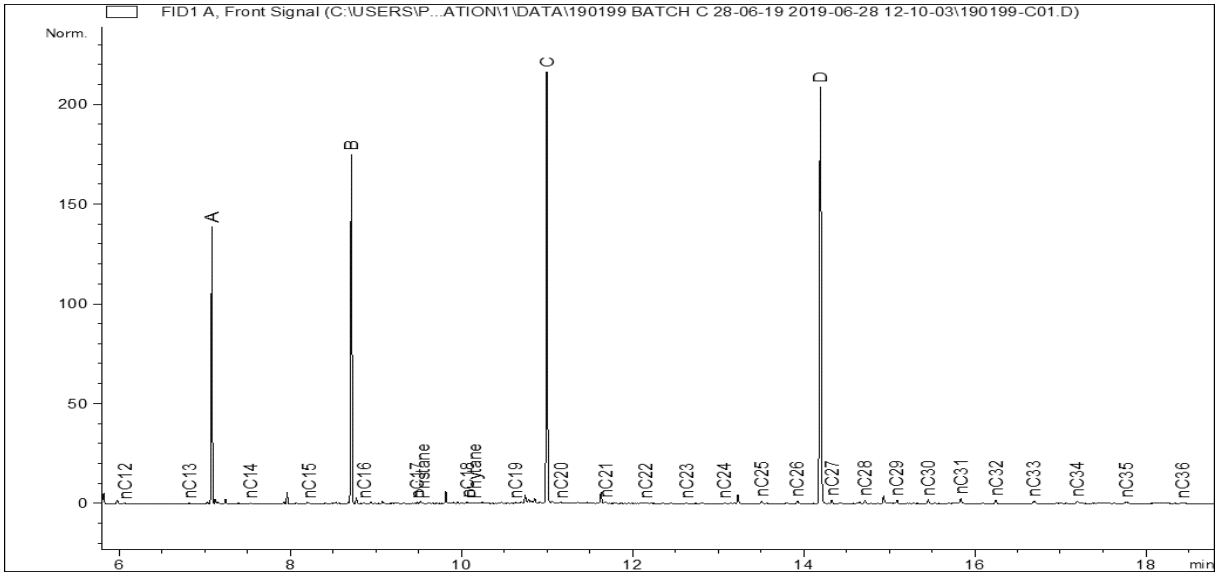
Station EBSHHW_04 (Mid)



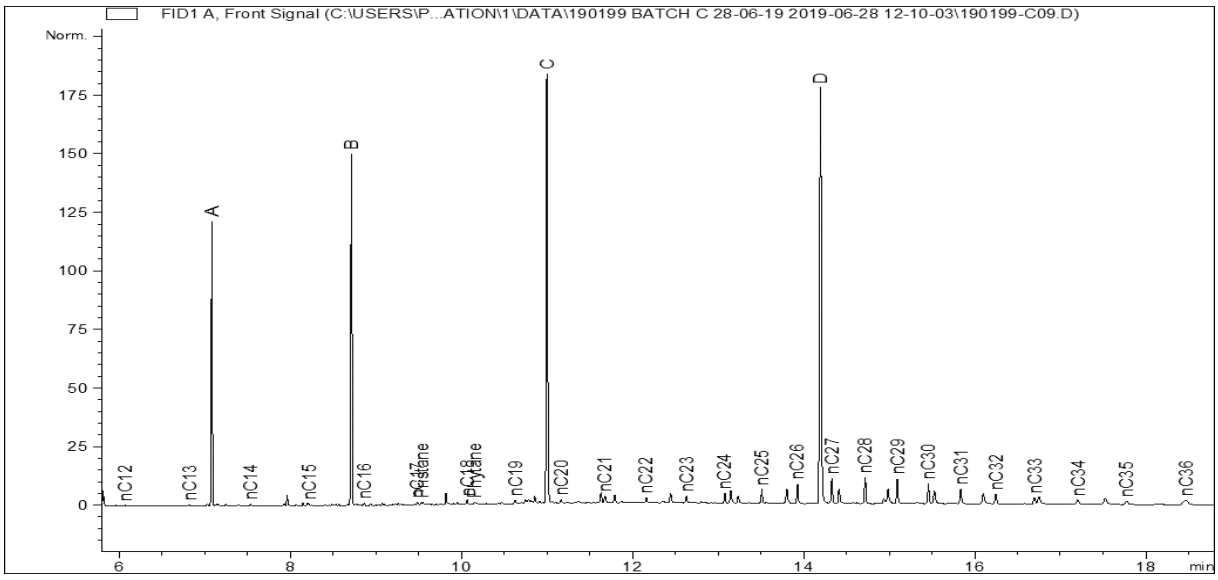
Station EBSHHW_04 (Bottom)



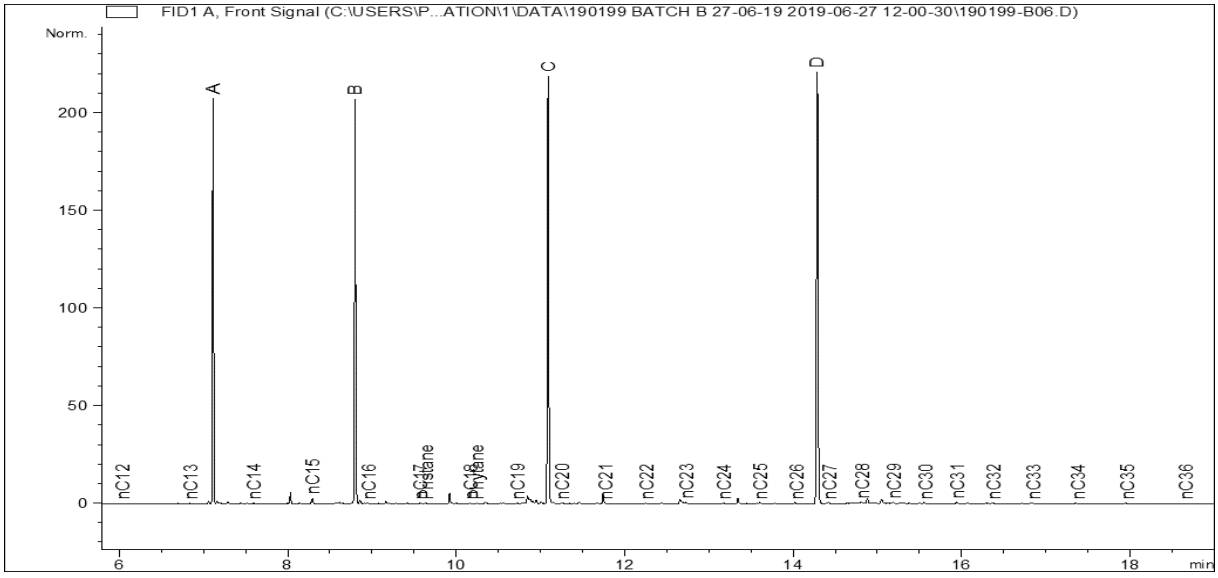
Station EBSHHW_05 (Surface)



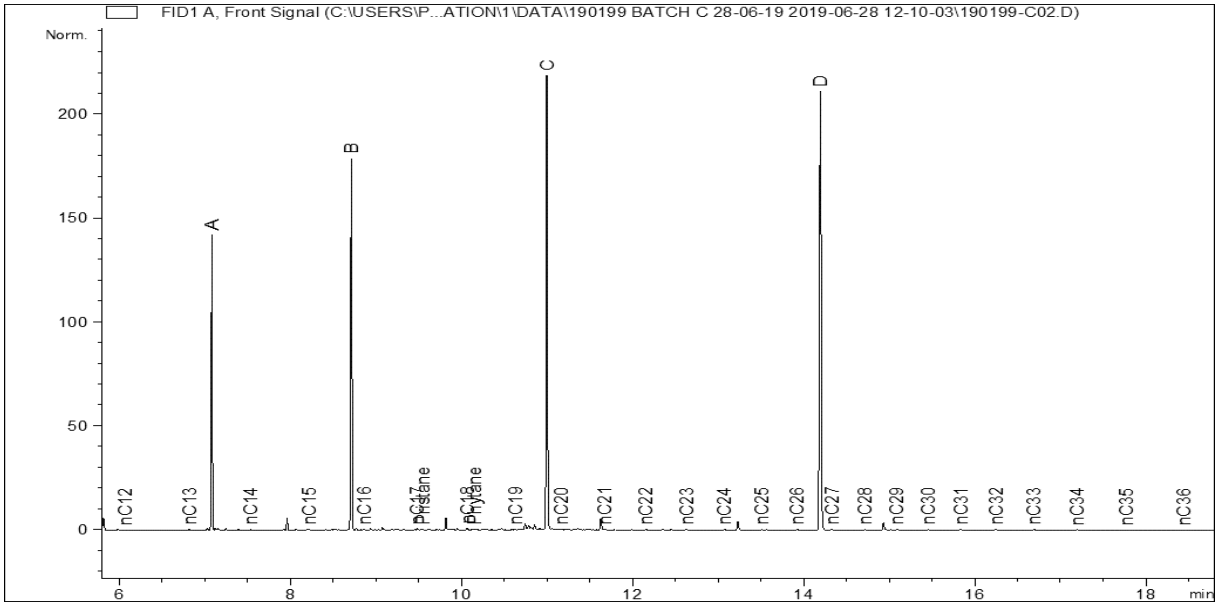
Station EBSHHW_05 (Mid)



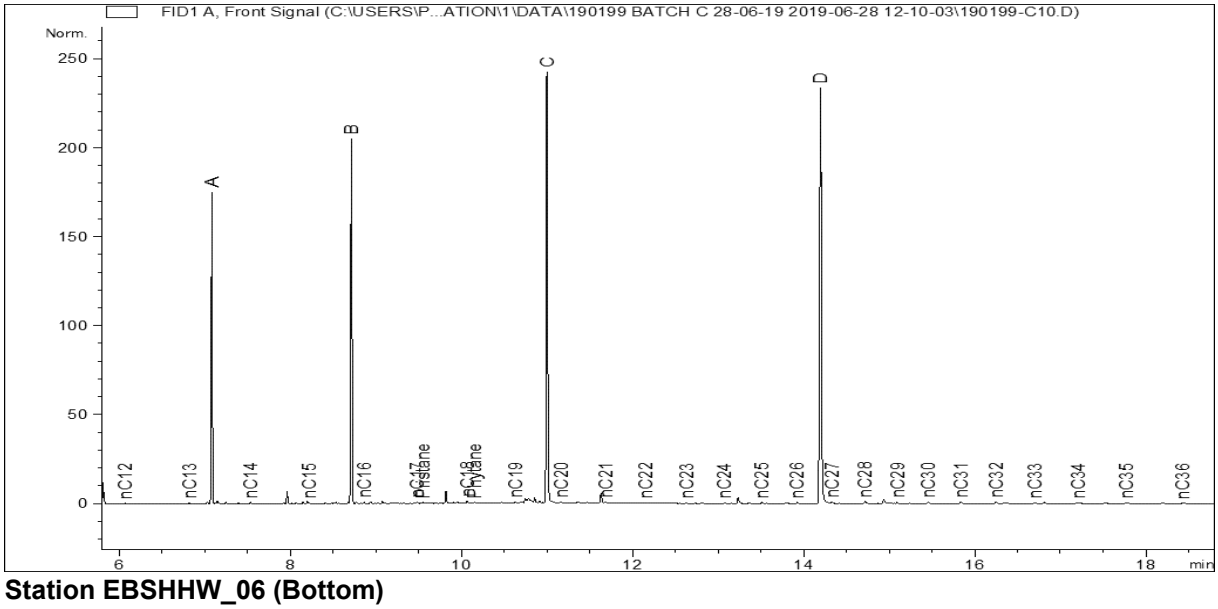
Station EBSHHW_05 (Bottom)



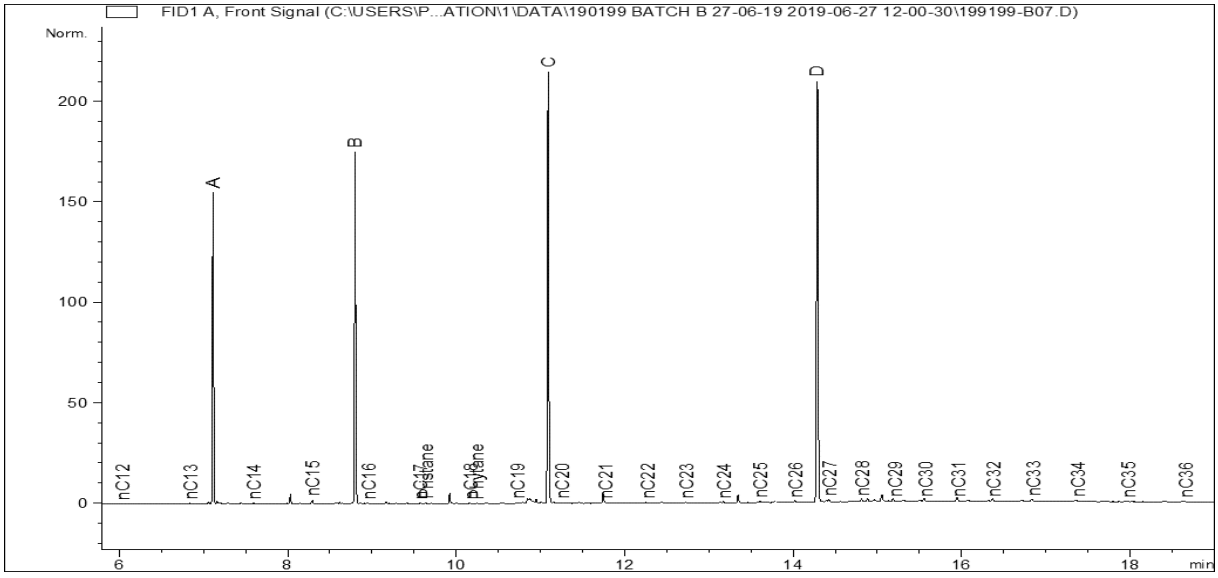
Station EBSHHW_06 (Surface)



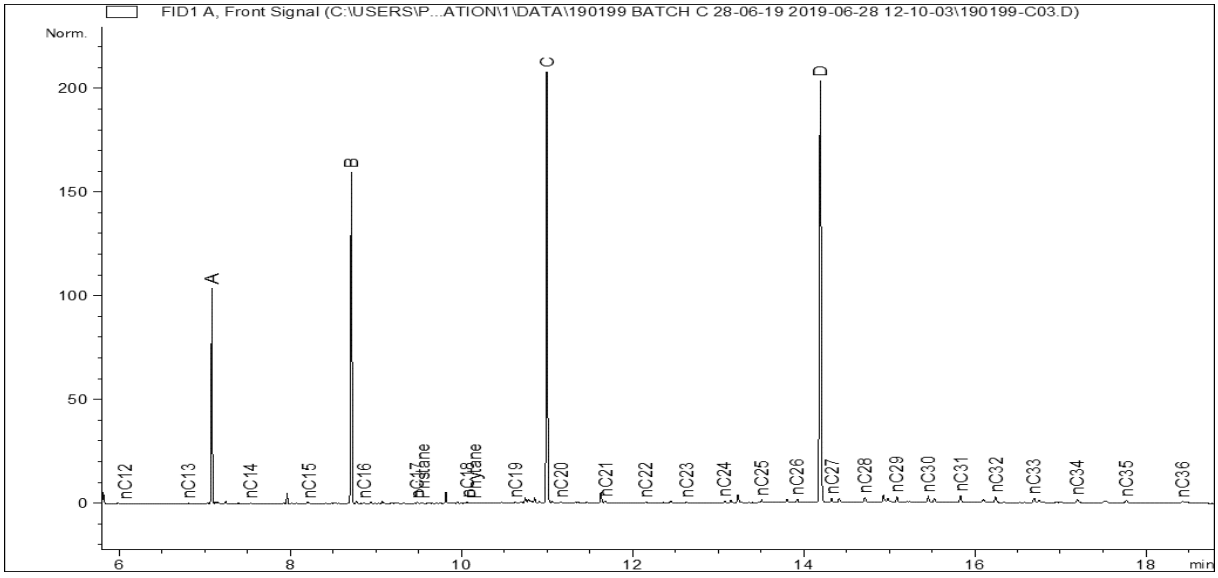
Station EBSHHW_06 (Mid)



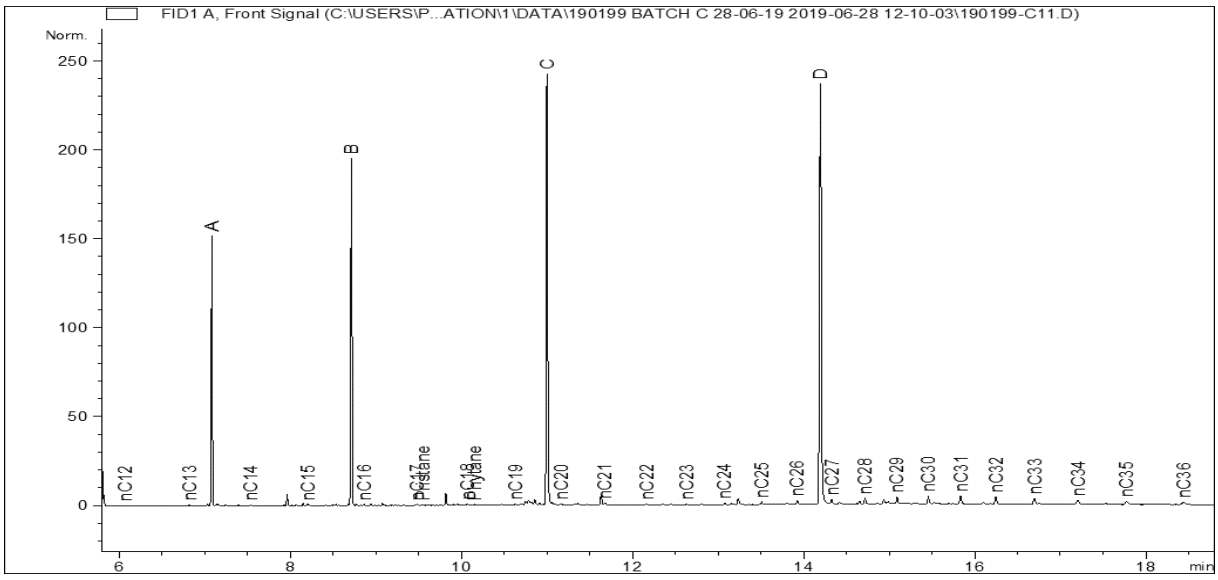
Station EBSHHW_06 (Bottom)



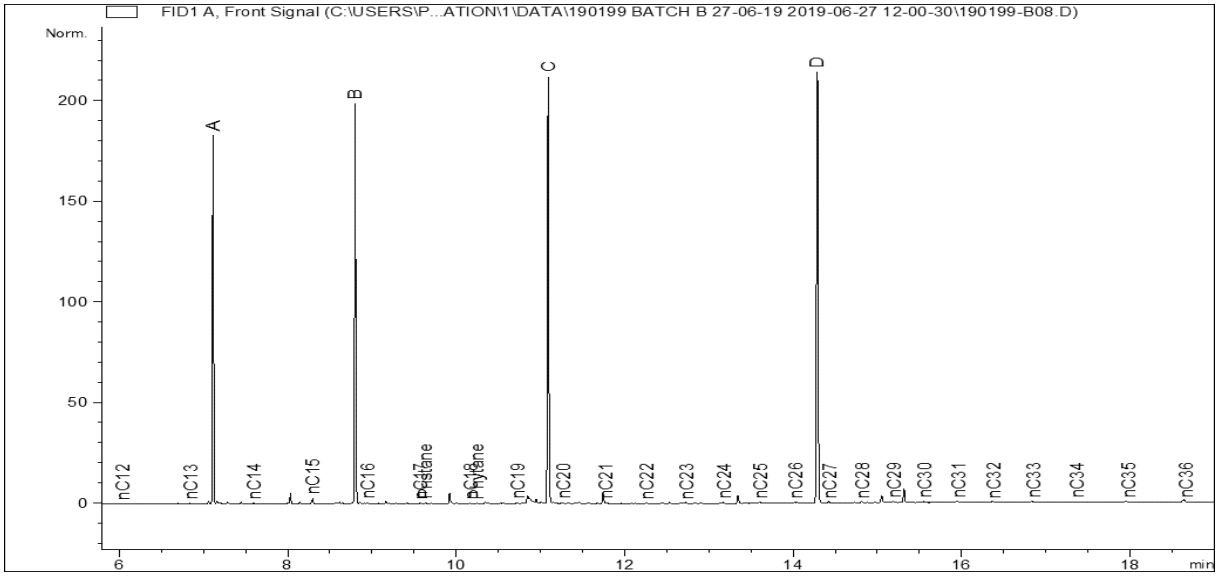
Station EBSHHW_07 (Surface)



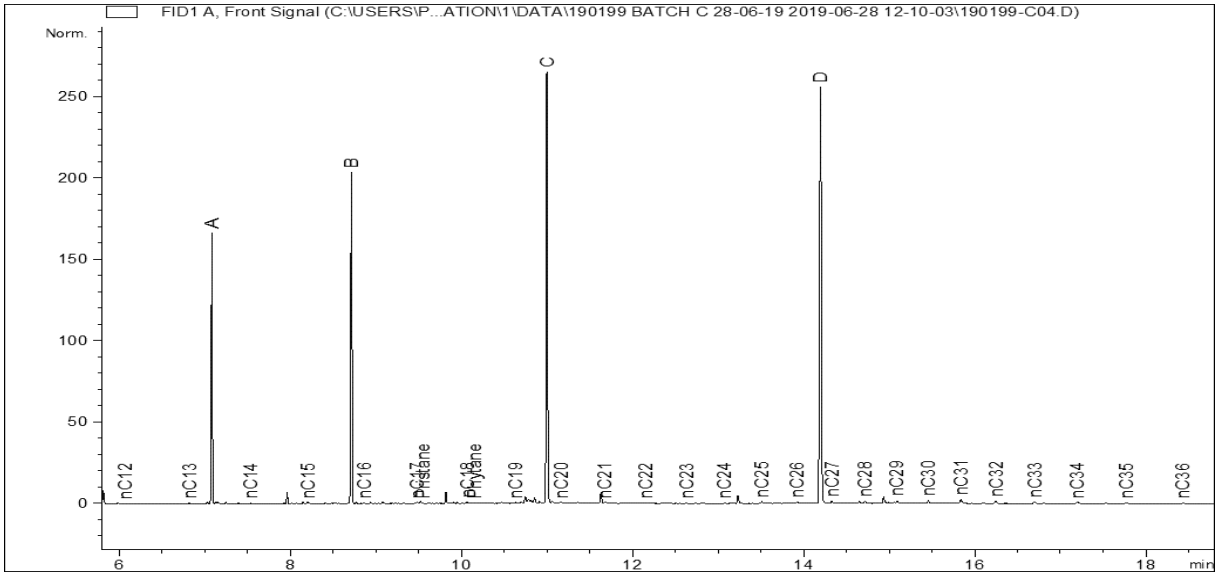
Station EBSHHW_07 (Mid)



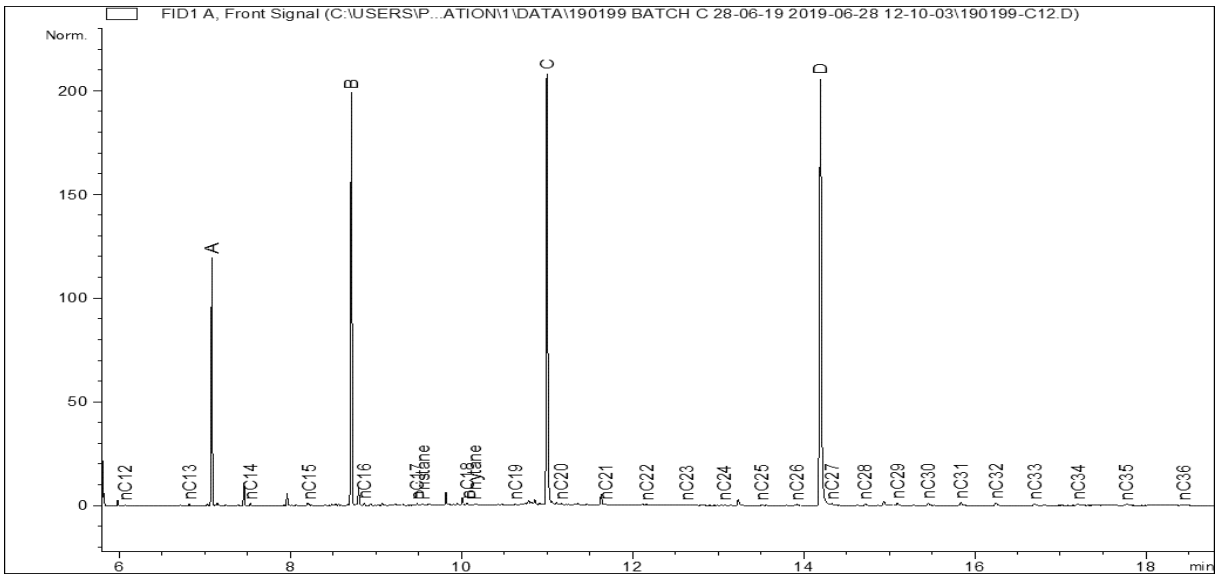
Station EBSHHW_07 (Bottom)



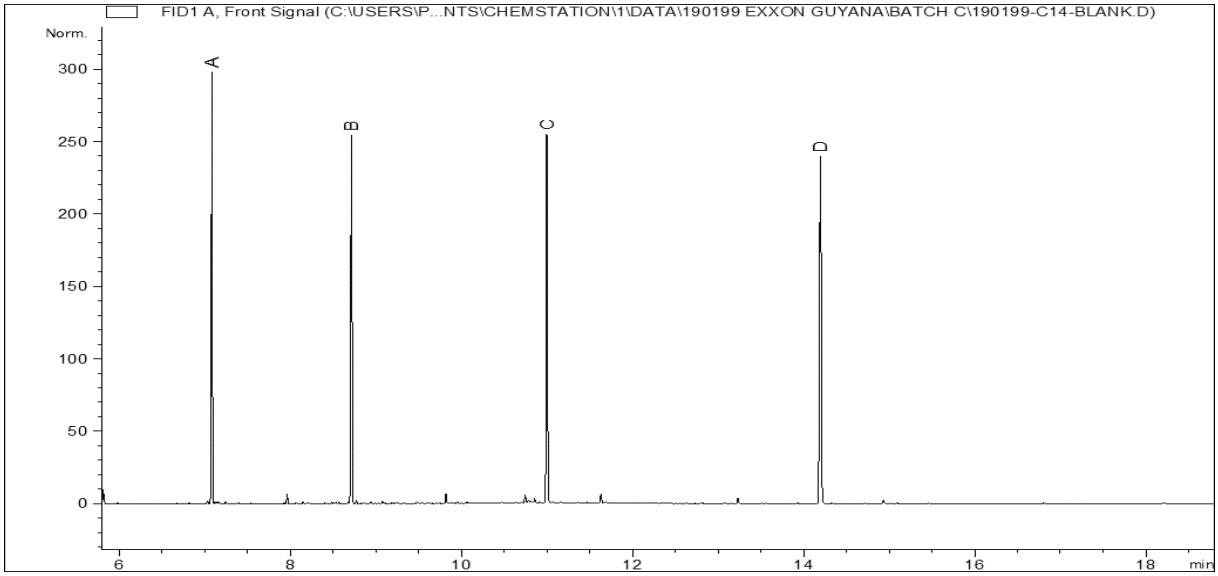
Station EBSHHW_08 (Surface)



Station EBSHHW_08 (Mid)



Station EBSHHW_08 (Bottom)


FID1 A, Front Signal (C:\USERS\P...NTS\CHEMSTATION\1\DATA\190199 EXXON GUYANA\BATCH C\190199-C14-BLANK.D)
Norm.
300
250
200
150
100
50
0
A
B
C
D
6
8
10
12
14
16
18
min

Blank

E.2 N-ALKANE CONCENTRATIONS

E.2.1 Sediment

n-Alkane [ng/g]	Station							
	EBSHH_01	EBSHH_02	EBSHH_03	EBSHH_04	EBSHH_05	EBSHH_06	EBSHH_07	EBSHH_08
nC_{12}	2.2	1.7	1.9	2.1	2.2	2.0	1.1	1.4
nC_{13}	3.4	3.1	3.3	3.2	3.6	3.4	1.5	2.5
nC_{14}	12.0	5.7	4.7	10.2	11.5	4.9	3.0	9.0
nC_{15}	8.9	7.8	10.3	10.0	10.9	8.8	6.2	10.8
nC_{16}	5.7	6.2	6.0	6.9	7.8	6.3	3.1	6.2
nC_{17}	12.5	13.7	18.4	14.6	16.8	16.2	7.1	14.3
nC_{18}	7.8	8.4	8.9	9.0	10.2	8.6	4.3	8.2
nC_{19}	7.4	8.3	9.9	10.5	10.6	9.6	4.6	9.1
nC_{20}	5.5	6.3	7.1	7.2	7.5	6.9	3.6	6.4
nC_{21}	4.5	2.9	6.2	6.0	6.4	5.9	3.3	4.2
nC_{22}	5.7	6.5	6.9	7.5	7.9	7.6	3.7	6.8
nC_{23}	7.4	8.4	8.9	10.1	10.0	9.4	6.3	10.7
nC_{24}	5.8	7.3	6.7	7.1	7.2	7.6	3.9	8.4
nC_{25}	8.0	10.3	9.8	10.5	10.6	11.4	7.0	14.9
nC_{26}	5.6	8.7	7.1	6.9	6.9	9.2	4.6	11.2
nC_{27}	11.5	17.1	14.5	13.9	15.7	17.5	9.5	20.9
nC_{28}	6.2	10.3	8.5	8.3	8.6	11.6	4.6	14.1
nC_{29}	23.0	33.6	28.3	31.7	34.9	33.4	17.9	40.0
nC_{30}	6.2	11.3	9.1	9.6	10.2	11.9	4.6	17.0
nC_{31}	31.0	42.9	36.3	40.9	45.9	41.8	23.9	52.7
nC_{32}	6.8	8.9	8.9	9.4	10.5	10.7	7.3	17.0
nC_{33}	13.1	18.7	15.0	18.3	20.4	17.4	10.9	21.9
nC_{34}	2.3	3.9	2.5	4.0	3.3	3.2	2.4	6.2
nC_{35}	2.7	3.6	2.5	4.2	3.6	3.2	1.4	5.2
nC_{36}	1.1	1.7	1.6	2.4	1.5	1.3	0.7	2.7
Total Alkane [µg/g]	**0.207**	**0.257**	**0.243**	**0.264**	**0.285**	**0.270**	**0.147**	**0.322**
Pristane [ng/g]	1.6	1.4	1.9	1.5	1.7	1.8	1.7	2.8
Phytane [ng/g]	1.2	1.5	1.2	1.3	1.7	1.2	1.4	2.1

Notes:
Individual n-alkane, pristane and phytane concentrations expressed as ng/g of dry sediment
Total n-alkane concentrations expressed as µg/g of dry sediment

E.2.2 Water Samples

n-Alkane [ng/L]	Sample											
	EBSHHW_01 (Surface)	EBSHHW_01 (Mid)	EBSHHW_01 (Bottom)	EBSHHW_02 (Surface)	EBSHHW_02 (Mid)	EBSHHW_02 (Bottom)	EBSHHW_03 (Surface)	EBSHHW_03 (Mid)	EBSHHW_03 (Bottom)	EBSHHW_04 (Surface)	EBSHHW_04 (Mid)	EBSHHW_04 (Bottom)
nC_{12}	4.3	5.3	6.9	2.8	7.1	4.7	5.4	4.7	6.4	4.2	6.0	7.3
nC_{13}	9.8	10.8	10.9	9.0	15.8	10.2	10.3	13.8	8.5	9.8	12.8	9.7
nC_{14}	18.3	13.3	12.6	12.2	18.1	11.5	13.5	16.2	11.1	11.8	14.1	13.3
nC_{15}	8.8	4.7	7.4	15.2	4.3	6.2	14.9	5.5	6.6	14.5	3.1	9.7
nC_{16}	9.9	13.2	11.9	11.1	13.8	12.7	14.7	9.2	9.9	9.7	12.1	13.0
nC_{17}	8.0	6.5	14.2	9.7	7.6	7.9	8.2	7.5	11.8	6.3	7.3	10.3
nC_{18}	13.4	10.2	18.6	10.1	13.9	14.4	9.5	13.5	18.6	8.3	12.1	15.9
nC_{19}	6.5	7.0	14.2	3.3	5.3	7.8	6.6	5.8	13.3	7.2	6.2	15.8
nC_{20}	9.9	7.5	14.1	3.8	6.4	7.1	6.3	7.3	14.7	7.1	7.5	10.3
nC_{21}	4.5	4.2	6.7	4.5	2.7	12.3	4.4	4.3	13.4	2.7	5.8	9.9
nC_{22}	4.8	4.5	4.1	4.3	3.6	5.8	4.7	3.6	6.6	3.8	4.6	4.9
nC_{23}	7.9	5.7	8.8	5.6	4.9	6.1	6.6	5.7	7.9	5.1	4.0	5.9
nC_{24}	12.5	8.4	11.9	8.7	9.9	5.2	13.0	6.3	9.2	7.9	6.8	8.4
nC_{25}	18.7	11.9	14.2	19.1	22.1	5.9	30.5	9.3	9.2	12.4	10.1	11.2
nC_{26}	20.5	10.9	14.9	10.3	12.5	7.1	30.7	7.9	9.6	16.6	12.9	11.4
nC_{27}	20.7	13.1	15.0	15.2	20.3	7.6	44.7	11.6	12.5	21.4	19.1	24.6
nC_{28}	24.2	12.0	14.8	13.8	10.2	5.8	36.5	9.2	11.9	26.8	22.1	11.9
nC_{29}	21.3	10.0	17.4	11.1	10.1	6.5	39.6	8.2	12.1	30.3	24.3	18.4
nC_{30}	20.1	10.8	10.9	13.2	10.1	7.6	35.5	8.9	11.1	34.9	26.8	12.5
nC_{31}	23.5	15.0	22.4	27.2	16.9	8.3	43.0	10.4	14.6	40.1	33.7	25.6
nC_{32}	18.9	12.3	11.6	10.1	10.0	6.8	25.9	5.3	14.3	36.2	35.6	14.9
nC_{33}	17.9	12.2	12.7	9.3	9.4	5.2	24.5	6.4	14.5	36.1	37.0	15.2
nC_{34}	12.9	8.9	8.0	6.2	7.6	2.7	17.2	5.4	9.8	30.2	27.2	10.5
nC_{35}	9.1	7.6	4.5	6.0	7.0	6.1	14.4	4.9	7.3	20.1	18.6	8.2
nC_{36}	9.8	6.9	7.7	3.5	6.3	10.2	13.3	3.0	7.9	15.6	16.6	4.4
Total Alkane [µg/L]	**0.336**	**0.233**	**0.296**	**0.245**	**0.256**	**0.192**	**0.474**	**0.194**	**0.273**	**0.419**	**0.386**	**0.303**
Pristane [ng/L]	9.1	6.7	5.6	7.1	12.5	4.0	7.5	7.7	7.1	8.5	8.6	6.6
Phytane [ng/L]	2.9	2.7	10.4	1.5	3.9	2.3	2.5	4.4	4.0	4.1	3.2	3.0

Notes:
Individual n-alkane, pristane and phytane concentrations expressed as ng/L
Total n-alkane concentrations expressed as µg/L

n-Alkane [ng/L]	Sample											
	EBSHHW_05 (Surface)	EBSHHW_05 (Mid)	EBSHHW_05 (Bottom)	EBSHHW_06 (Surface)	EBSHHW_06 (Mid)	EBSHHW_06 (Bottom)	EBSHHW_07 (Surface)	EBSHHW_07 (Mid)	EBSHHW_07 (Bottom)	EBSHHW_08 (Surface)	EBSHHW_08 (Mid)	EBSHHW_08 (Bottom)
nC_{12}	4.2	6.8	8.2	5.2	6.9	5.8	5.8	6.0	6.6	0.9	5.6	8.5
nC_{13}	7.0	9.8	15.3	9.7	11.0	13.2	11.1	10.7	9.8	10.7	9.5	14.9
nC_{14}	11.0	15.1	26.3	12.6	13.6	17.4	14.5	13.5	14.8	12.1	14.7	23.4
nC_{15}	13.2	6.8	17.1	15.1	7.4	8.4	17.4	6.4	7.1	13.7	6.4	9.1
nC_{16}	10.5	11.4	28.5	9.9	14.4	15.6	15.5	17.1	13.5	12.5	14.7	19.3
nC_{17}	6.8	9.2	47.9	6.5	13.5	15.2	10.8	15.1	16.0	7.0	15.4	19.6
nC_{18}	11.1	19.4	67.6	9.8	17.8	23.3	13.5	21.7	23.7	11.7	18.1	25.4
nC_{19}	7.9	9.8	61.3	6.8	13.7	12.9	8.1	18.2	19.3	4.4	16.4	16.1
nC_{20}	9.4	8.1	45.3	7.8	13.1	16.9	12.2	14.0	16.0	7.7	18.8	13.7
nC_{21}	4.1	16.3	87.8	6.6	11.1	9.7	3.7	18.6	10.4	4.6	11.7	9.5
nC_{22}	4.0	5.2	54.2	4.5	3.7	5.5	6.3	11.2	6.9	6.5	6.0	5.3
nC_{23}	4.1	7.6	69.0	11.2	4.7	7.2	8.1	14.7	10.3	7.7	7.4	5.4
nC_{24}	6.1	10.1	105	9.5	6.6	8.1	11.3	17.2	15.7	12.2	8.1	4.6
nC_{25}	9.8	22.2	143	9.6	8.8	9.8	14.2	21.9	20.9	12.8	14.9	6.9
nC_{26}	7.6	19.3	210	11.5	8.8	11.3	16.6	31.4	28.8	5.4	10.6	7.0
nC_{27}	10.0	30.6	275	11.0	10.2	11.0	20.0	36.7	37.5	12.1	18.1	12.2
nC_{28}	10.7	27.1	306	14.0	10.0	20.7	24.6	46.3	50.8	13.1	17.1	15.1
nC_{29}	12.4	29.0	290	10.9	9.6	14.1	25.8	55.7	59.1	12.4	22.6	20.9
nC_{30}	15.2	32.1	240	11.9	10.9	12.4	26.5	61.3	68.7	8.7	24.8	26.4
nC_{31}	20.9	52.3	206	15.5	13.2	15.5	38.8	80.0	94.3	14.2	44.9	30.8
nC_{32}	17.1	42.7	142	11.4	10.9	14.4	31.7	71.9	85.4	12.0	26.0	25.8
nC_{33}	19.5	37.1	102	11.1	10.6	11.9	31.8	65.5	77.1	14.0	24.3	24.5
nC_{34}	13.4	27.0	79.1	9.3	7.0	9.0	22.2	54.3	64.2	10.5	20.3	16.5
nC_{35}	11.3	20.6	63.4	9.3	6.2	9.0	15.5	43.8	47.3	16.4	15.7	16.7
nC_{36}	6.5	17.5	60.7	6.0	3.8	4.6	15.3	30.5	43.7	52.4	10.8	11.2
Total Alkane [µg/L]	**0.254**	**0.493**	**2.75**	**0.247**	**0.248**	**0.303**	**0.421**	**0.784**	**0.848**	**0.296**	**0.403**	**0.389**
Pristane [ng/L]	8.4	9.0	70.0	7.5	7.6	11.5	9.5	10.1	7.6	8.4	8.9	12.4
Phytane [ng/L]	3.6	3.6	23.4	4.3	3.7	4.7	5.0	5.2	6.6	5.3	7.0	6.3

Notes:
Individual n-alkane, pristane and phytane concentrations expressed as ng/L
Total n-alkane concentrations expressed as µg/L

E.3 AROMATIC HYDROCARBON CONCENTRATIONS

E.3.1 Sediment

E.3.1.1 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/g]	Station								NOAA ERL (Buchman, 2008)	NOAA ERM (Buchman, 2008)
	EBSHH_01	EBSHH_02	EBSHH_03	EBSHH_04	EBSHH_05	EBSHH_06	EBSHH_07	EBSHH_08		
Naphthalene	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	**160**	**2100**
Acenaphthylene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**44**	**640**
Acenaphthene	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	0.1	**16**	**500**
Fluorene	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	**19**	**540**
Phenanthrene	0.6	0.7	0.9	1.0	1.0	0.8	0.4	0.9	**240**	**1500**
Anthracene	< 0.1	< 0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	**85.3**	**1100**
Fluoranthene	0.5	0.5	0.6	0.7	0.8	0.5	0.2	0.8	**600**	**5100**
Pyrene	0.4	0.3	0.4	0.6	0.6	0.4	0.3	0.8	**665**	**2600**
Benzo(a)anthracene	0.2	0.2	0.2	0.3	0.3	0.2	0.1	0.4	**261**	**1600**
Chrysene	0.4	0.4	0.5	0.7	0.6	0.5	0.2	0.7	**384**	**2800**
Benzo(b)fluoranthene	0.8	0.9	1.1	1.4	1.4	1.2	0.5	1.4	-	-
Benzo(k)fluoranthene	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.3	-	-
Benzo(a)pyrene	0.1	0.1	0.1	0.3	0.3	0.2	0.1	0.4	**430**	**1600**
Indeno(1,2,3-cd)pyrene	0.2	0.2	0.2	0.4	0.3	0.3	0.1	0.5	-	-
Benzo(ghi)perylene	0.3	0.3	0.3	0.5	0.5	0.4	0.2	0.7	-	-
Dibenzo(a,h)anthracene	0.1	0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	**63.4**	**260**
Total US EPA 16	**3.9**	**4.0**	**4.8**	**6.6**	**6.7**	**5.1**	**2.4**	**7.5**	-	-

Notes:
Concentrations expressed as ng/g dry sediment
PAH = Polycyclic aromatic hydrocarbon
OSPAR = Oslo and Paris Convention
ERL = Effects range low
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbon pollutants

Key:	Below ERL	Above ERL	Above ERM

E.3.1.2 Total 2 to 6 Ring PAH Concentrations

PAH [ng/g]	Station							
	EBSHH_01	EBSHH_02	EBSHH_03	EBSHH_04	EBSHH_05	EBSHH_06	EBSHH_07	EBSHH_08
Naphthalene (128)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 128	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 128	1	1	1	1	1	1	1	1
C_3 128	1	1	1	1	1	1	1	1
C_4 128	1	1	1	1	1	1	1	1
TOTAL 128	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Phenanthrene/anthracene (178)	1	1	1	1	1	1	< 1	1
C_1 178	1	1	1	1	1	1	1	1
C_2 178	2	2	2	2	2	2	2	2
C_3 178	1	1	2	2	2	2	1	2
TOTAL 178	**5**	**5**	**6**	**6**	**6**	**6**	**4**	**6**
Dibenzothiophene (DBT)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_3 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 184	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**
Fluoranthene/pyrene (202)	< 1	< 1	1	2	2	1	< 1	2
C_1 202	1	1	1	1	1	1	< 1	1
C_2 202	1	1	1	1	1	1	1	1
C_3 202	1	1	1	1	1	1	1	2
TOTAL 202	**3**	**3**	**4**	**5**	**5**	**4**	**2**	**6**
Benzanthracenes/ benzphenanthrenes (228)	1	1	2	2	2	2	1	2
C_1 228	1	1	1	1	1	1	1	2
C_2 228	1	1	2	2	2	2	1	3
TOTAL 228	**3**	**3**	**5**	**5**	**5**	**5**	**3**	**7**
m/z 252*	17	18	23	28	30	25	18	32
C_1 252	2	2	2	3	3	2	2	4
C_2 252	1	1	1	2	2	1	1	2
TOTAL 252	**20**	**21**	**26**	**33**	**35**	**28**	**21**	**38**
m/z 276†	1	1	1	1	1	1	1	2
C_1 276	< 1	< 1	< 1	1	1	1	< 1	1
C_2 276	< 1	< 1	1	1	1	1	< 1	1
TOTAL 276	**1**	**1**	**2**	**3**	**3**	**3**	**1**	**4**
NPD‡	**8**	**8**	**9**	**9**	**9**	**9**	**7**	**9**
% NPD	**23**	**22**	**20**	**16**	**16**	**18**	**21**	**14**
Total 2 to 6 ring PAH	**35**	**36**	**46**	**55**	**57**	**49**	**34**	**64**

Notes:
PAH = Polycyclic aromatic hydrocarbon
Concentrations expressed as ng/g dry sediment
* = m/z 252 - benzfluoranthenes/benzpyrenes/perylene
† = m/z 276 - anthanthrene/indenopyrenes/benzperylenes
‡ = NPD - naphthalenes, phenanthrenes and dibenzothiophenes (totals)

E.3.2 Water Samples

E.3.2.1 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/L]	EBSHHW_01 (Surface)	EBSHHW_01 (Mid)	EBSHHW_01 (Bottom)	EBSHHW_02 (Surface)	EBSHHW_02 (Mid)	EBSHHW_02 (Bottom)	EBSHHW_03 (Surface)	EBSHHW_03 (Mid)	EBSHHW_03 (Bottom)	NOAA Chronic Value (Buchman, 2008)
Naphthalene	1.0	1.0	1.1	1.1	1.1	1.0	1.1	1.0	1.1	**1400**
Acenaphthylene	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	**-**
Acenaphthene	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1	**40000**
Fluorene	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.3	**-**
Phenanthrene	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.5	0.6	**4600**
Anthracene	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**-**
Fluoranthene	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.1	0.2	**11000**
Pyrene	0.4	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.4	**-**
Benzo(a)anthracene	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	**-**
Chrysene	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.2	**-**
Benzo(b)fluoranthene	< 0.1	< 0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	**-**
Benzo(k)fluoranthene	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.2	**-**
Benzo(a)pyrene	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	**-**
Indeno(1,2,3-cd)pyrene	0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	**-**
Benzo(ghi)perylene	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	**-**
Dibenzo(a,h)anthracene	0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	**-**
Total US EPA 16	**3.4**	**2.7**	**3.7**	**3.3**	**2.8**	**3.3**	**2.8**	**2.6**	**4.1**	**-**

Notes:
Concentrations expressed as ng/L of water
PAH = Polycyclic aromatic hydrocarbon
OSPAR = Oslo and Paris Convention
ERL = Effects range low
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbon pollutants

Key:	Below ERL	Above Chronic Value

PAH [ng/L]	EBSHHW_04 (Surface)	EBSHHW_04 (Mid)	EBSHHW_04 (Bottom)	EBSHHW_05 (Surface)	EBSHHW_05 (Mid)	EBSHHW_05 (Bottom)	EBSHHW_06 (Surface)	EBSHHW_06 (Mid)	EBSHHW_06 (Bottom)	NOAA Chronic Value (Buchman, 2008)
Naphthalene	1.3	0.9	1.1	0.8	0.9	3.0	1.0	1.0	1.3	**1400**
Acenaphthylene	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	-
Acenaphthene	0.2	0.1	0.1	0.1	0.2	1.0	0.1	0.2	0.2	**40000**
Fluorene	0.3	0.2	0.3	0.2	0.4	1.9	0.2	0.2	0.3	-
Phenanthrene	0.6	0.5	0.6	0.5	0.6	3.7	0.5	0.6	0.6	**4600**
Anthracene	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	-
Fluoranthene	0.2	0.1	0.2	0.1	0.2	0.7	0.1	0.2	0.2	**11000**
Pyrene	0.3	0.2	0.3	0.3	0.2	0.8	0.3	0.3	0.2	-
Benzo(a)anthracene	0.2	0.3	0.3	0.3	0.3	0.6	0.3	0.3	0.2	-
Chrysene	< 0.1	< 0.1	0.1	< 0.1	0.1	0.6	< 0.1	0.1	0.1	-
Benzo(b)fluoranthene	< 0.1	< 0.1	0.2	0.1	0.1	0.6	< 0.1	0.1	0.1	-
Benzo(k)fluoranthene	< 0.1	< 0.1	0.1	0.1	0.1	0.4	< 0.1	< 0.1	< 0.1	-
Benzo(a)pyrene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	< 0.1	< 0.1	< 0.1	-
Indeno(1,2,3-cd)pyrene	< 0.1	< 0.1	0.1	< 0.1	0.2	0.1	< 0.1	0.1	< 0.1	-
Benzo(ghi)perylene	0.1	0.1	0.1	0.1	0.1	0.5	< 0.1	0.1	0.1	-
Dibenzo(a,h)anthracene	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.2	< 0.1	< 0.1	< 0.1	-
Total US EPA 16	**3.5**	**2.5**	**3.6**	**2.7**	**3.6**	**15.3**	**2.6**	**3.3**	**3.4**	-

Notes:
Concentrations expressed as ng/L of water
PAH = Polycyclic aromatic hydrocarbon
OSPAR = Oslo and Paris Convention
ERL = Effects range low
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbon pollutants

Key:	Below ERL	Above Chronic Value

PAH [ng/L]	EBSHHW_07 (Surface)	EBSHHW_07 (Mid)	EBSHHW_07 (Bottom)	EBSHHW_08 (Surface)	EBSHHW_08 (Mid)	EBSHHW_08 (Bottom)	NOAA Chronic Value (Buchman, 2008)
Naphthalene	1.1	1.4	1.2	1.0	1.2	1.2	**1400**
Acenaphthylene	0.1	0.1	0.2	0.1	0.1	0.1	-
Acenaphthene	0.2	0.2	0.2	0.2	0.2	0.3	**40000**
Fluorene	0.3	0.4	0.3	0.2	0.3	0.4	-
Phenanthrene	0.6	0.7	0.7	0.6	0.7	0.8	**4600**
Anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	-
Fluoranthene	0.1	0.2	0.2	0.4	0.2	0.2	**11000**
Pyrene	0.3	0.3	0.3	0.5	0.3	0.3	-
Benzo(a)anthracene	0.3	0.3	0.2	0.3	0.3	0.3	-
Chrysene	< 0.1	0.1	< 0.1	0.3	0.1	0.1	-
Benzo(b)fluoranthene	< 0.1	0.2	0.1	0.3	0.1	0.1	-
Benzo(k)fluoranthene	< 0.1	0.1	< 0.1	0.1	0.1	< 0.1	-
Benzo(a)pyrene	0.1	0.1	0.1	0.1	< 0.1	< 0.1	-
Indeno(1,2,3-cd)pyrene	< 0.1	0.2	0.1	0.2	0.1	< 0.1	-
Benzo(ghi)perylene	< 0.1	0.1	< 0.1	0.2	0.1	< 0.1	-
Dibenzo(a,h)anthracene	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	-
Total US EPA 16	**3.1**	**4.4**	**3.6**	**4.5**	**3.9**	**3.9**	-

Notes:
Concentrations expressed as ng/L of water
PAH = Polycyclic aromatic hydrocarbon
OSPAR = Oslo and Paris Convention
ERL = Effects range low
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbon pollutants

Key:	Below ERL	Above Chronic Value

E.3.2.2 Total 2 to 6 Ring PAHs

PAH [ng/L]	EBSHHW01 (Surface)	EBSHHW01 (Mid)	EBSHHW01 (Bottom)	EBSHHW02 (Surface)	EBSHHW02 (Mid)	EBSHHW02 (Bottom)	EBSHHW03 (Surface)	EBSHHW03 (Mid)	EBSHHW03 (Bottom)	EBSHHW04 (Surface)	EBSHHW04 (Mid)	EBSHHW04 (Bottom)	EBSHHW05 (Surface)	EBSHHW05 (Mid)	EBSHHW05 (Bottom)	EBSHHW06 (Surface)	EBSHHW06 (Mid)	EBSHHW06 (Bottom)	EBSHHW07 (Surface)	EBSHHW07 (Mid)	EBSHHW07 (Bottom)	EBSHHW08 (Surface)	EBSHHW08 (Mid)	EBSHHW08 (Bottom)
Naphthalene (128)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1
C_1 128	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
C_2 128	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1
C_3 128	2	3	3	3	2	3	3	3	3	3	3	3	3	3	5	3	3	2	3	4	3	3	2	3
C_4 128	2	2	2	1	1	1	2	2	2	2	2	2	2	2	4	2	2	2	3	2	2	2	2	2
TOTAL 128	**7**	**8**	**8**	**7**	**6**	**7**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**17**	**8**	**8**	**7**	**9**	**9**	**8**	**8**	**7**	**8**
Phenanthrene/Anthracene (178)	1	< 1	1	1	< 1	1	1	< 1	1	1	< 1	1	< 1	1	4	1	1	1	1	1	1	1	1	1
C_1 178	1	1	1	1	1	< 1	1	< 1	< 1	1	1	< 1	< 1	1	2	1	1	< 1	1	1	1	1	< 1	< 1
C_2 178	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	2	1	1	1	1
C_3 178	2	2	2	3	2	2	2	2	2	2	2	2	2	2	9	2	2	2	3	4	2	2	2	2
TOTAL 178	**5**	**4**	**5**	**6**	**4**	**4**	**5**	**3**	**4**	**5**	**4**	**4**	**3**	**5**	**18**	**5**	**5**	**4**	**6**	**8**	**5**	**5**	**4**	**4**
Dibenzothiophene (DBT)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 184	1	1	1	1	< 1	1	1	1	< 1	< 1	< 1	1	< 1	1	1	< 1	1	1	1	1	< 1	< 1	1	1
C_3 184	< 1	< 1	1	1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	1	1	1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1
TOTAL 184	**1**	**1**	**2**	**2**	**< 1**	**1**	**2**	**1**	**< 1**	**< 1**	**< 1**	**1**	**1**	**2**	**3**	**< 1**	**1**	**1**	**1**	**2**	**< 1**	**< 1**	**1**	**1**
Fluoranthene/Pyrene (202)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 202	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1
C_2 202	1	1	< 1	1	< 1	< 1	1	< 1	< 1	< 1	< 1	1	1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1
C_3 202	2	1	1	2	1	2	2	2	1	2	1	1	1	2	2	1	2	1	2	2	1	1	1	1
TOTAL 202	**3**	**3**	**1**	**3**	**1**	**2**	**3**	**2**	**1**	**2**	**1**	**2**	**2**	**2**	**6**	**1**	**2**	**1**	**2**	**2**	**1**	**3**	**1**	**1**
Benzanthracenes/Benzphenanthrenes (228)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1
C_1 228	1	1	< 1	< 1	1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1
C_2 228	2	3	1	3	2	1	2	2	2	2	2	2	3	2	3	2	2	2	3	2	2	2	1	1
TOTAL 228	**4**	**5**	**2**	**4**	**4**	**2**	**3**	**3**	**3**	**4**	**3**	**3**	**4**	**3**	**7**	**3**	**3**	**3**	**4**	**3**	**3**	**4**	**2**	**2**
m/z 252*	2	2	2	2	1	1	2	2	2	2	2	2	2	1	5	2	1	2	2	2	1	2	1	1
C_1 252	4	5	3	2	3	3	2	3	2	4	2	3	4	2	8	3	2	2	2	3	3	2	2	2
C_2 252	6	10	6	6	5	4	6	5	5	6	5	7	7	4	20	9	4	5	5	7	6	5	5	6
TOTAL 252	**12**	**17**	**11**	**10**	**9**	**8**	**10**	**10**	**9**	**12**	**9**	**12**	**13**	**7**	**33**	**14**	**7**	**9**	**9**	**12**	**10**	**9**	**8**	**9**
m/z 276†	2	2	2	1	1	1	2	2	1	2	1	2	2	1	3	2	1	2	2	2	1	2	2	1
C_1 276	2	3	2	1	2	2	2	1	1	2	1	3	2	2	4	2	2	2	1	3	3	2	1	2
C_2 276	2	4	2	2	2	3	3	3	2	4	2	4	4	2	5	4	2	3	2	2	3	3	2	3
TOTAL 276	**6**	**9**	**6**	**4**	**5**	**6**	**7**	**6**	**4**	**8**	**4**	**9**	**8**	**5**	**12**	**8**	**5**	**7**	**5**	**7**	**7**	**7**	**5**	**6**
NPD013‡	**13**	**13**	**15**	**15**	**10**	**12**	**15**	**12**	**12**	**13**	**12**	**13**	**12**	**15**	**38**	**13**	**14**	**12**	**16**	**19**	**13**	**13**	**12**	**13**
% NPD	**34**	**28**	**43**	**42**	**34**	**40**	**39**	**36**	**41**	**33**	**41**	**33**	**31**	**47**	**40**	**33**	**45**	**38**	**44**	**44**	**38**	**36**	**43**	**42**
Total 2 to 6 Ring PAH	**38**	**47**	**35**	**36**	**29**	**30**	**38**	**33**	**29**	**39**	**29**	**39**	**39**	**32**	**96**	**39**	**31**	**32**	**36**	**43**	**34**	**36**	**28**	**31**

Notes:
PAH = Polycyclic aromatic hydrocarbon
Concentrations expressed as ng/L of water
* = m/z 252 - benzfluoranthenes/benzpyrenes/perylene
† = m/z 276 - anthanthrene/indenopyrenes/benzperylenes
‡ = NPD - naphthalenes, phenanthrenes and dibenzothiophenes (totals)

E.4 DISTRIBUTION OF AROMATIC HYDROCARBONS

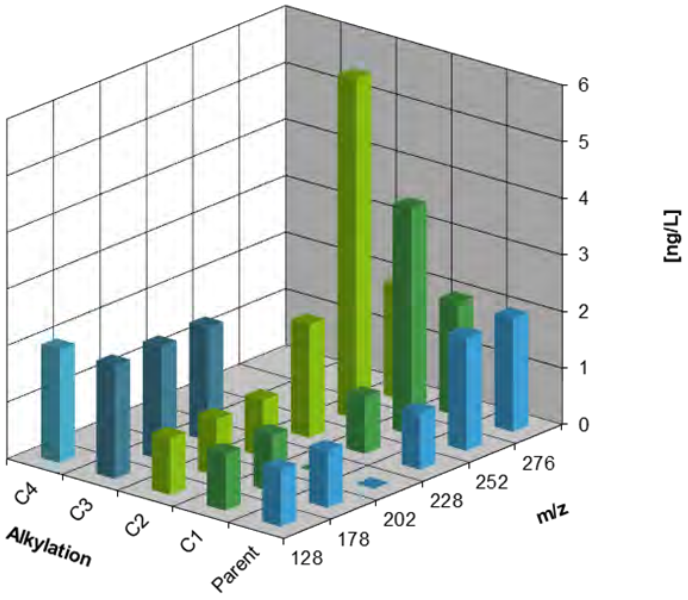
The layout of the three-dimensional plots are as follows:

- Naphthalenes (molecular mass 128, 142, 156, 170, 184);
- Phenanthrenes/anthracenes (molecular mass 178, 192, 206, 220);
- Fluoranthenes/pyrenes (molecular mass 202, 216, 230, 244);
- Chrysene/benzanthracenes (molecular mass 228, 242, 256);
- Benzfluoranthenes/benzpyrenes/perylenes (molecular mass 252, 266, 280);
- Anthanthrenes/indenopyrenes/benzoperylenes (molecular mass 276, 290, 304).

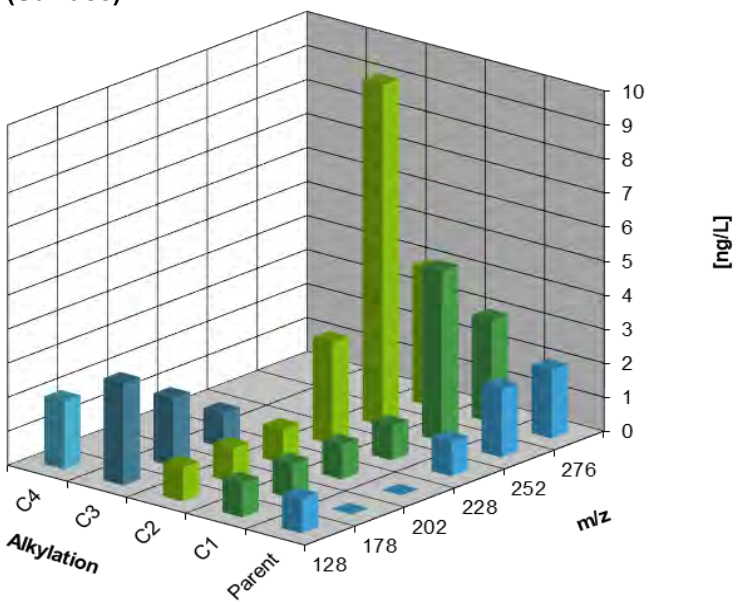
E.4.1 Sediment

Concentrations of aromatic hydrocarbons in sediments were too low, hence three-dimensional plots are not presented.

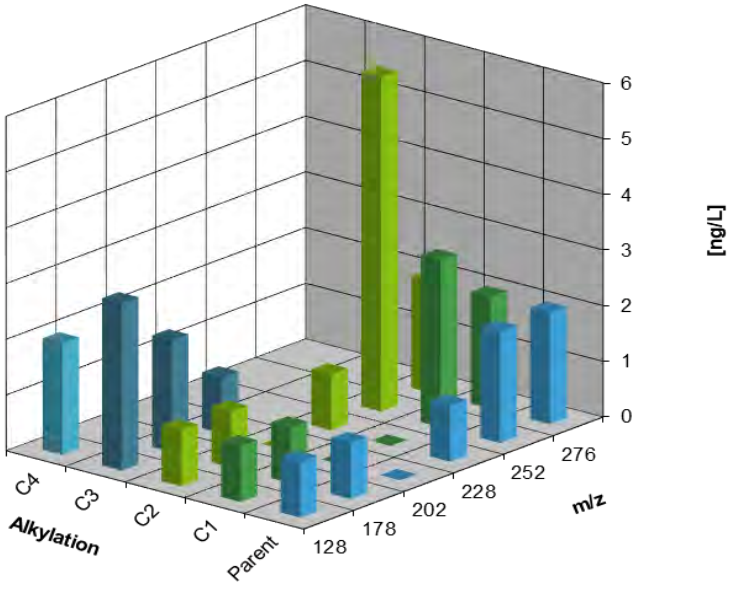
E.4.2 Water Samples



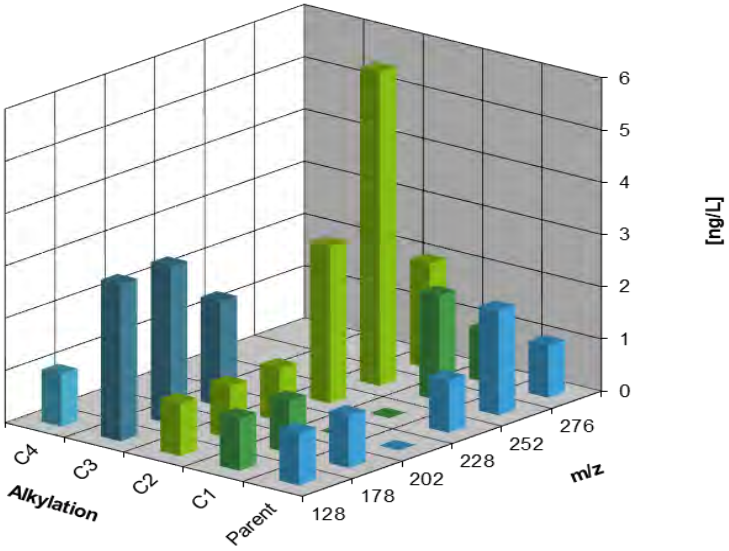
Station EBSHHW_01 (Surface)



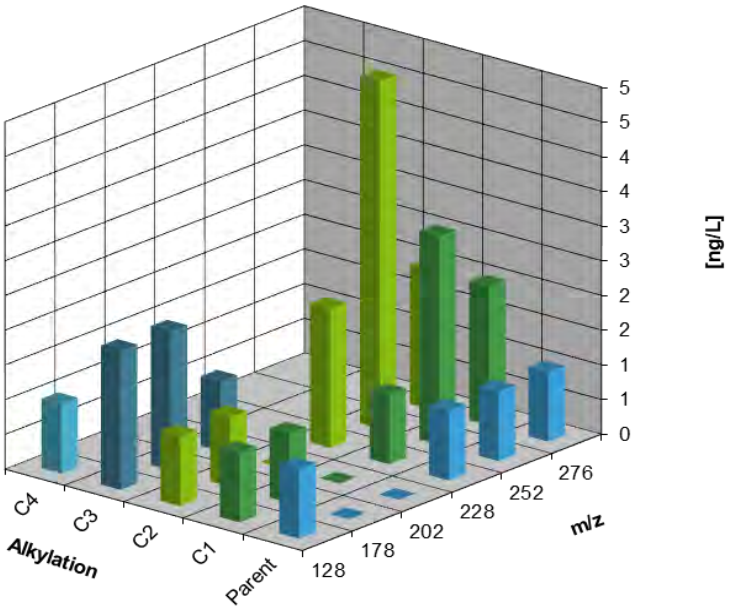
Station EBSHHW_01 (Mid)



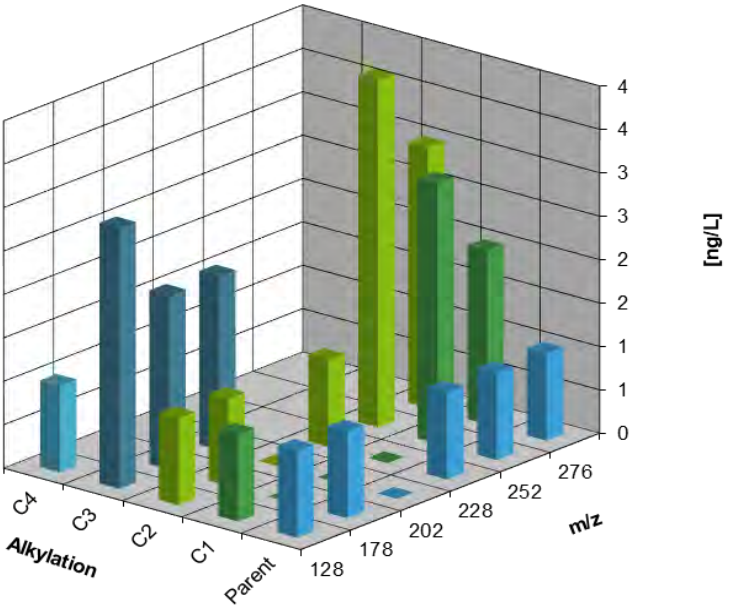
Station EBSHHW_01 (Bottom)



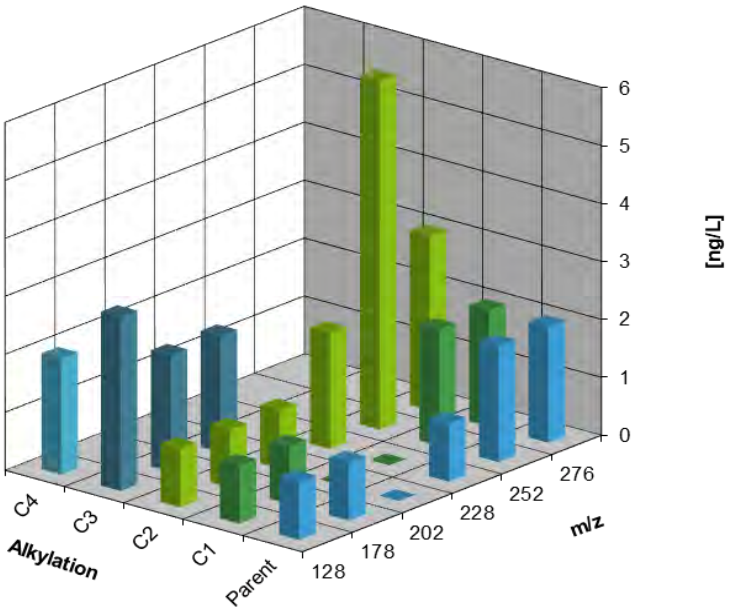
Station EBSHHW_02 (Surface)



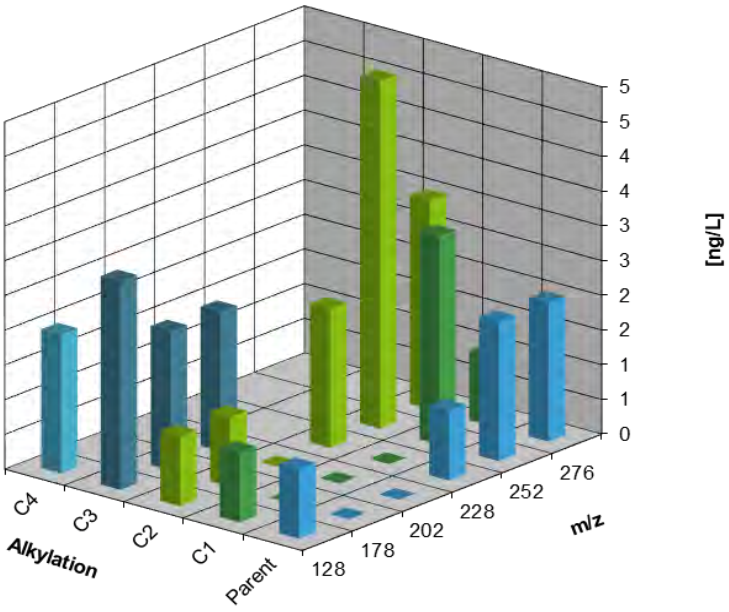
Station EBSHHW_02 (Mid)



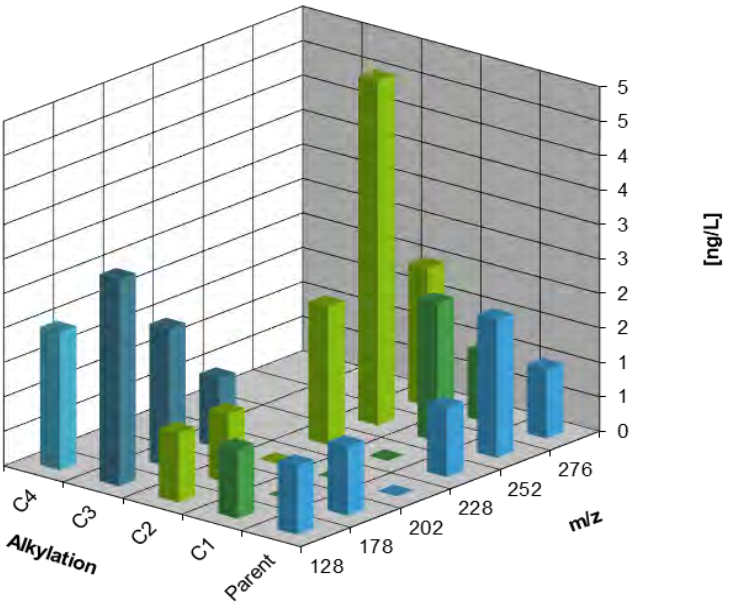
Station EBSHHW_02 (Bottom)



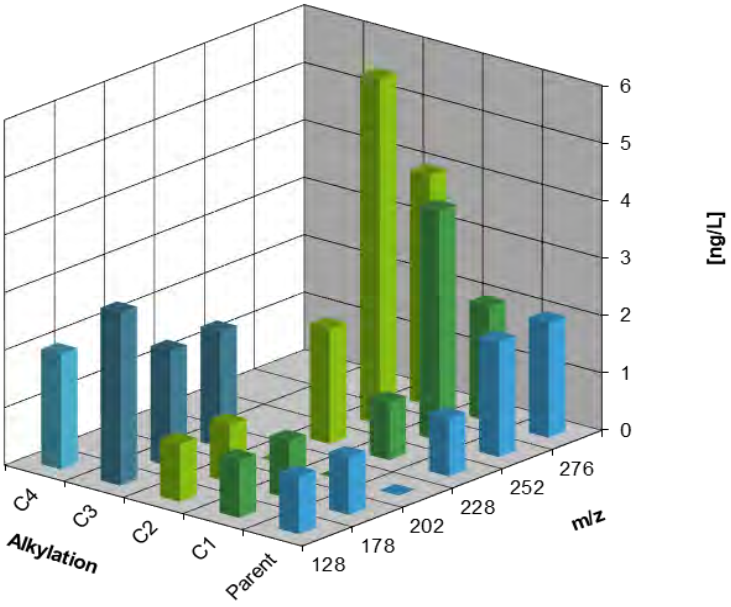
Station EBSHHW_03 (Surface)



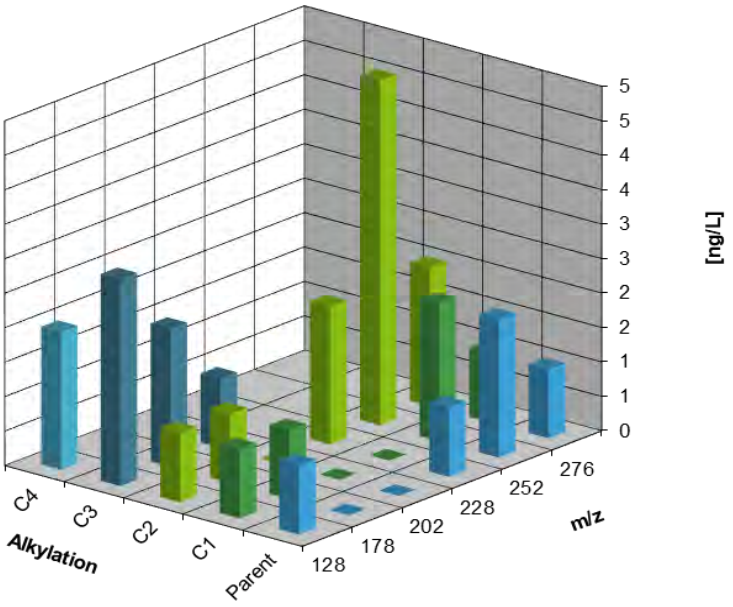
Station EBSHHW_03 (Mid)



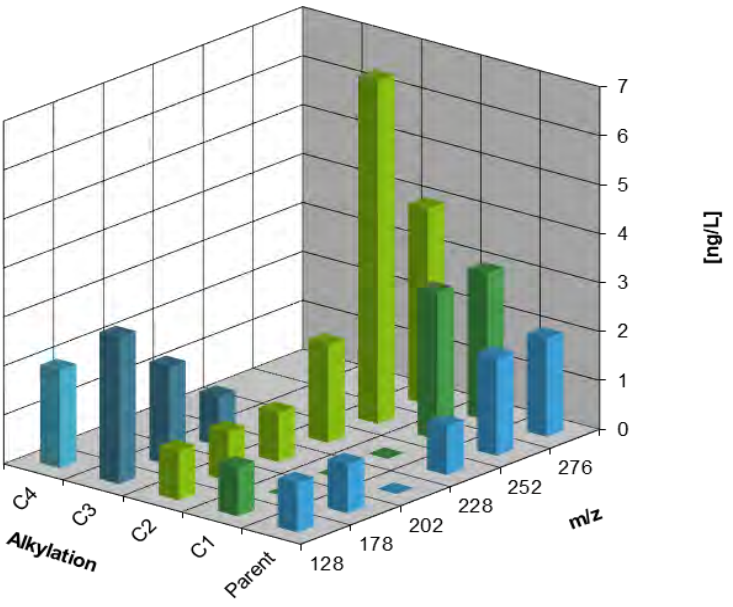
Station EBSHHW_03 (Bottom)



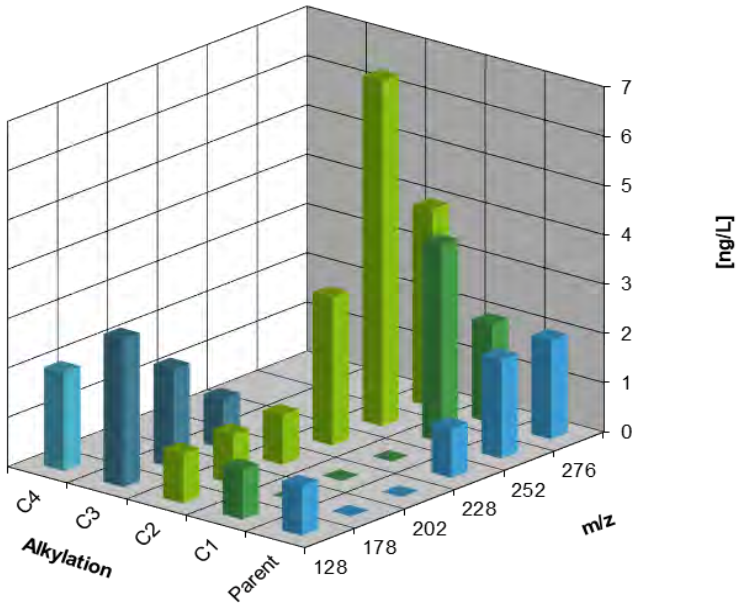
Station EBSHHW_04 (Surface)



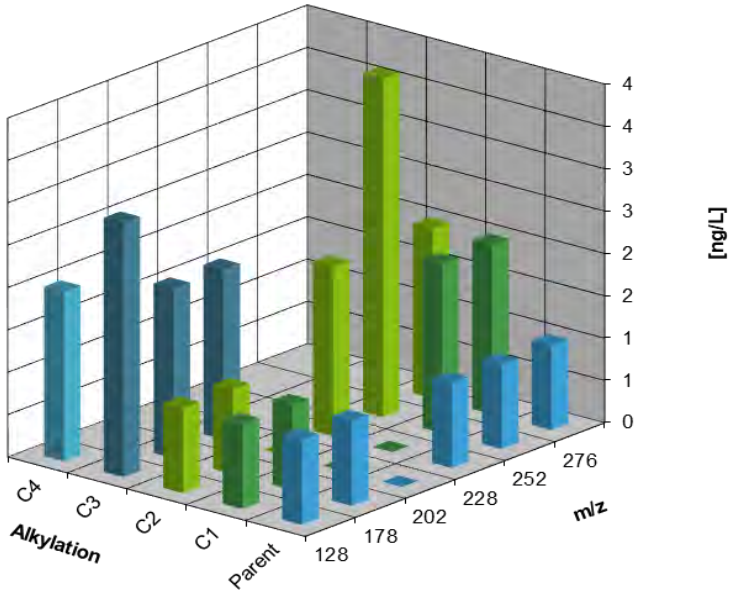
Station EBSHHW_04 (Mid)



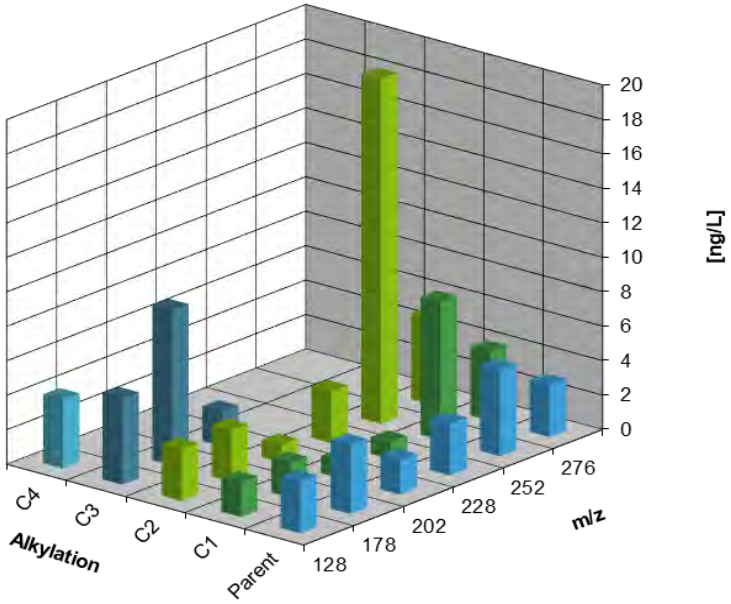
Station EBSHHW_04 (Bottom)



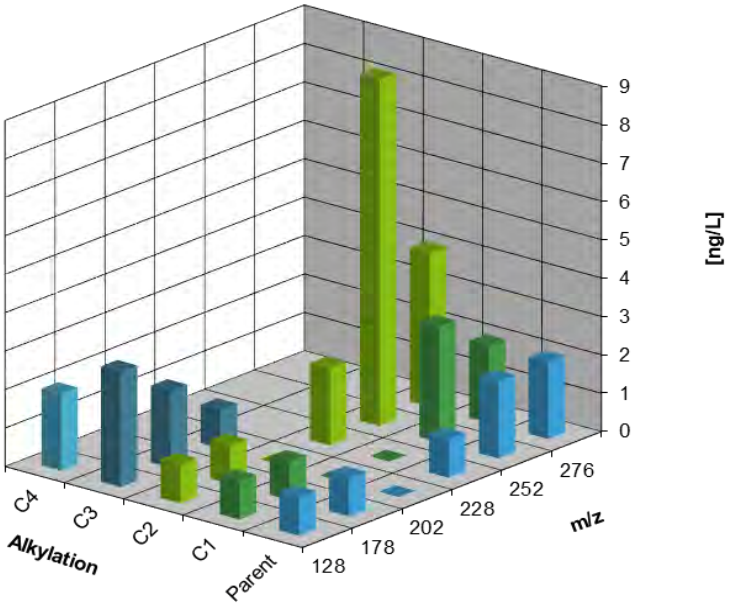
Station EBSHHW_05 (Surface)



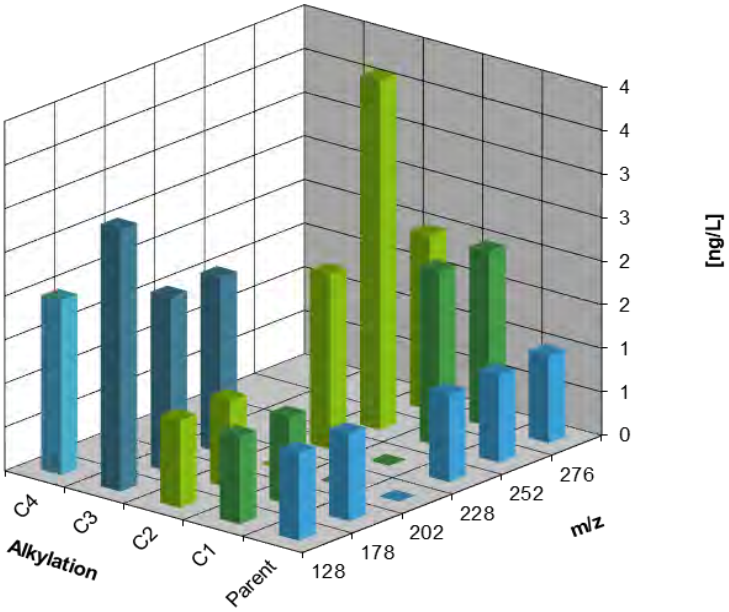
Station EBSHHW_05 (Mid)



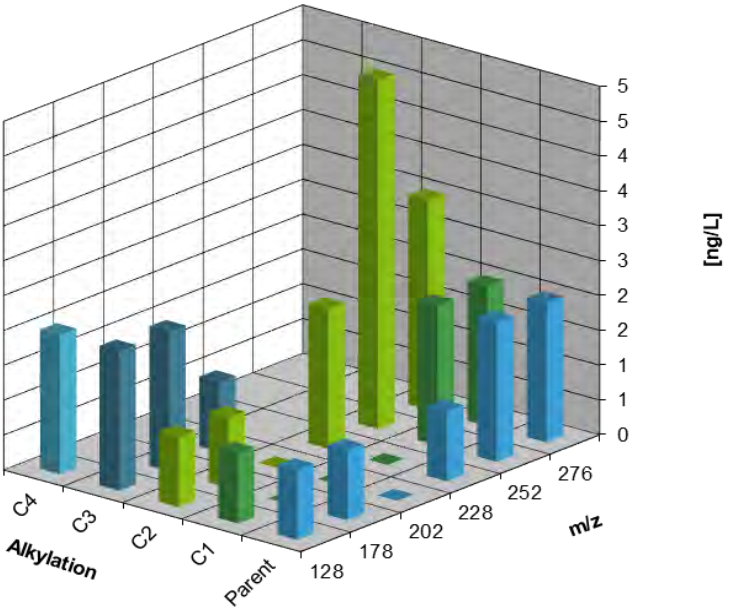
Station EBSHHW_05 (Bottom)



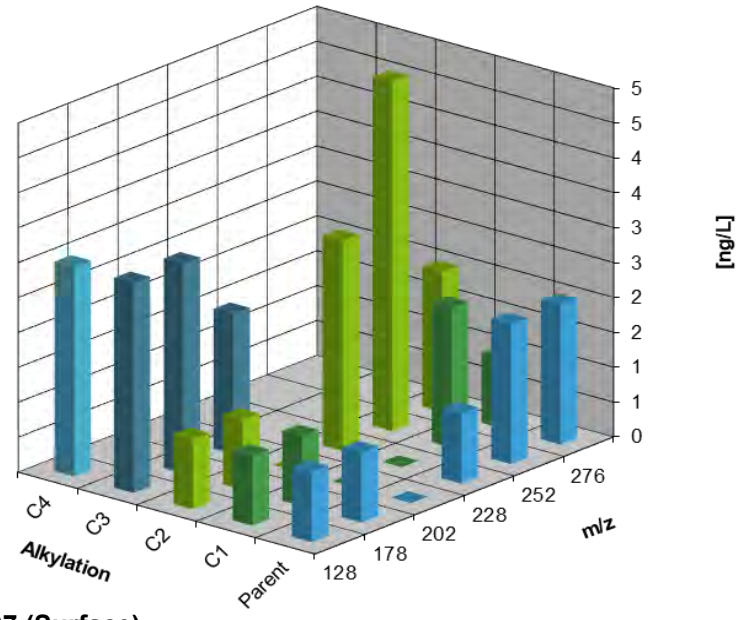
Station EBSHHW_06 (Surface)



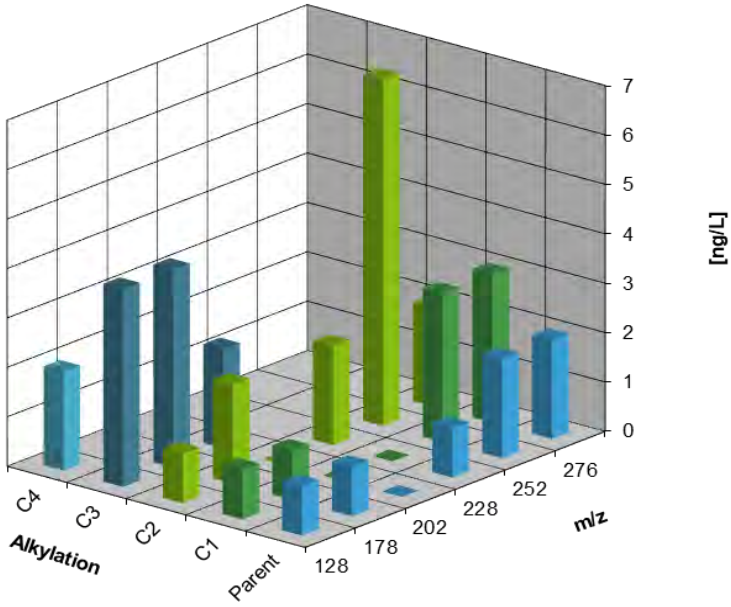
Station EBSHHW_06 (Mid)



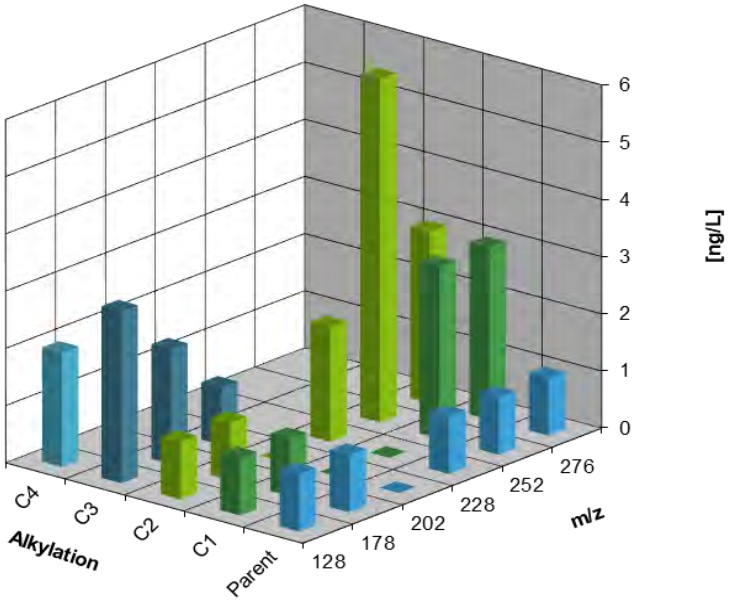
Station EBSHHW_06 (Bottom)



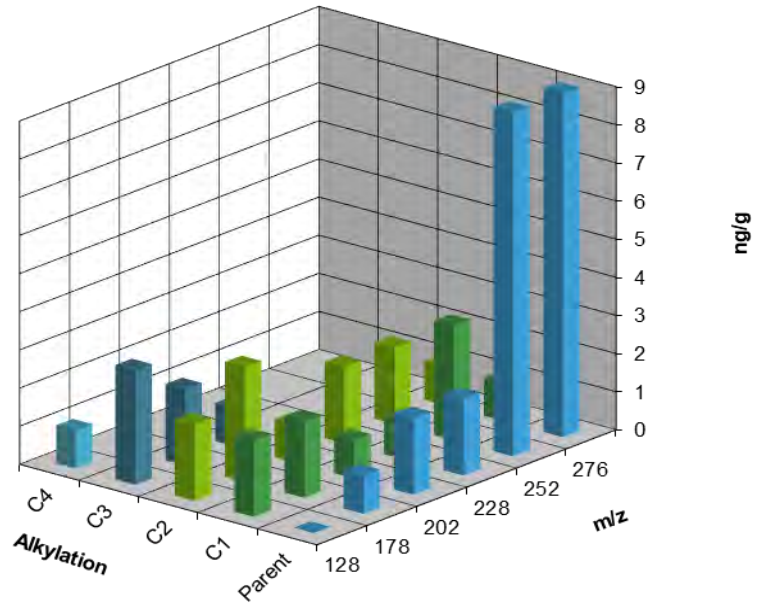
Station EBSHHW_07 (Surface)



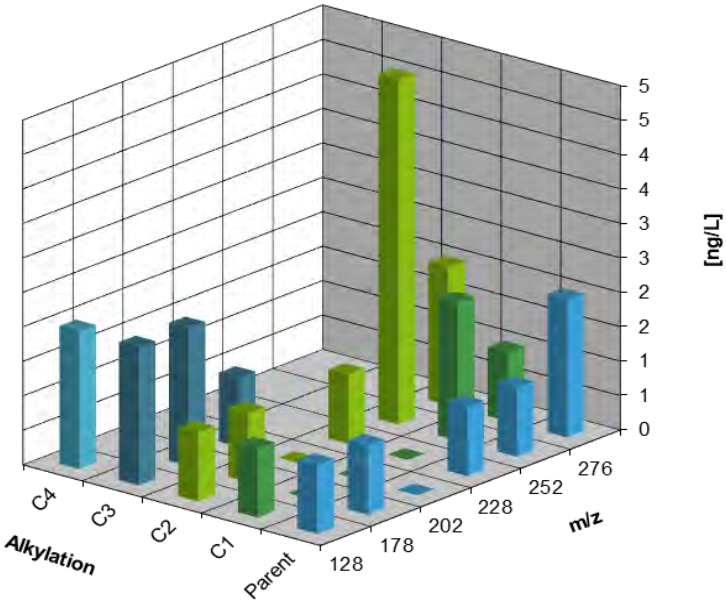
Station EBSHHW_07 (Mid)



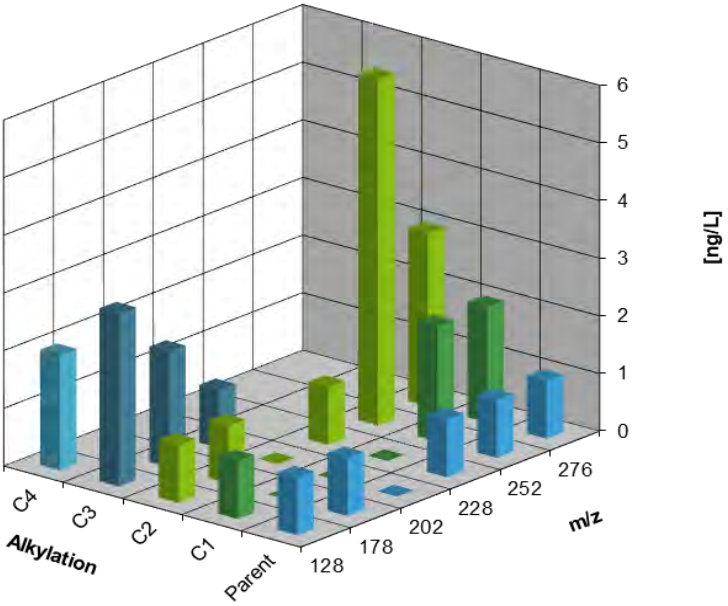
Station EBSHHW_07 (Bottom)



Station EBSHHW_08 (Surface)

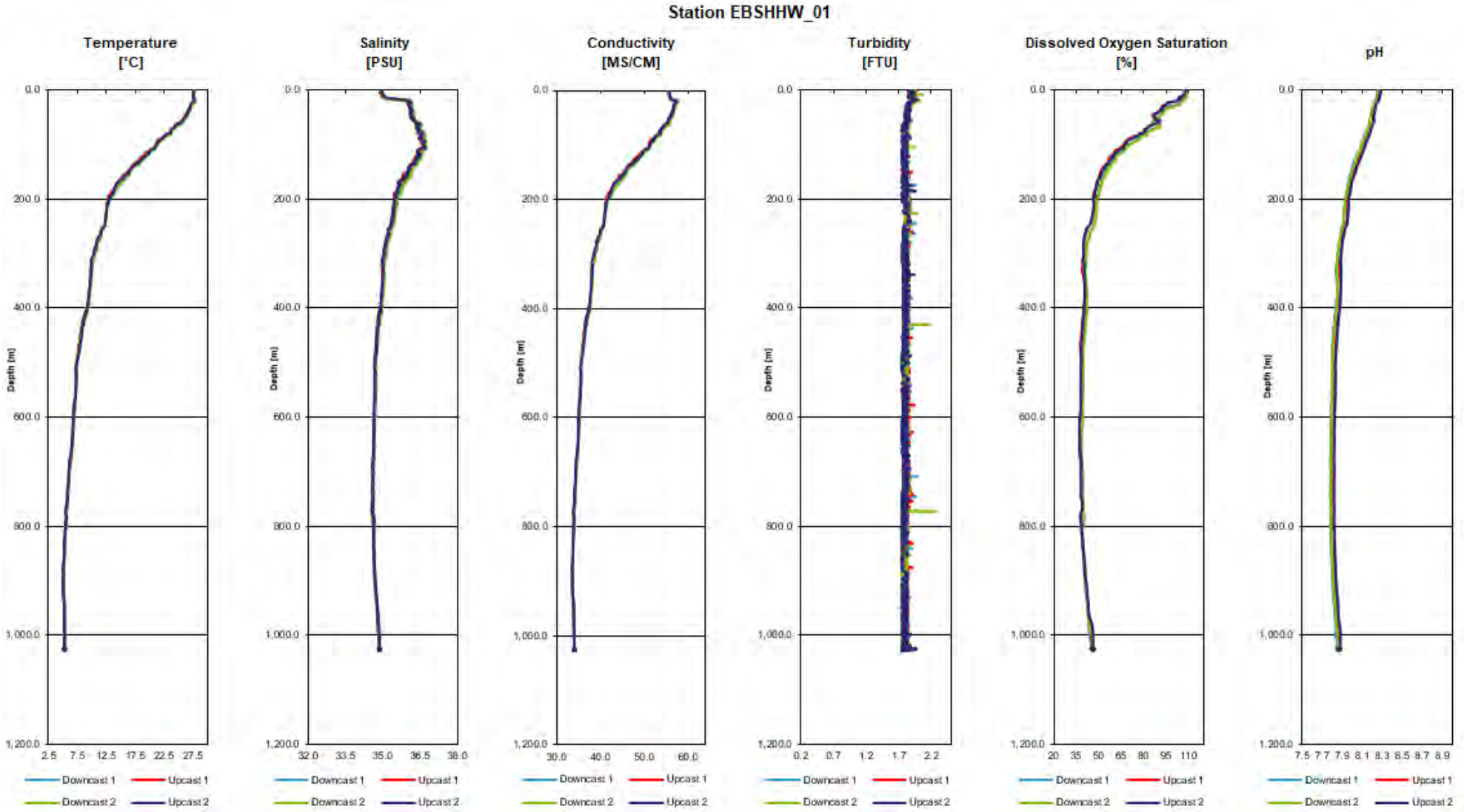


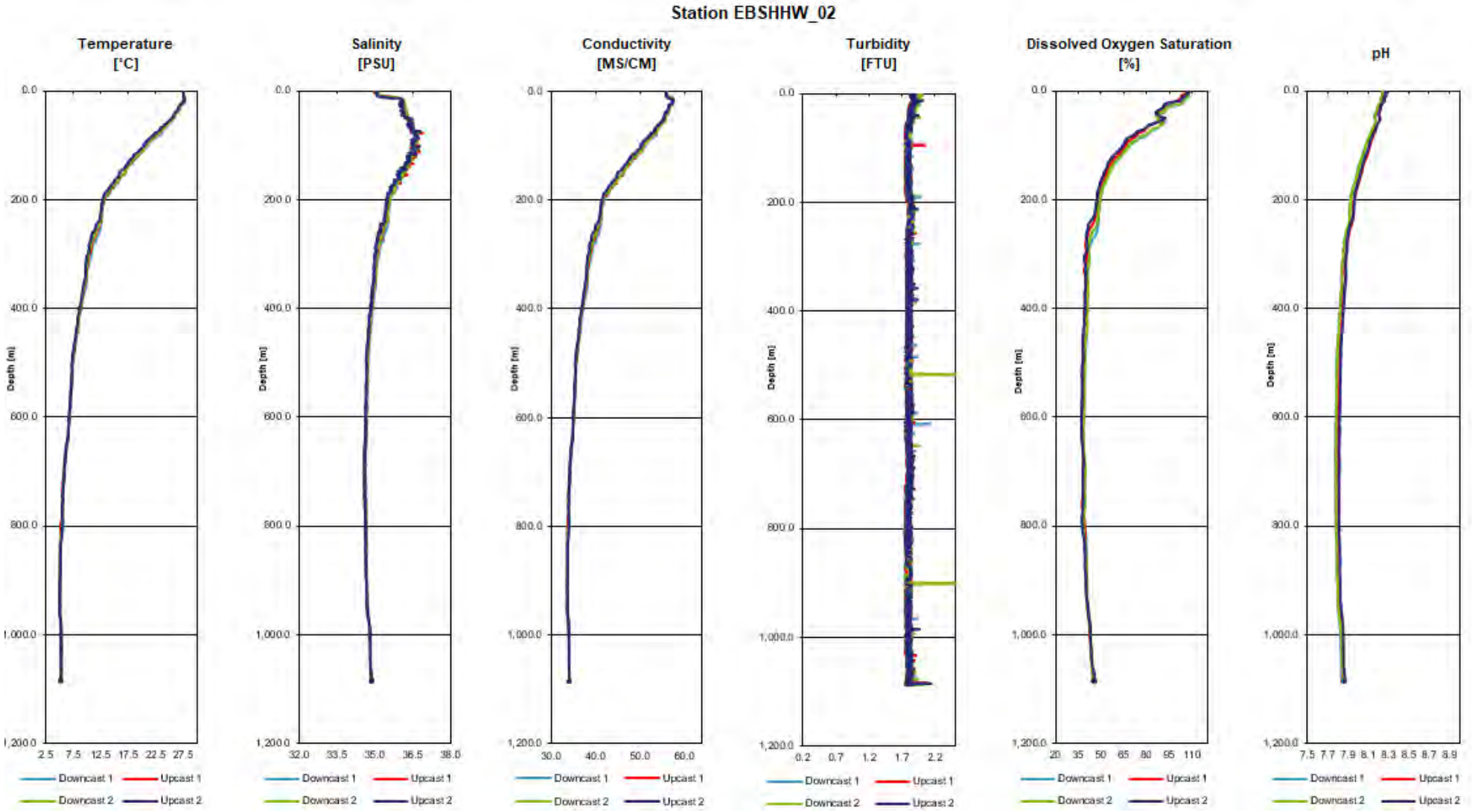
Station EBSHHW_08 (Mid)

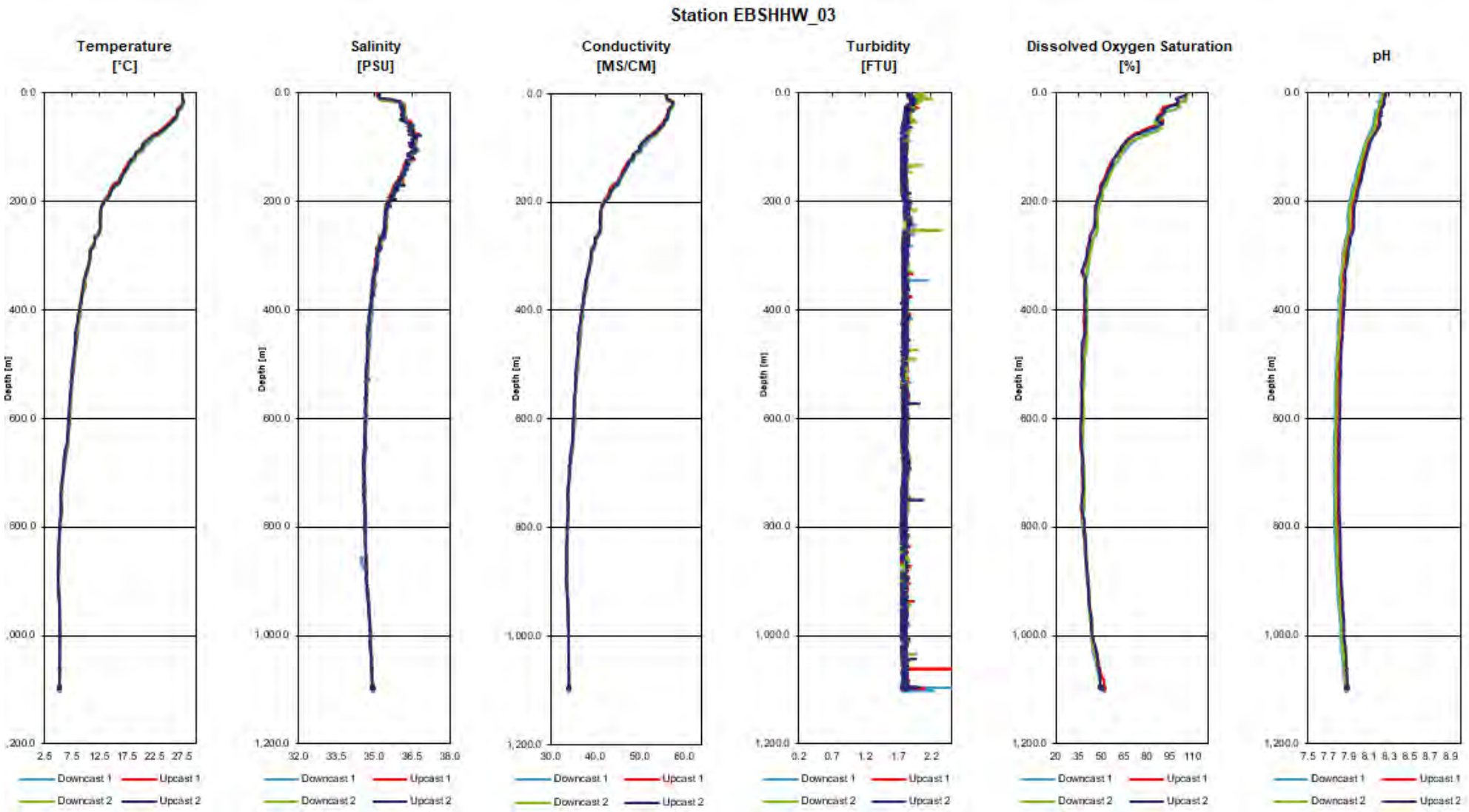


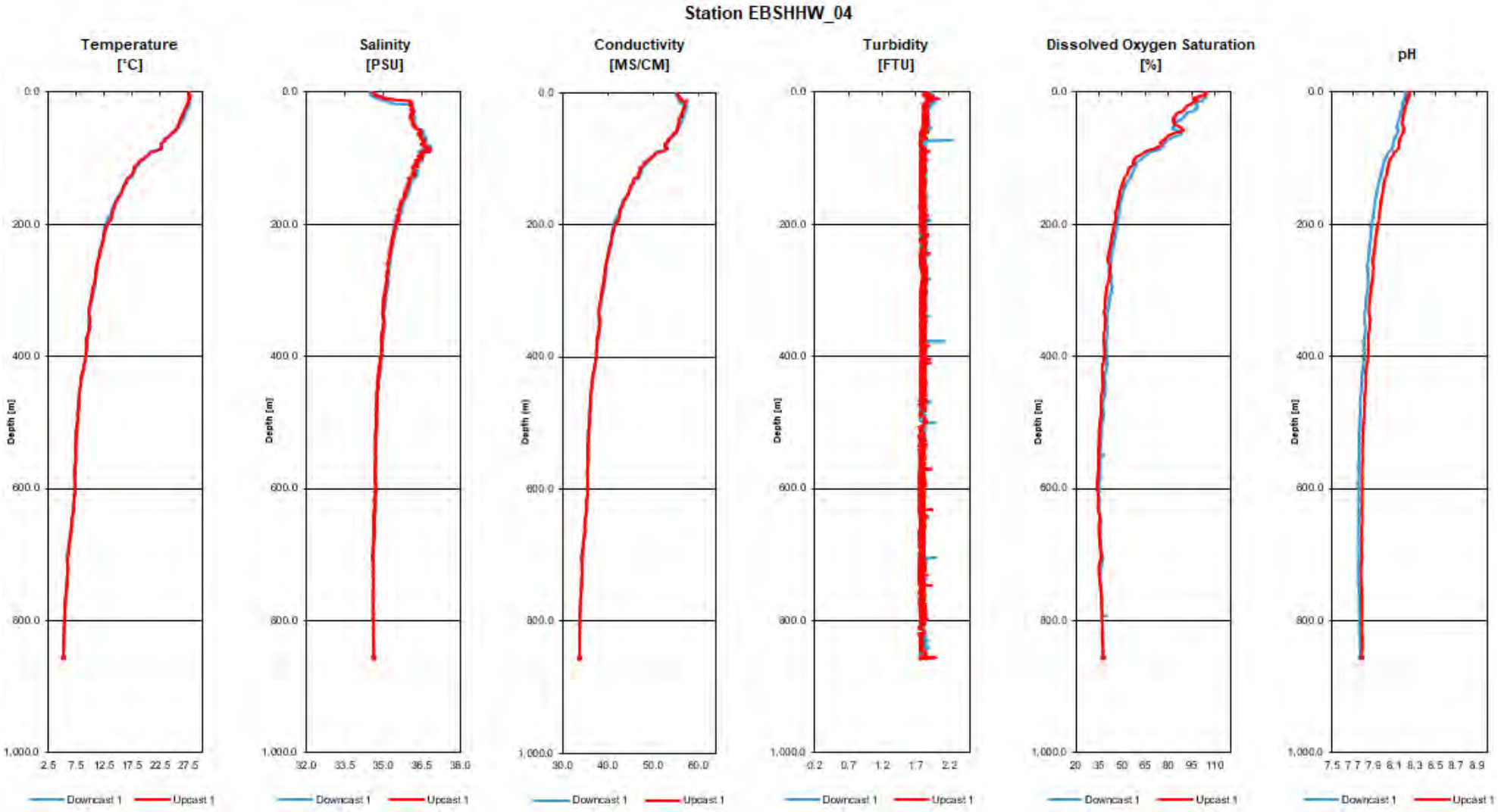
Station EBSHHW_08 (Bottom)

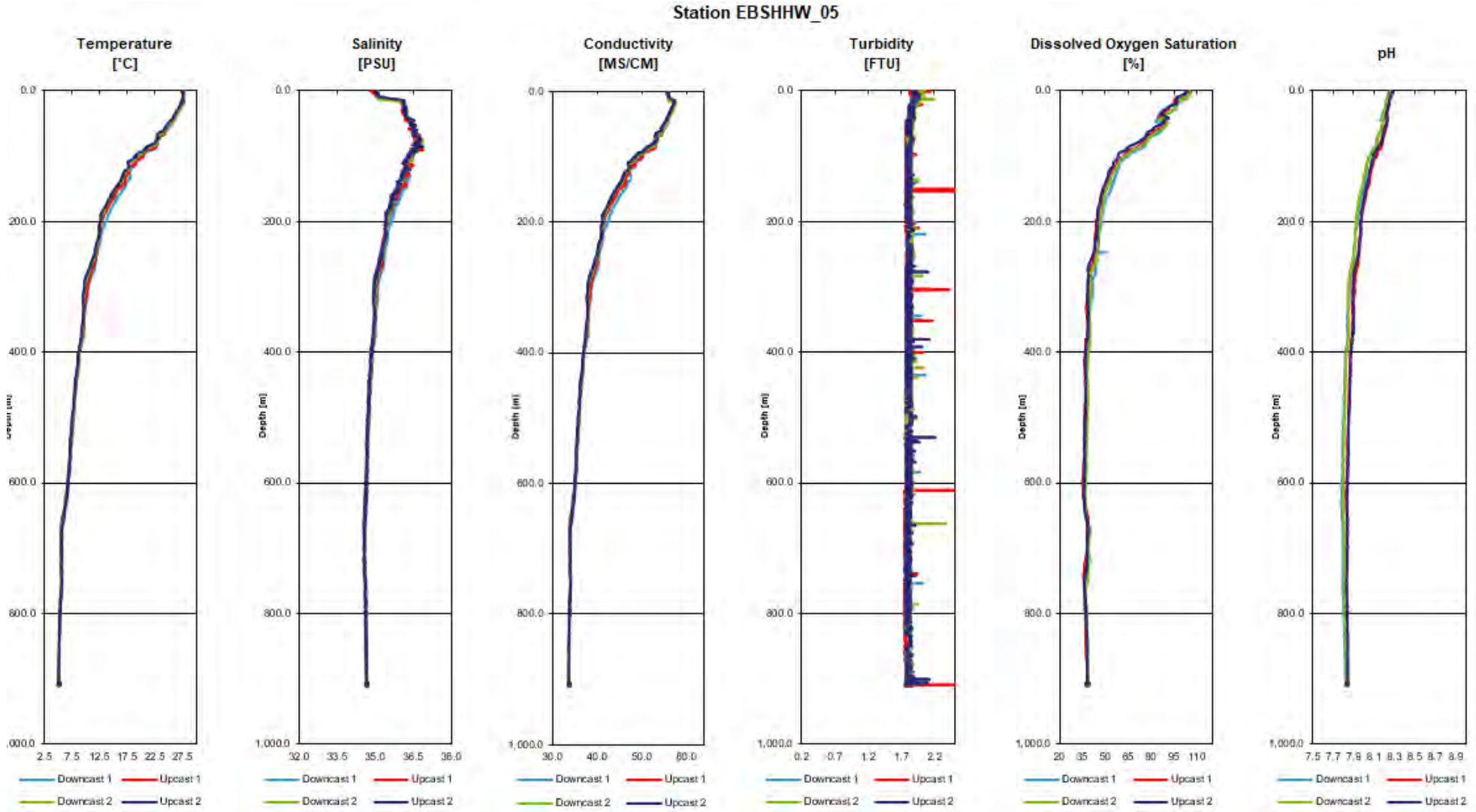
F. WATER PROFILES

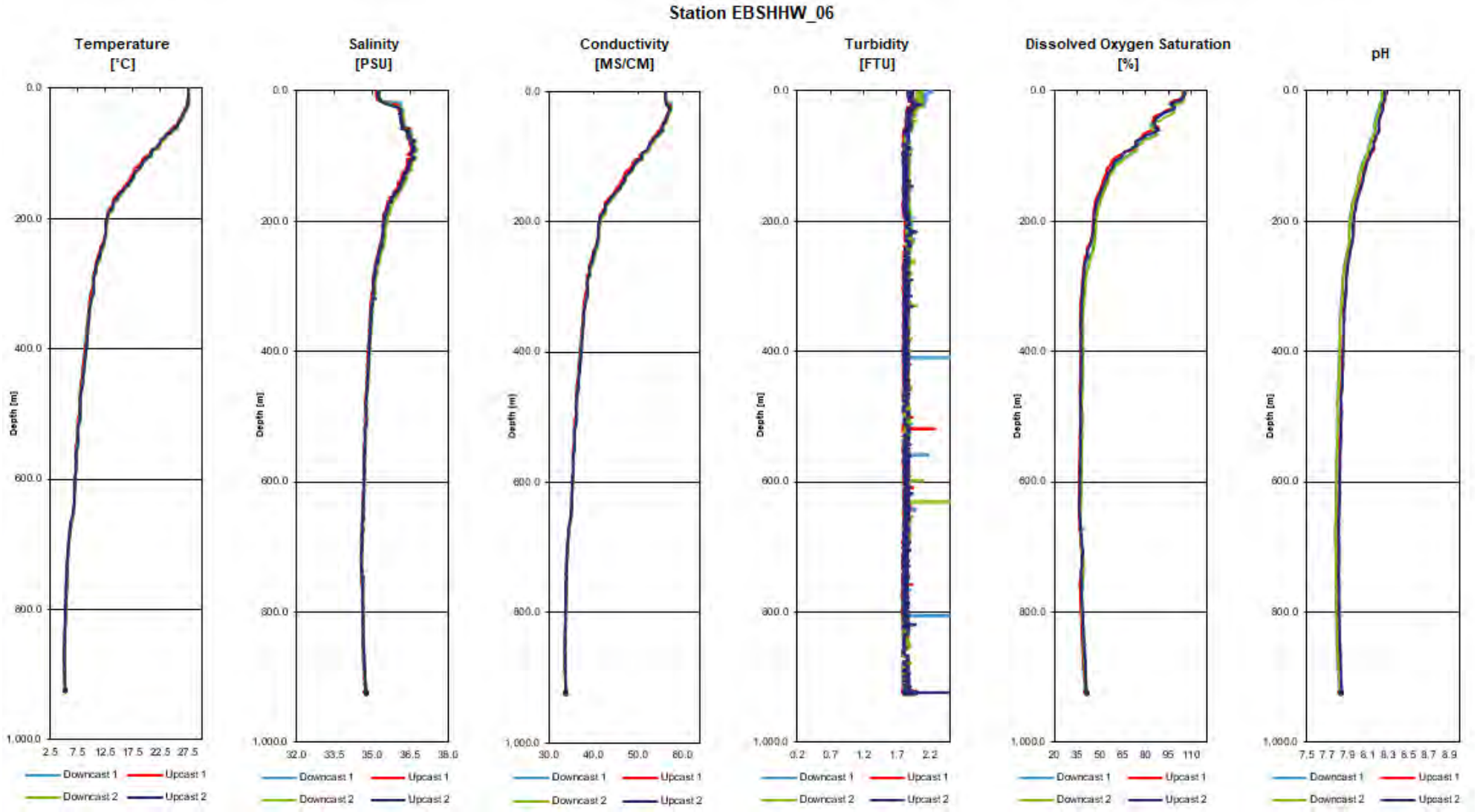


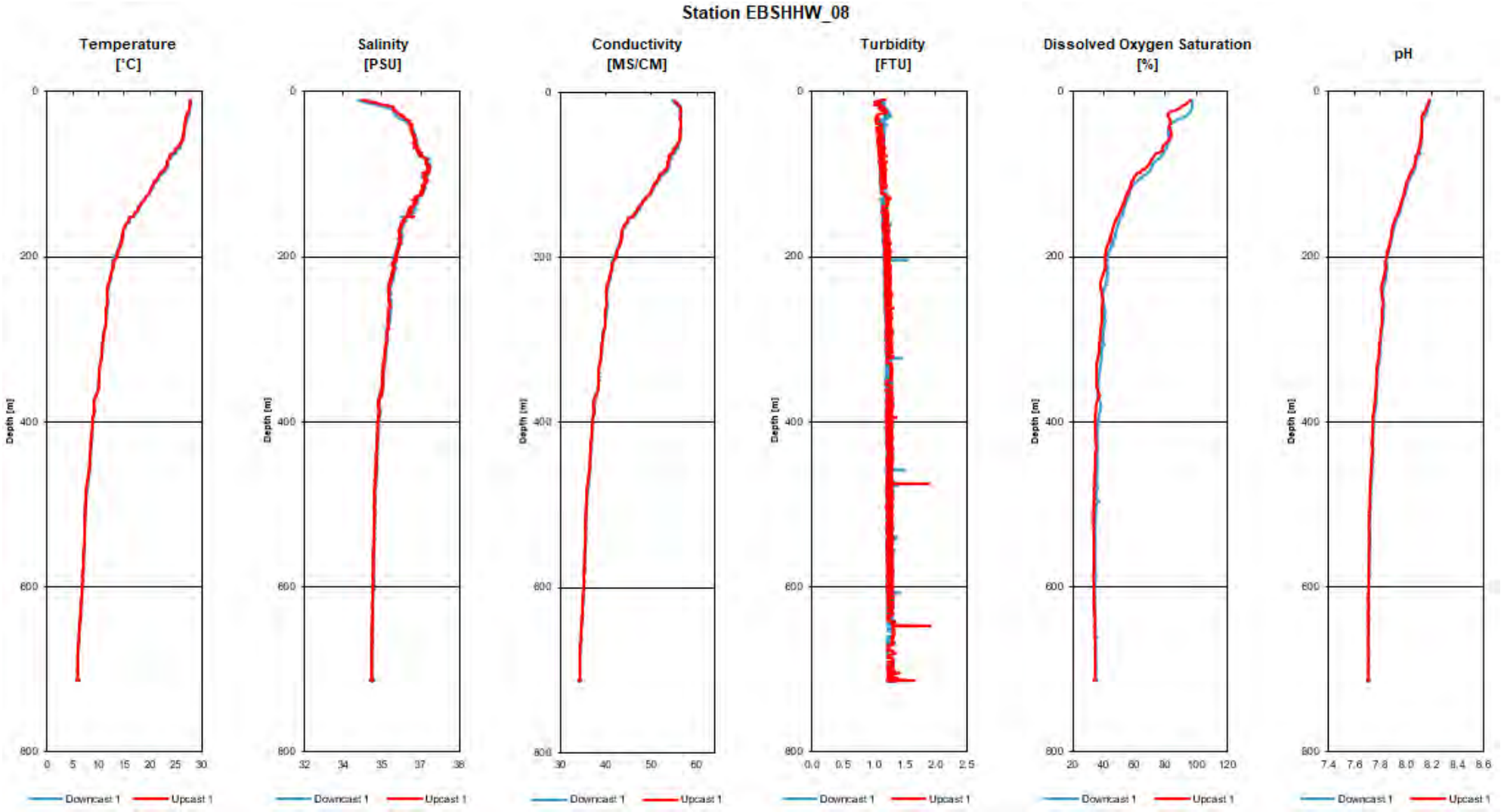

Station EBSHHW_02
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSHHW_03
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSHHW_04
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
-0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1


Station EBSHHW_05
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSHHW_06
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSHHW_08
Temperature
[°C]
Salinity
[PSU]
Conductivity
[MS/CM]
Turbidity
[FTU]
Dissolved Oxygen Saturation
[%]
pH
Depth [m]
0
200
400
600
800
0 5 10 15 20 25 30
32 34 35 37 38
30 40 50 60
0.0 0.5 1.0 1.5 2.0 2.5
20 40 60 80 100 120
7.4 7.6 7.8 8.0 8.2 8.4 8.6
Downcast 1
Upcast 1

G. SEABED PHOTOGRAPHS

STATION EBSHHDD_01

Photograph: vlcsnap-2019-07-11-11h49min48s352.png
(Video snapshot)

Easting: 483 858.5 mE
Northing: 880 794.9 mN
Depth: 1031 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal burrows

Photograph: vlcsnap-2019-07-11-12h20min38s479.png
(Video snapshot)

Easting: 483 882.3 mE
Northing: 880 794.9 mN
Depth: 1031 m

Sediment Type:
Mud

Fauna:
No fauna visible

STATION EBSHHDD_01a

Photograph: vlcsnap-2019-07-11-13h06min15s905.png
(Video snapshot)

Easting: 483 857.3 mE
Northing: 880 796.7 mN
Depth: 1032 m

Sediment Type:
Mud

Fauna:
No fauna visible

Photograph: vlcsnap-2019-07-11-13h16min55s532.png
(Video snapshot)

Easting: 483 886.0 mE
Northing: 880 801.5 mN
Depth: 1032 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal burrow

STATION EBSHHDD_01b

Photograph: vlcsnap-2019-07-11-13h33min17s929.png
(Video snapshot)

Easting: 483 886.0 mE
Northing: 880 804.5 mN
Depth: 1033 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal burrow

Photograph: vlcsnap-2019-07-11-13h36min52s757.png
(Video snapshot)

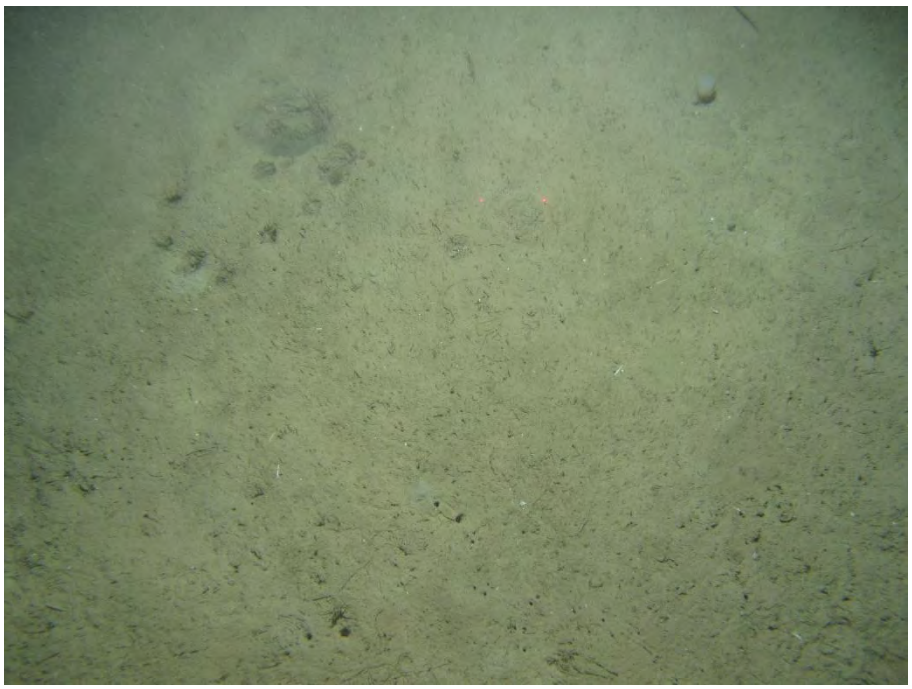
Easting: 483 865.4 mE
Northing: 880 803.3 mN
Depth: 1033 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal burrow

STATION EBSHHDD_01c



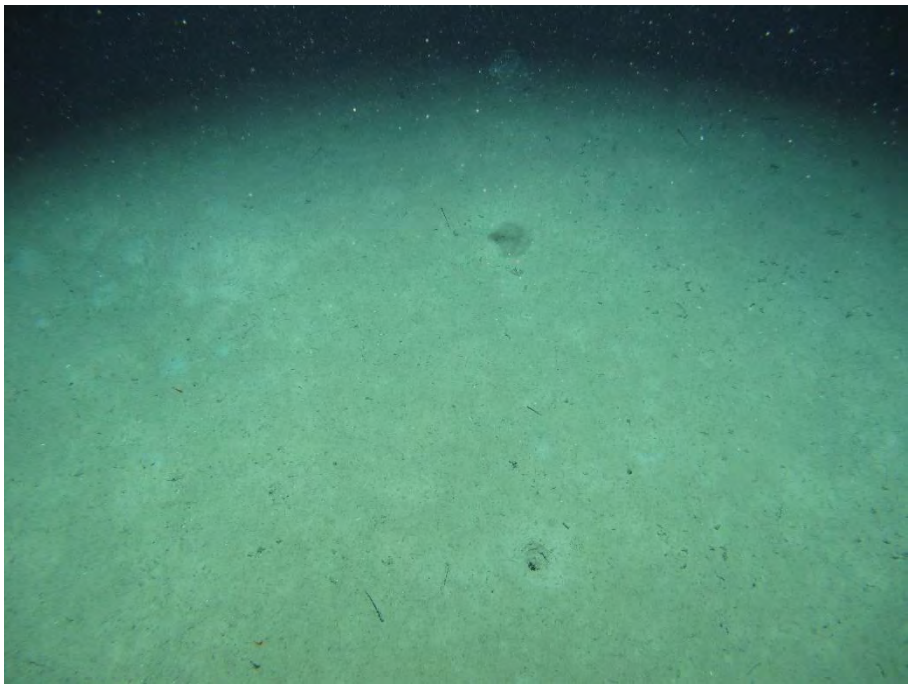
Photograph:
EBSHH01DDc_06

Easting: 483 852.8 mE
Northing: 880 802.4 mN
Depth: 1033 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal burrows and tracks



Photograph:
EBSHH01DDc_25

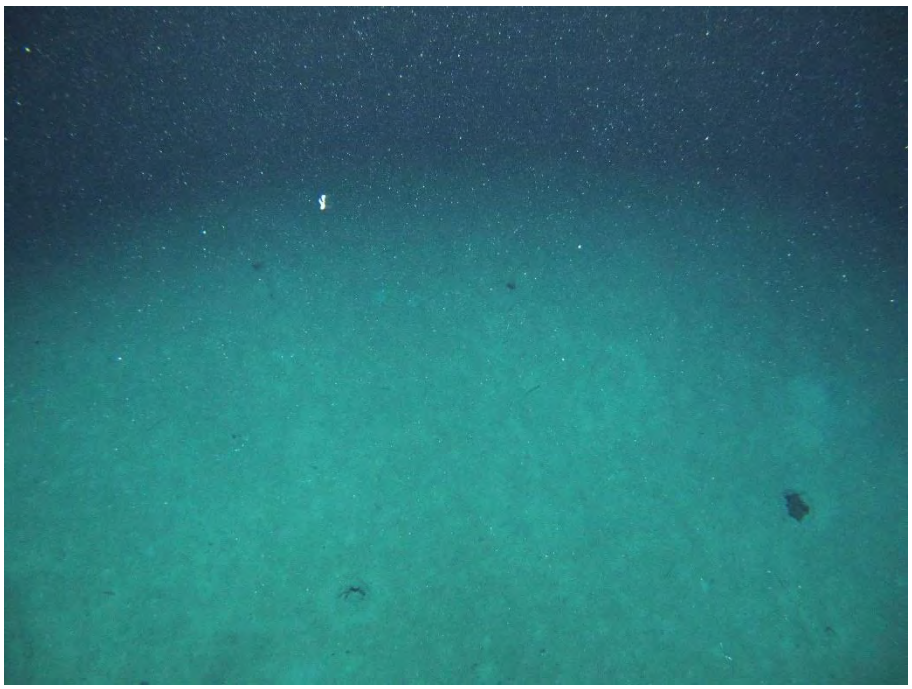
Easting: 483 928.4 mE
Northing: 880 799.8 mN
Depth: 1033 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes and burrows

STATION EBSHHDD_02



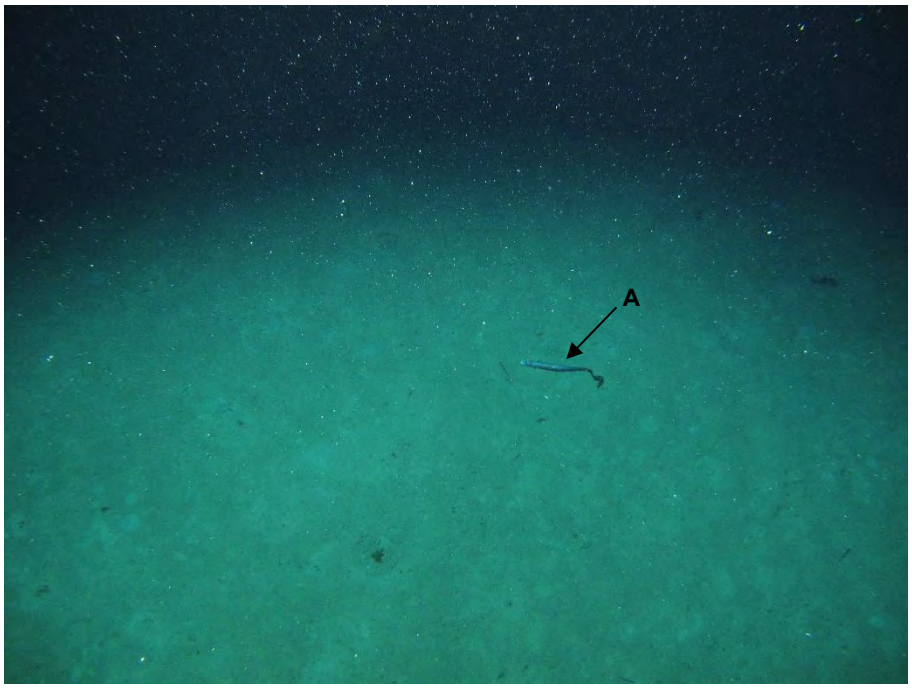
Photograph:
EBSHH02DD_03

Easting: 488 336.8 mE
Northing: 878 561.0 mN
Depth: 1094 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes and burrows



Photograph:
EBSHH02DD_18

Easting: 488 373.8 mE
Northing: 878 571.7 mN
Depth: 1094 m

Sediment Type:
Mud

Fauna:
A: Eels tail fish (Halosauridae)

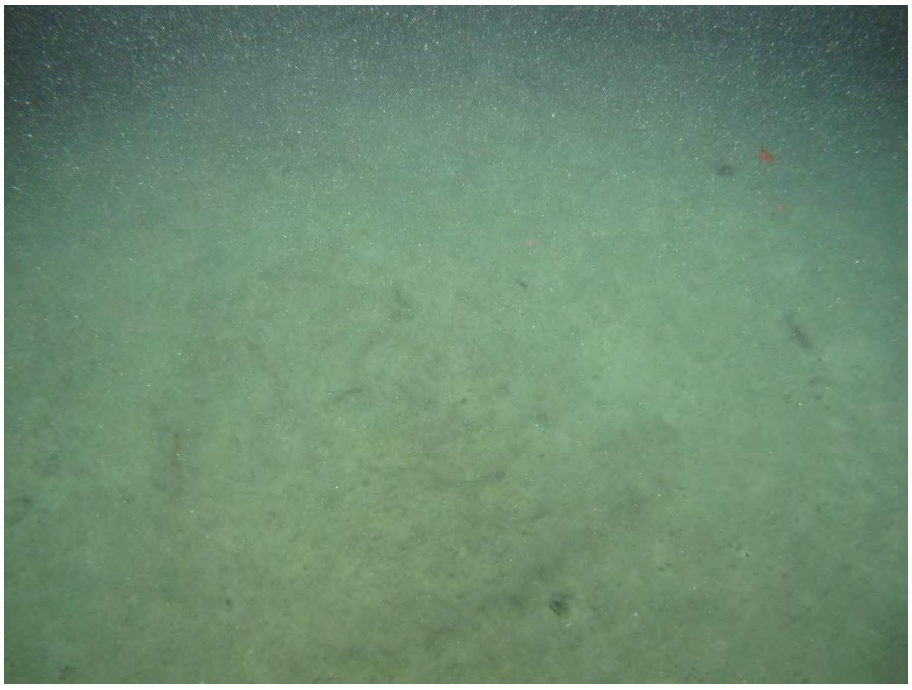
STATION EBSHHDD_03

Photograph:
EBSHH03DD_01

Easting: 492 807.0 mE
Northing: 876 327.1 mN
Depth: 1108 m

Sediment Type:
Mud

Fauna:
A: Possible buried xenophyophore (Xenophyophoroidea)



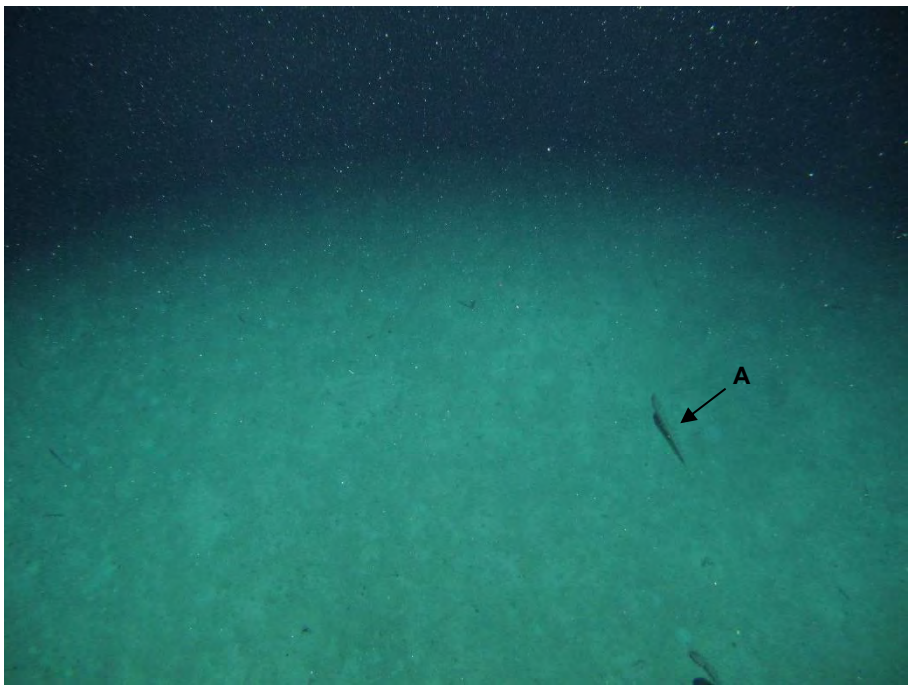
Photograph:
EBSHH03DD_07

Easting: 492 843.7 mE
Northing: 876 330.6 mN
Depth: 1108 m

Sediment Type:
Mud

Fauna:
No fauna visible

STATION EBSHHDD_03a



Photograph:
EBSHH03DDa_02

Easting: 492 785.0 mE
Northing: 876 327.3 mN
Depth: 1106 m

Sediment Type:
Mud

Fauna:
A: Small unidentified fish (Pisces)

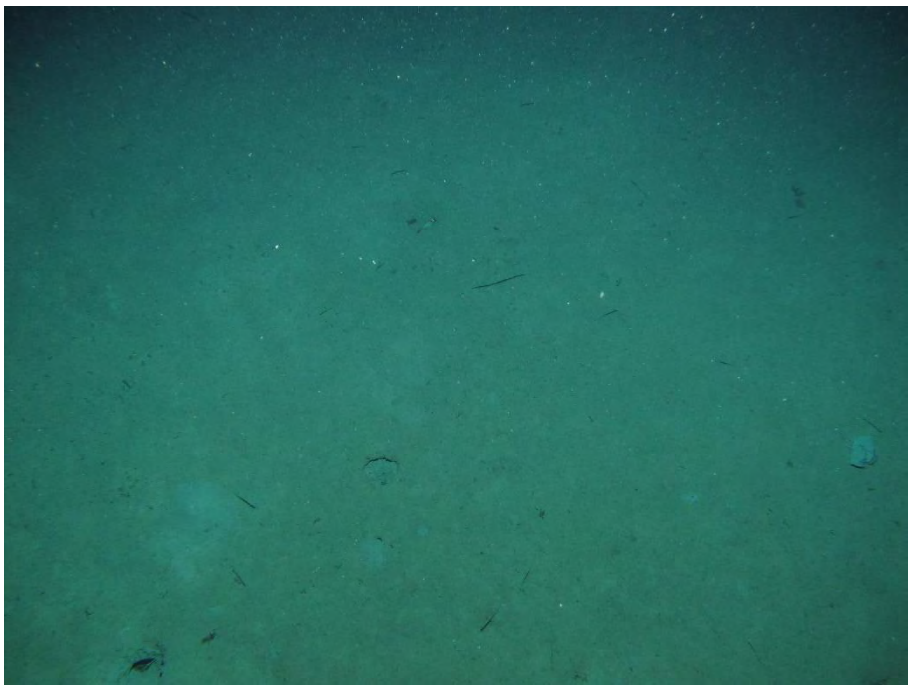
Photograph:
EBSHH03DDa_24

Easting: 492 851.5 mE
Northing: 876 319.6 mN
Depth: 1106 m

Sediment Type:
Mud

Fauna:
A: Sea pen (Pennatulacea)

STATION EBSHHDD_04



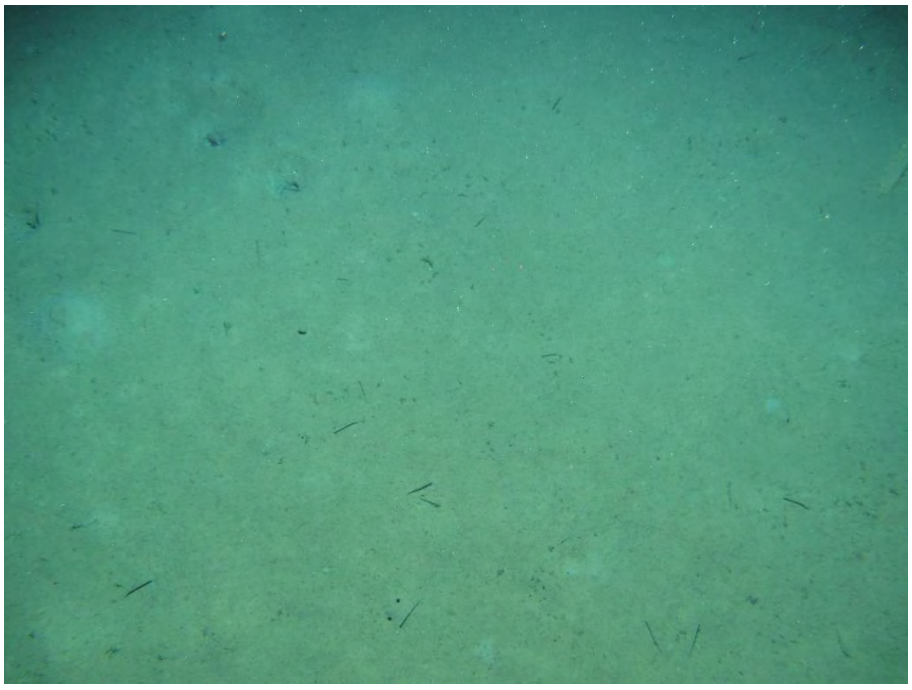
Photograph:
EBSHH04DD_05

Easting: 484 283.3 mE
Northing: 876 104.0 mN
Depth: 881 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes and burrows



Photograph:
EBSHH04DD_23

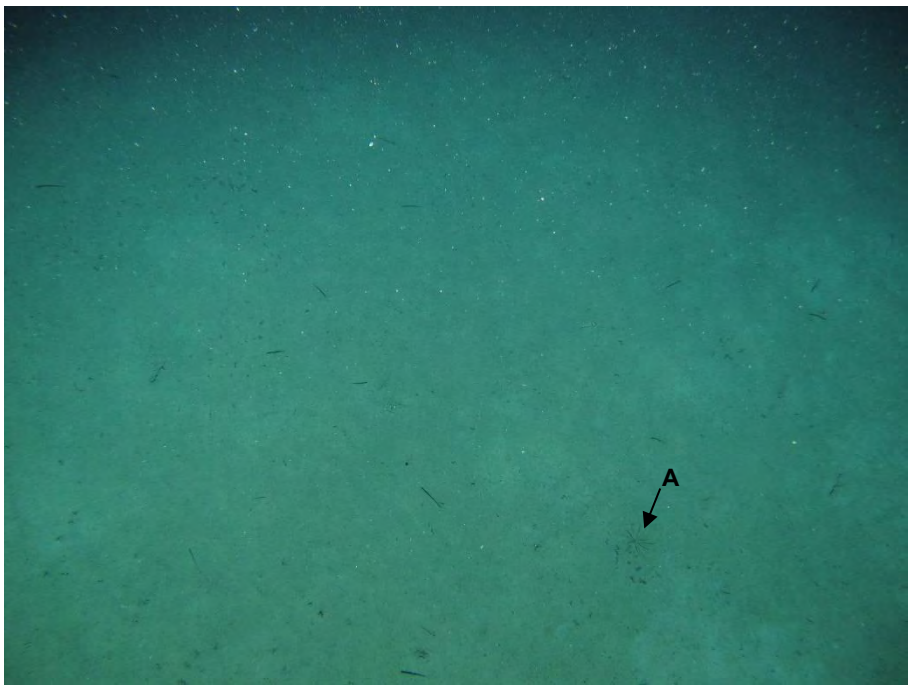
Easting: 484 350.6 mE
Northing: 876 102.6 mN
Depth: 883 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes and burrows

STATION EBSHHDD_05



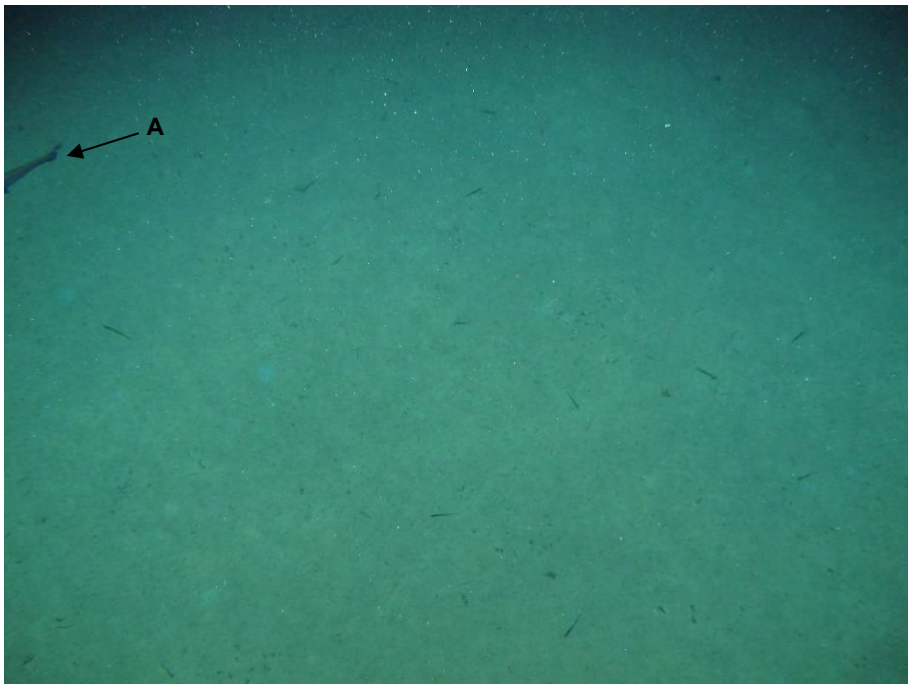
Photograph:
EBSHH05DD_07

Easting: 488 793.7 mE
Northing: 873 879.2 mN
Depth: 921 m

Sediment Type:
Mud

Fauna:
A: Burrowing anemone (Cerianthidae)

Faunal tubes



Photograph:
EBSHH05DD_13

Easting: 488 817.3 mE
Northing: 873 882.2 mN
Depth: 921 m

Sediment Type:
Mud

Fauna:
A: Unidentified fish (Pisces)

Faunal tubes

STATION EBSHHDD_05a

Photograph:
EBSHH05DDa_14

Easting: 488 825.5 mE
Northing: 873 855.6 mN
Depth: 921 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes and burrows

Photograph:
EBSHH05DDa_17

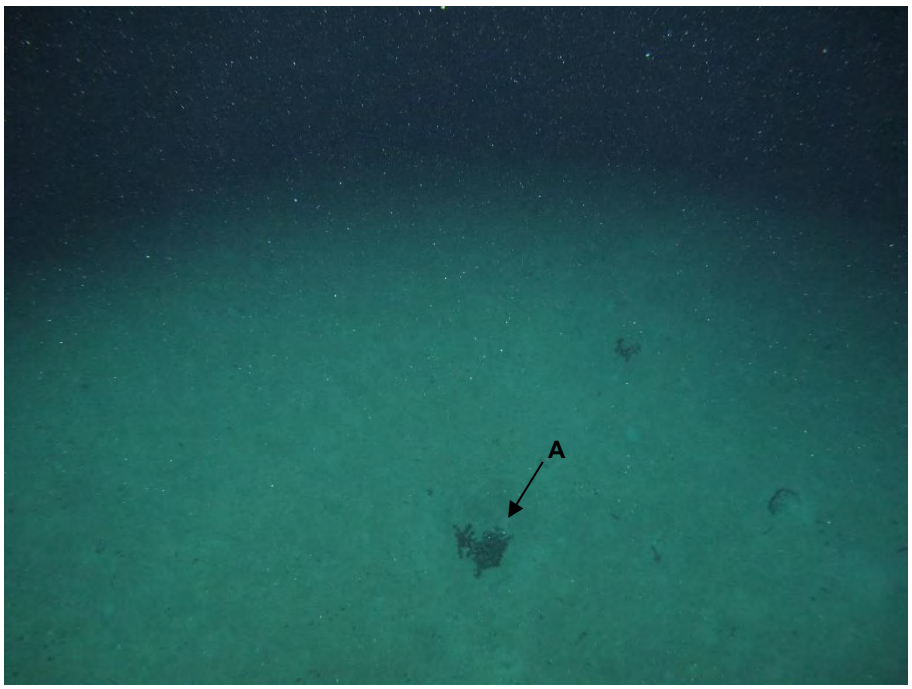
Easting: 488 832.5 mE
Northing: 873 857.9 mN
Depth: 921 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes and burrows

STATION EBSHHDD_06



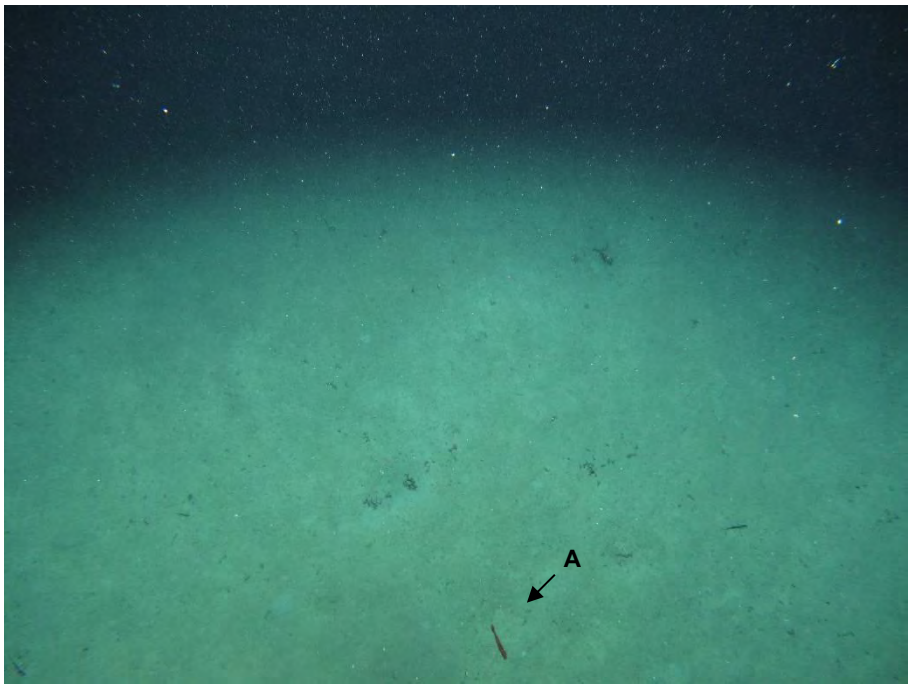
Photograph:
EBSHH06DD_02

Easting: 493 580.5 mE
Northing: 871 749.3 mN
Depth: 931 m

Sediment Type:
Mud

Fauna:
A: Sea cucumber (Holothuroidea)

Faunal burrow



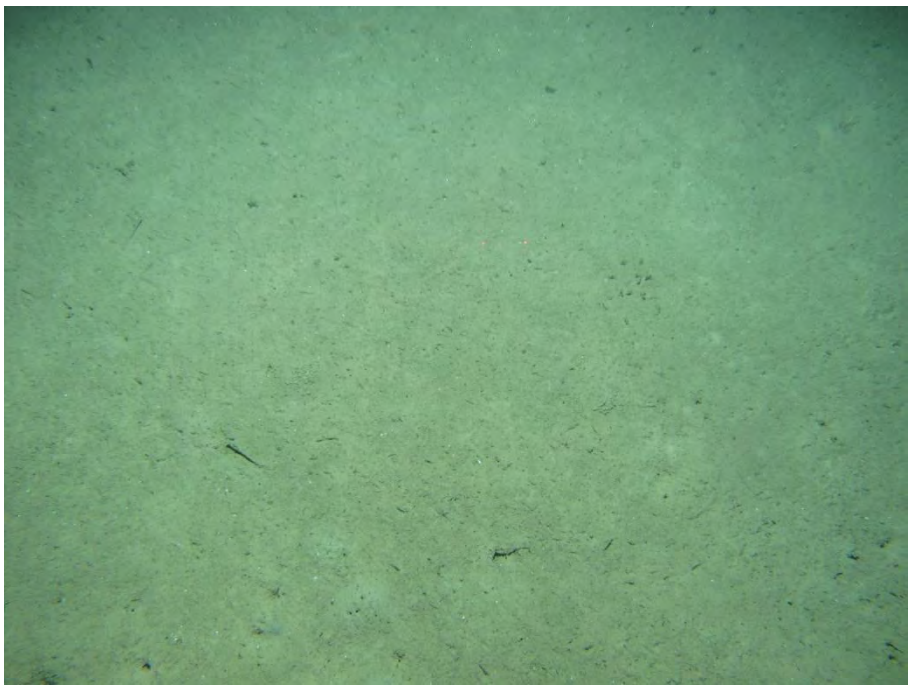
Photograph:
EBSHH06DD_17

Easting: 493 616.5 mE
Northing: 871 757.8 mN
Depth: 931 m

Sediment Type:
Mud

Fauna:
A: Sea pen (Pennatulacea)

STATION EBSHHDD_06a



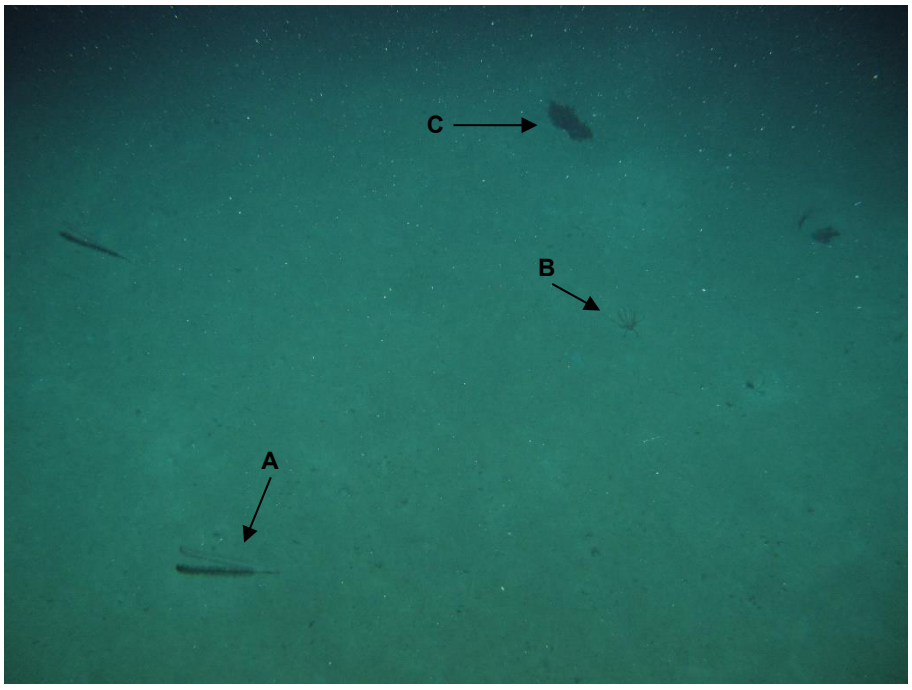
Photograph:
EBSHH06DDa_03

Easting: 493 620.9 mE
Northing: 871 739.2 mN
Depth: 932 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tracks



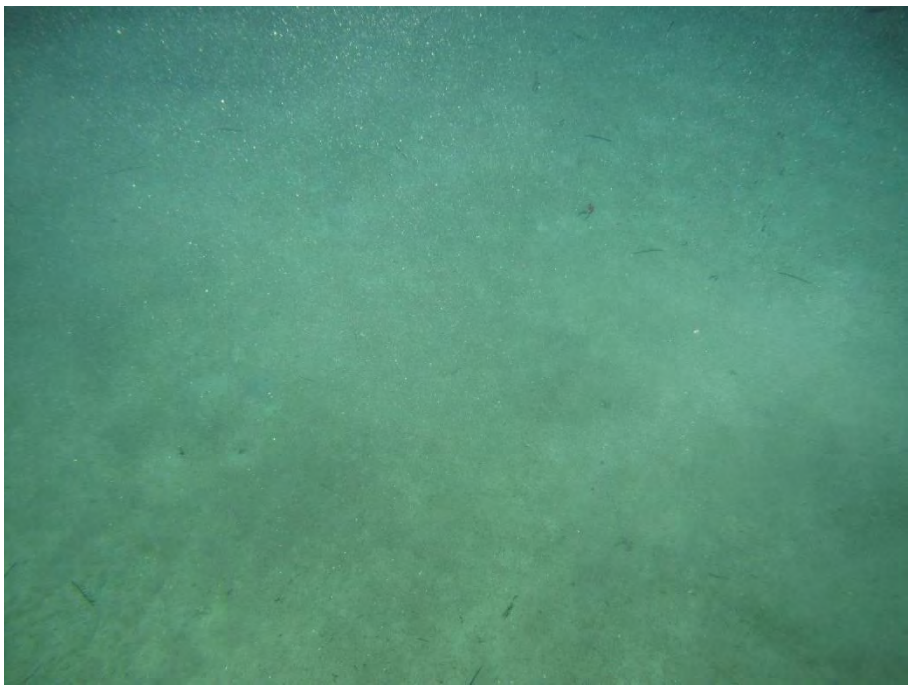
Photograph:
EBSHH06DDa_16

Easting: 493 615.7 mE
Northing: 871 808.3 mN
Depth: 932 m

Sediment Type:
Mud

Fauna:
A: Sea pen (Pennatulacea)
B: Burrowing anemone (Cerianthidae)
C: Sea cucumber (Holothuroidea)

STATION EBSHHDD_07



Photograph:
EBSHH07DD_16

Easting: 484 772.9 mE
Northing: 871 395.1 mN
Depth: 665 m

Sediment Type:
Mud

Fauna:
No fauna visible

Faunal tubes

Photograph:
EBSHH07DD_21

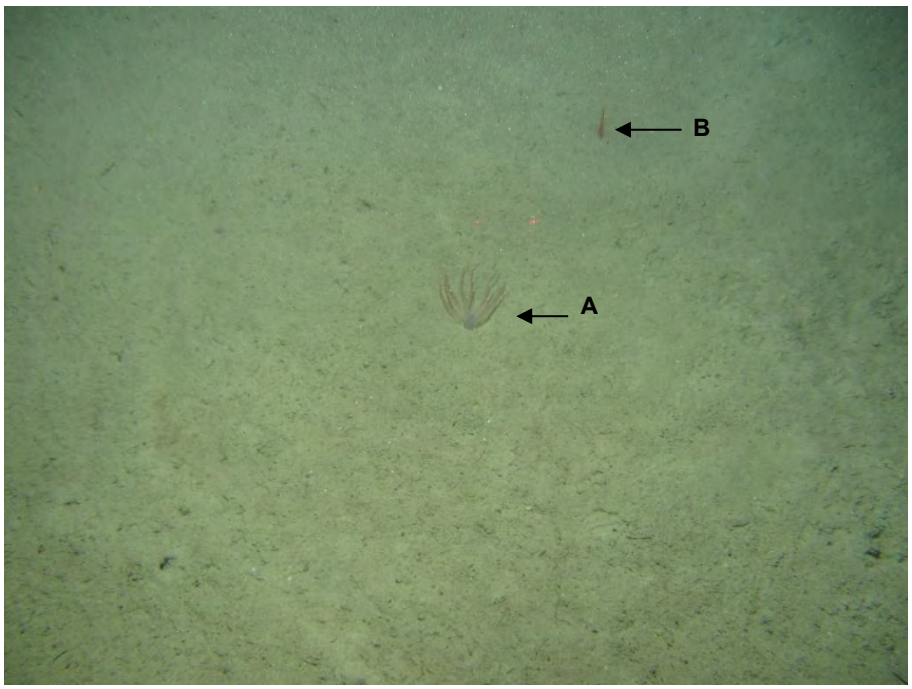
Easting: 484 793.6 mE
Northing: 871 407.2 mN
Depth: 665 m

Sediment Type:
Mud

Fauna:
A: Sea cucumber (Holothuroidea)

Faunal tubes

STATION EBSHHDD_08

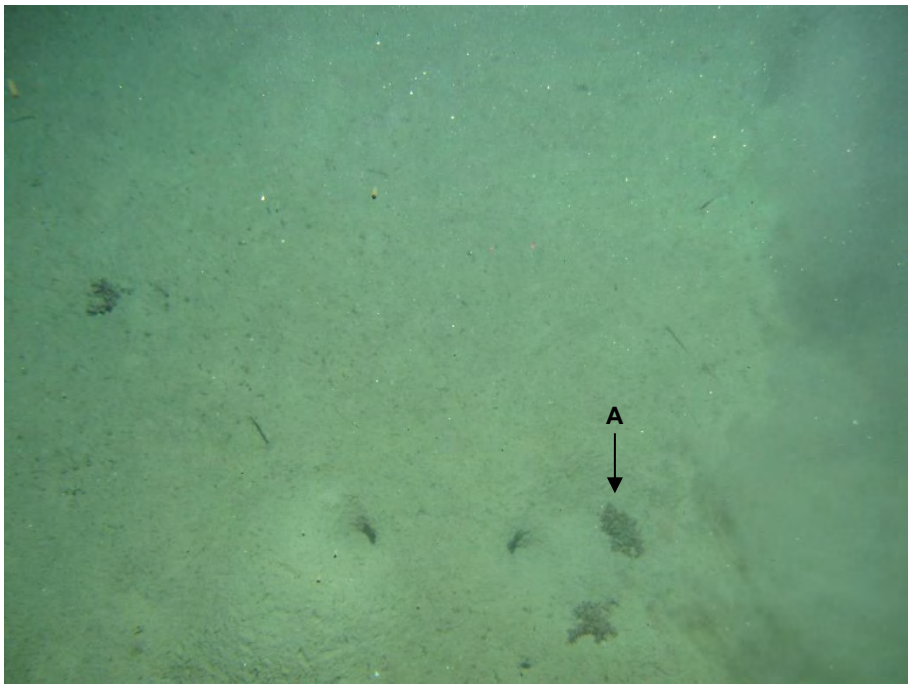


Photograph:
EBSHH08DD_10

Easting: 489 241.4 mE
Northing: 869 161.8 mN
Depth: 717 m

Sediment Type:
Mud

Fauna:
A: Burrowing anemone (Cerianthidae)
B: Shrimp (Caridea)



Photograph:
EBSHH08DD_31

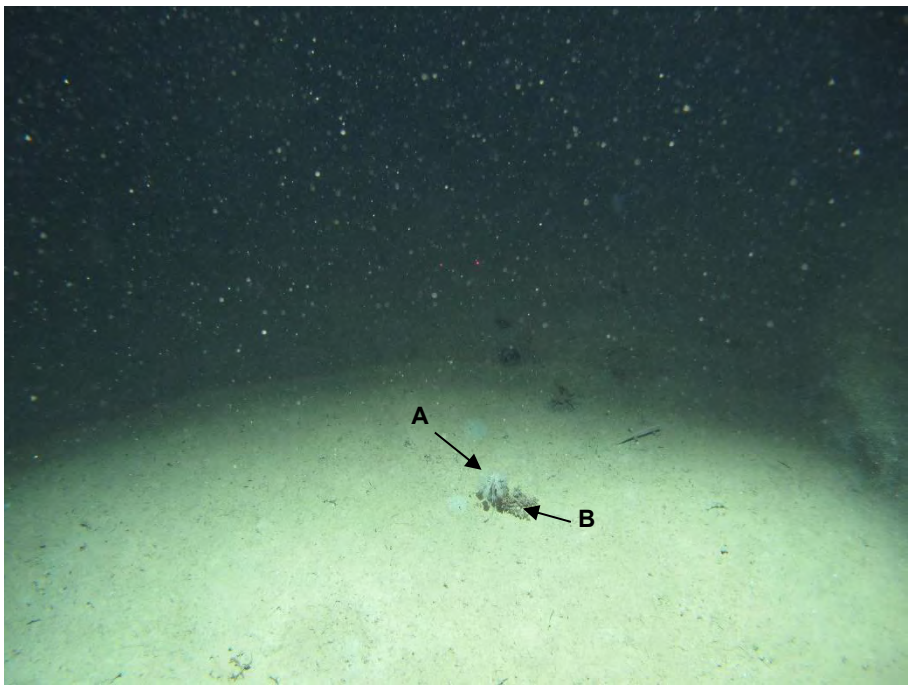
Easting: 489 291.4 mE
Northing: 869 178.5 mN
Depth: 722 m

Sediment Type:
Mud

Fauna:
A: Possible soft coral (Alcyonacea)

Faunal tubes and burrows

STATION GEOPC010DD

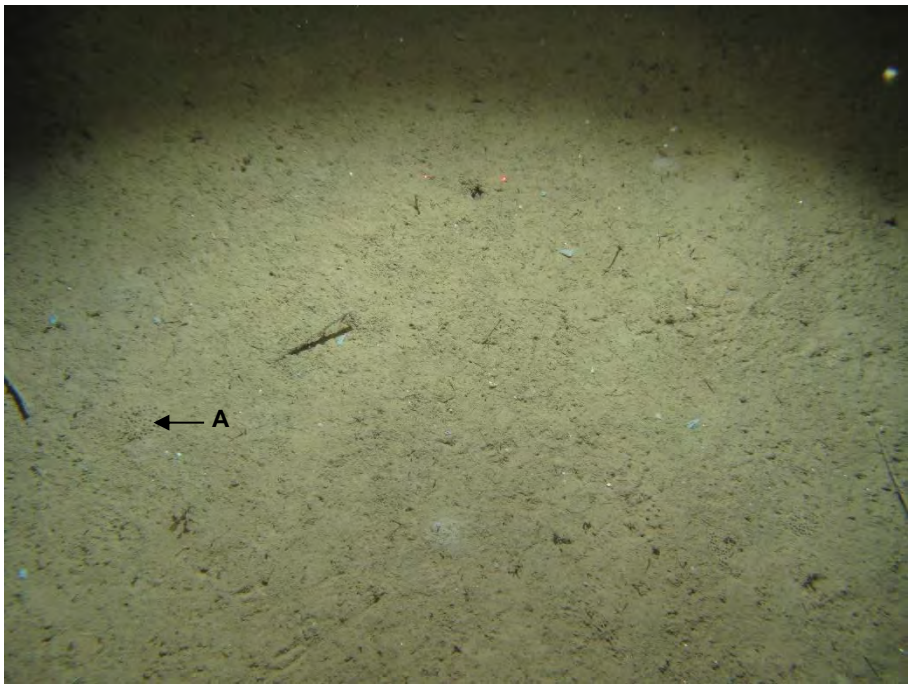


Photograph:
GEOPC010DD_05

Easting: 487 681.6 mE
Northing: 873 561.4 mN
Depth: 880 m

Sediment Type:
Mud

Fauna:
A: Carnivorous sponge (*Chondrocladia* sp.)
B: Sea cucumber (Holothuroidea)



Photograph:
GEOPC010DD_15

Easting: 487 710.9 mE
Northing: 873 561.4 mN
Depth: 880 m

Sediment Type:
Mud

Fauna:
A: Possible buried xenophyophore (Xenophyophoroidea)

Faunal tracks

TRANSECT TR01

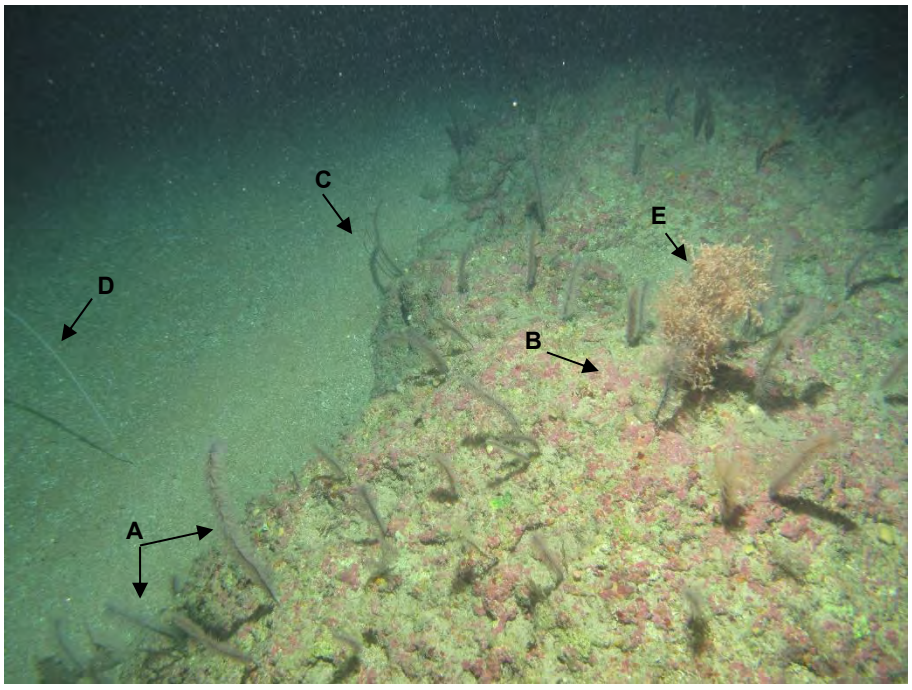
Photograph: TR01_26

Easting: 484 582.9 mE
Northing: 858 797.8 mN
Depth: 109 m

Sediment Type:
Muddy sand

Fauna:
No fauna visible

Faunal holes in honeycomb formation



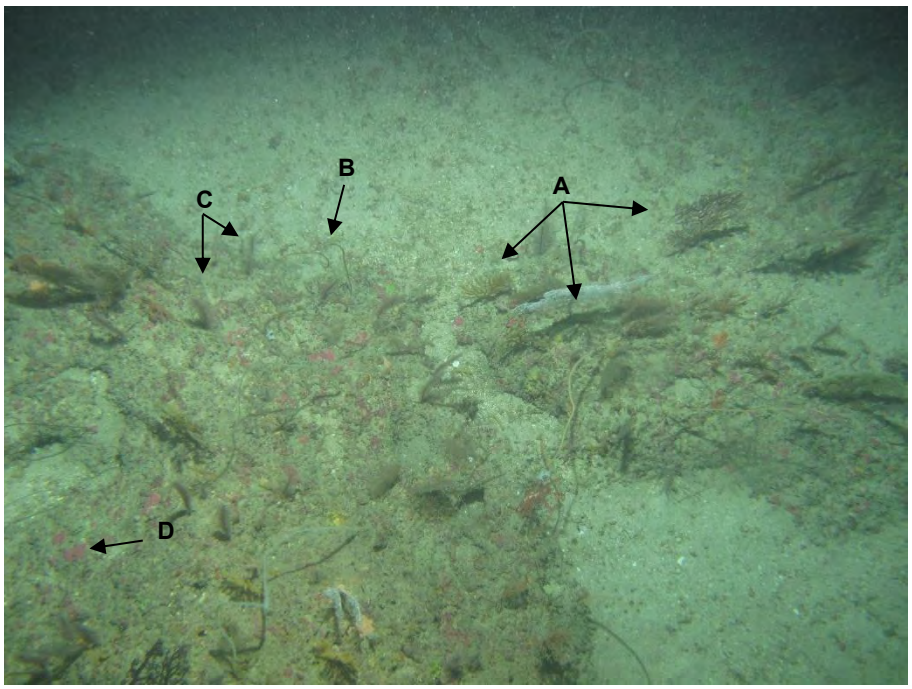
Photograph: TR01_29

Easting: 484 596.7 mE
Northing: 858 815.6 mN
Depth: 109 m

Sediment Type:
Exposed elevated bedrock interspersed with muddy sand

Fauna:
A: Bottlebrush black coral (*Tanacetipathes* sp.)
B: Coralline algae (Corallinales)
C: Wire coral (*Stichopathes* sp.)
D: Sea whip (Octocorallia)
E: Branching stony coral (Scleractinia)

TRANSECT TR02

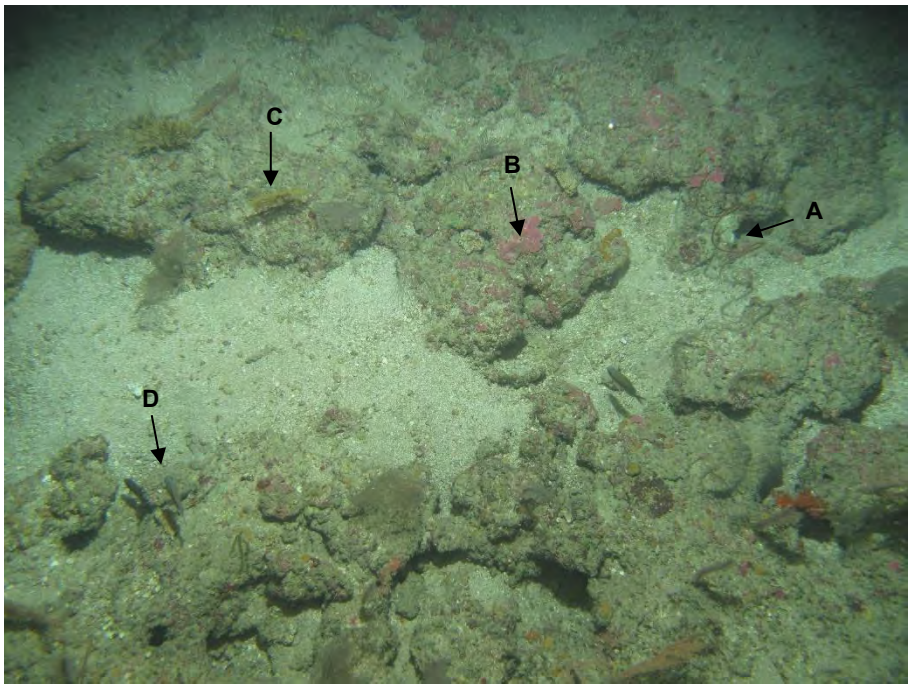


Photograph: TR02_10

Easting: 483 156.8 mE
Northing: 856 227.6 mN
Depth: 95 m

Sediment Type:
Exposed bedrock interspersed with gravelly muddy sand

Fauna:
A: Sea fan (Gorgoniidae)
B: Bottlebrush black coral (*Tanacetipathes* sp)
C: Coralline algae (Corallinales)
D: Encrusting pink sponge (Porifera)



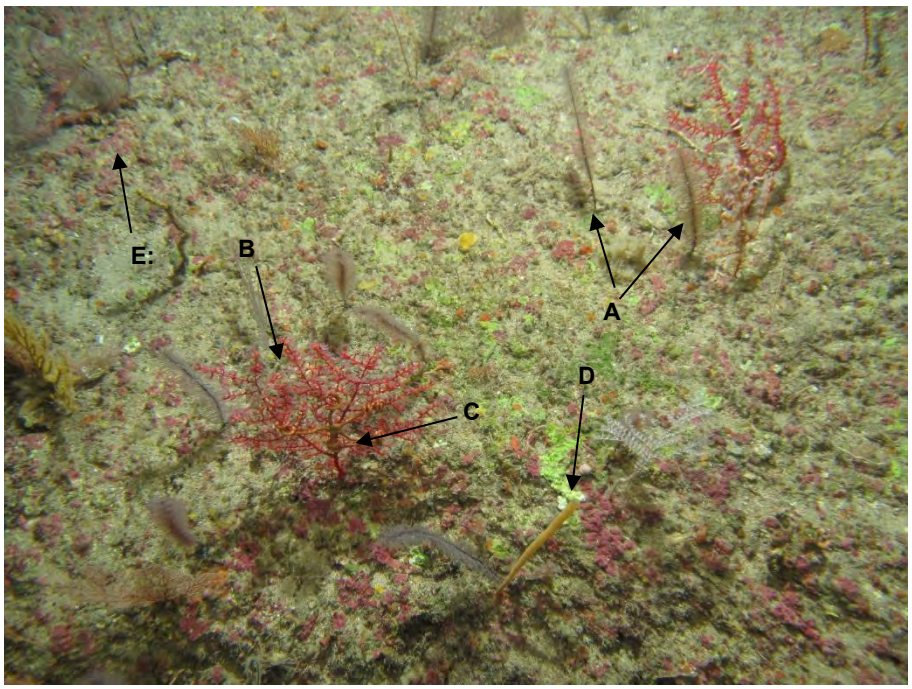
Photograph: TR02_34

Easting: 483 231.9 mE
Northing: 856 136.8 mN
Depth: 95 m

Sediment Type:
Exposed bedrock interspersed with gravelly muddy sand

Fauna:
A: Wire coral (*Stichopathes* sp.)
B: Coralline algae (Corallinales)
C: Sea fan (Gorgoniidae)
D: Small reef dwelling fish (Pisces)

TRANSECT TR03

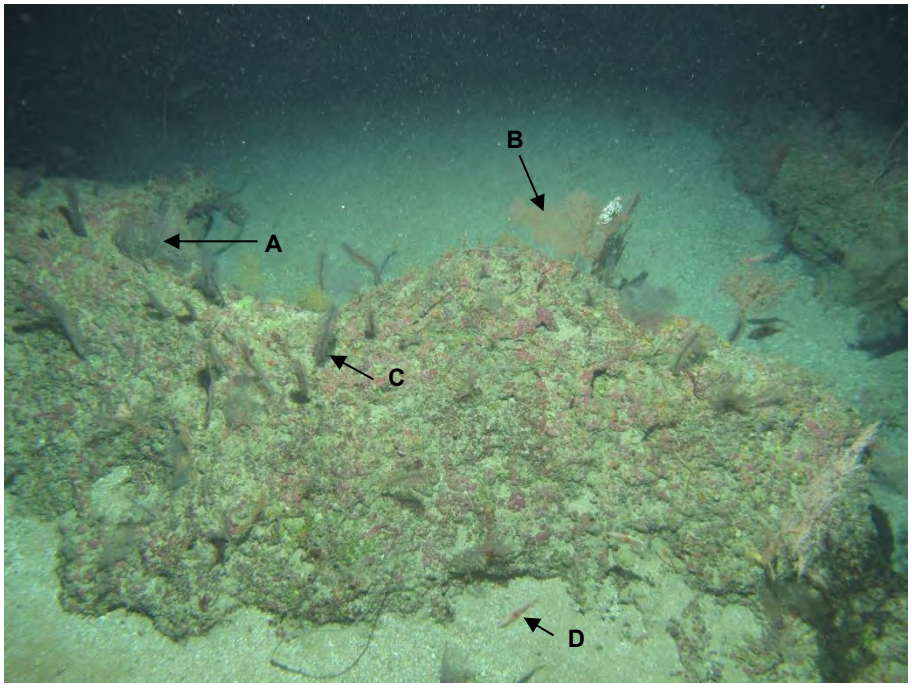


Photograph: TR03_13

Easting: 487 007.0 mE
Northing: 856 866.3 mN
Depth: 102 m

Sediment Type:
Exposed bedrock

Fauna:
A: Bottlebrush black coral (*Tanacetipathes* sp)
B: Red sea fan (Gorgoniidae)
C: Brittlestar (Ophiuroidea) associated with sea fan
D: Thin tubular sponge (Porifera)
E: Coralline algae (Corallinales)



Photograph: TR03_32

Easting: 487 080.2 mE
Northing: 856 896.7 mN
Depth: 102 m

Sediment Type:
Exposed, elevated bedrock interspersed with gravelly muddy sand

Fauna:
A: Black coral (Antipatharia)
B: Sea fan (Gorgoniidae)
C: Bottlebrush black coral (*Tanacetipathes* sp)
D: Small unidentified reef dwelling fish (Pisces)

TRANSECT TR04

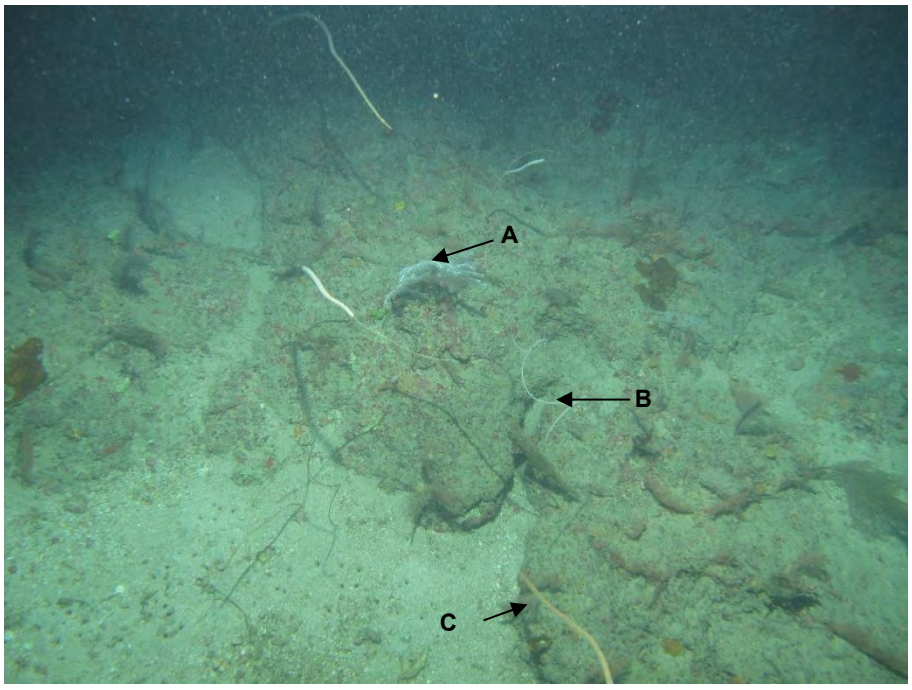
Photograph: TR04_04

Easting: 489 658.6 mE
Northing: 852 138.8 mN
Depth: 100 m

Sediment Type:
Gravelly, muddy sand

Fauna:
No fauna visible

Small faunal holes arranged in honeycomb formation



Photograph: TR04_46

Easting: 489 776.9 mE
Northing: 852 285.4 mN
Depth: 93 m

Sediment Type:
Exposed, elevated bedrock interspersed with gravelly muddy sand

Fauna:
A: Black coral (Antipatharia)
B: Wire coral (*Stichopathes* sp.)
C: Sea whip (Octocorallia)

Small faunal holes associated with soft sediment

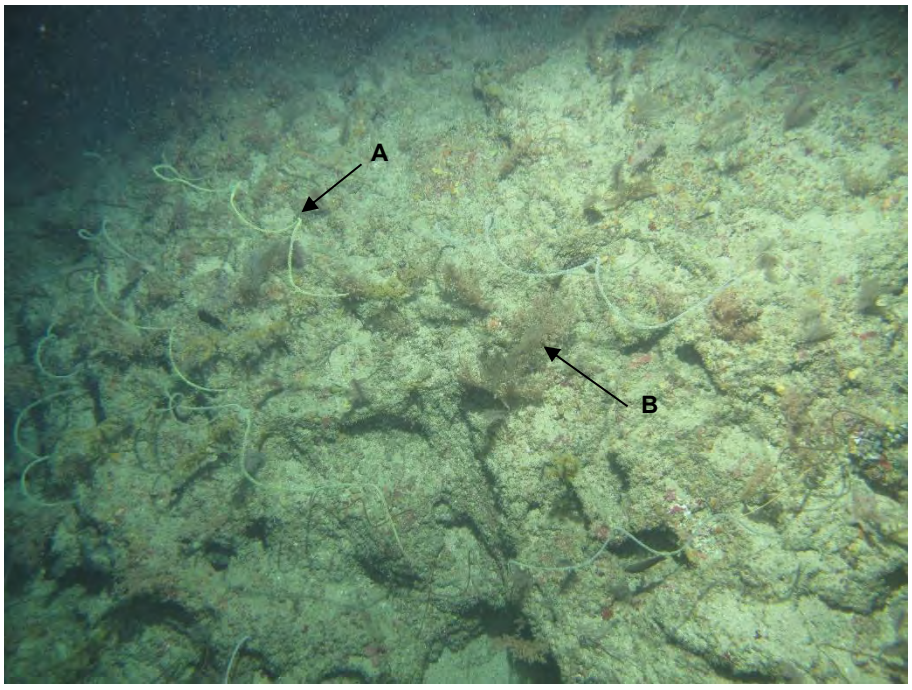
TRANSECT TR05

Photograph: TR05_02

Easting: 486 562.5 mE
Northing: 853 948.3 mN
Depth: 100 m

Sediment Type:
Gravelly, muddy sand

Fauna:
No fauna visible



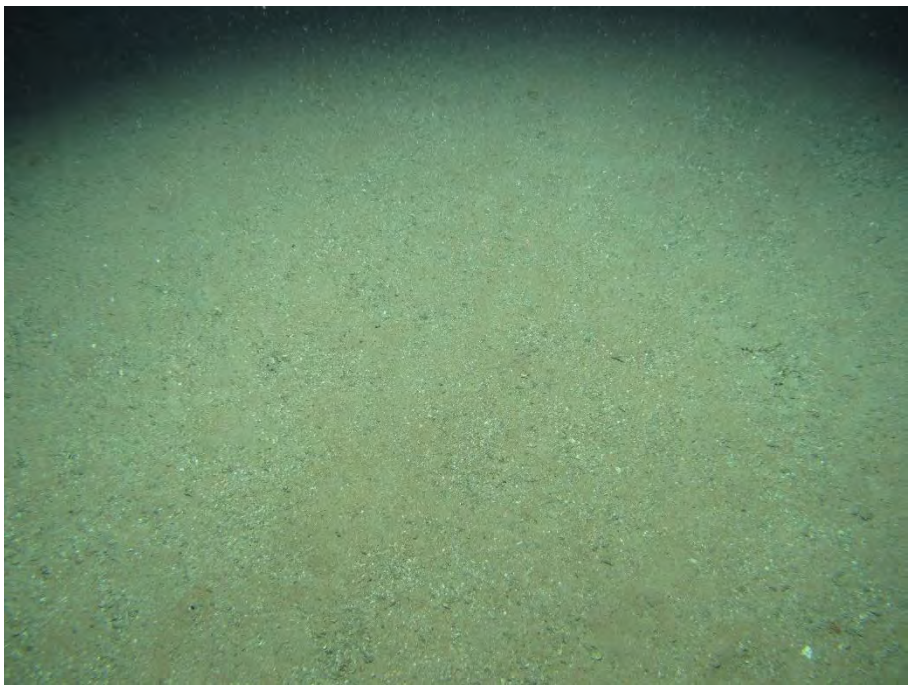
Photograph: TR05_24

Easting: 486 626.8 mE
Northing: 853 906.5 mN
Depth: 96 m

Sediment Type:
Exposed, elevated bedrock

Fauna:
A: Wire coral (*Stichopathes* sp.)
B: Black coral (Antipatharia)

TRANSECT TR06

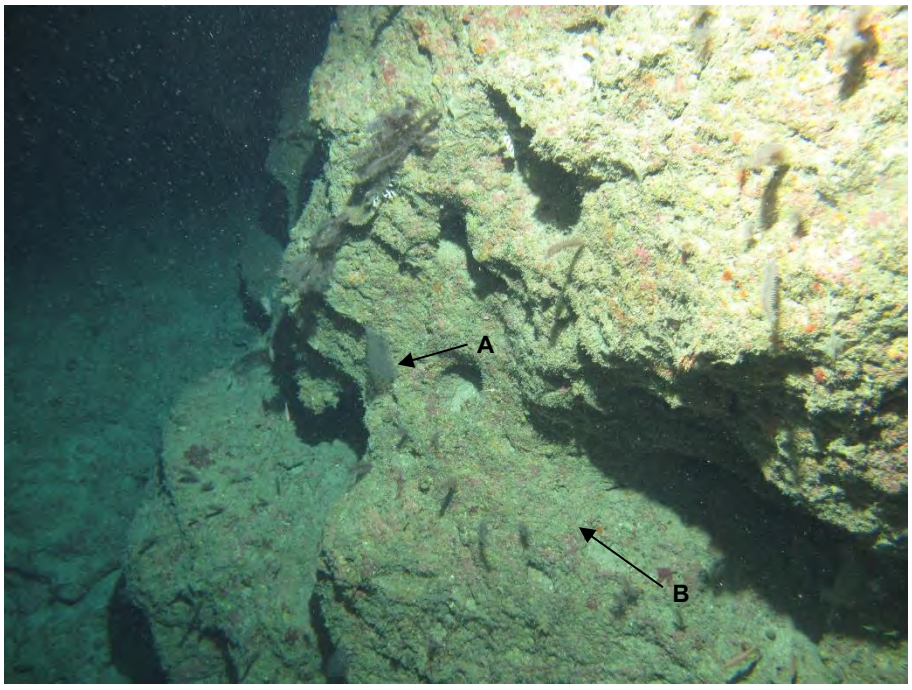


Photograph: TR06_12

Easting: 490 529.4 mE
Northing: 855 796.0 mN
Depth: 112 m

Sediment Type:
Gravelly, muddy sand

Fauna:
No fauna visible



Photograph: TR05_34

Easting: 490 622.6 mE
Northing: 855 800.5 mN
Depth: 111 m

Sediment Type:
Exposed, elevated bedrock ledge approximately 5 m high

Fauna:
A: Bottlebrush black coral (*Tanacetipathes* sp)
B: Coralline algae (Corallinales)

H. MACROFAUNAL ANALYSIS

Group	Taxon	Aphia ID	Authority	Sample															
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
CNIDARIA	Edwardsiidae	100665	Andres, 1881		1						1					1		1	
NEMERTEA	NEMERTEA	152391	-						1				1		1				
SIPUNCULA	*Phascolion*	136025	Théel, 1875				2		1										
	Onchnesoma steenstrupii	424622	Koren & Danielssen, 1876											1					
	Phascolosoma?	136029	Leuckart, 1828					1	2							1	8		
	Aspidosiphon (*Akrikos*) *zinni*	136039	Cutler, 1969	1		2	2			2				5		2			
ANNELIDA	Sigalionidae dam.	943	Kinberg, 1856									1				1			1
	Glycera capitata	130118	Örsted, 1843					2					1						
	Bathyglycinde profunda	240611	(Hartman & Fauchald, 1971)				1								1				
	Ceratocephale	129371	Malmgren, 1867	1									1						
	Paralacydonia paradoxa	130545	Fauvel, 1913										1			1		3	2
	Linopherus	129189	Quatrefages, 1866															1	
	Paramphinome jeffreysii	129837	(McIntosh, 1868)		1									1					
	Paramphinome posterobranchiata	767303	Barroso & Paiva, 2008			1													
	Augeneria	129332	Monro, 1930										1						
	Drilonereis	129200	Claparède, 1870										1				1		
	Califia	324777	Hartman, 1957		1														
	Leitoscoloplos?	129418	Day, 1977										2						
	Leodamas?	325863	Kinberg, 1866												1				
	Scoloplos	129425	Blainville, 1828		1			2											
	Aricidea	129430	Webster, 1879			1		1	4						2				
	Levinsenia	129432	Mesnil, 1897		1	1									1		2		1
	Paradoneis	129433	Hartman, 1965												1				
	Spionidae	**913**	**Grube, 1850**	**1**	**1**	**1**	**1**		**1**	**1**				**1**	**1**		**1**	**1**	

Group	Taxon	Aphia ID	Authority	Sample														
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
	Spiochaetopterus?	129233	M Sars, 1856										1						
	Aphelochaeta	129240	Blake, 1991			2						1		1			1		
	Chaetozone	129242	Malmgren, 1867								1					1		2	
	Kirkegaardia	884676	Blake, 2016			1			1			1	1						
	Flabelligeridae sp. A	976	de Saint-Joseph, 1894		1														
	Diplocirrus	129290	Haase, 1915		1				1										
	Pherusa?	129293	Oken, 1807								1		1						
	Fauveliopsis	129288	McIntosh, 1922				2		2			2		1	1		1	1	1
	Caulleryaspis	724755	Sendall & Salazar-Vallejo, 2013																2
	Capitellidae sp. A	921	Grube, 1862					1											
	Notomastus	129220	M. Sars, 1851									1						1	
	Chirimia	129343	Light, 1991									1							
	Maldane	129352	Grube, 1860				1												
	Euclymeninae dam.	152232	Arwidsson, 1906	1															
	Travisia	129417	Johnston, 1840					2						1					
	Ophelina	129414	Örsted, 1843	1		1			1				2	2		1	1	2	1
	Scalibregmatidae dam.	925	Malmgren, 1867												2				
	Myriochele (*Myrioglobula*)	129426	Malmgren, 1867			1													
	Melinninae dam.	155483	Chamberlin, 1919			2					1								
	Ampharetinae sp. A	152252	Malmgren, 1866							1									
	Ampharetinae sp. B	152252	Malmgren, 1866			1													
	Ampharetinae sp. C	152252	Malmgren, 1866												1				
	Anobothrus	129158	Levinsen, 1884											1	2				
	Terebellides	129717	Sars, 1835											1					
	Terebellinae	**322588**	**Johnston, 1846**									**1**			**2**				
	Euchone	129528	Malmgren, 1866														1		
	Siboglinum	129103	Caullery, 1914	1		1		2											
	Grania	137349	Southern, 1913						2										

Group	Taxon	Aphia ID	Authority	Sample														
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
ARTHROPODA	Scalpellidae	106055	Pilsbry, 1907															1
	AMPHIPODA sp. A	1135	Latreille, 1816		1								2						
	Bathymedon?	101691	G.O. Sars, 1892		1							1							
	Phoxocephalidae sp. A	101403	G.O. Sars, 1891															1	
	Phoxocephalidae sp. B	101403	G.O. Sars, 1891	1				1											
	Phoxocephalidae sp. C	101403	G.O. Sars, 1891												1				
	Harpiniinae	176844	Barnard & Drummond, 1978	1	1	1		1	2				1					1	1
	LYSIANASSOIDEA	**176788**	**Dana, 1849**	**1**		**1**													
	Idunella	101581	G.O. Sars, 1894									1			1				
	Caleidoscopsis	548412	G. Karaman, 1974	1	1														
	Ampelisca	101445	Krøyer, 1842									1							
	Byblis	101446	Boeck, 1871	1				1											
	Haploops	101447	Liljeborg, 1856	1						1							1		
	HAUSTORIOIDEA sp. A	1055695	Stebbing, 1906			1		1											
	Pseudericthonius	236870	Schellenberg, 1926														2		
	Aoridae	101368	Stebbing, 1899						3										
	Anthuridae sp. A	118244	Leach, 1814							1									
	Hyssura	118298	Norman & Stebbing, 1886											1					
	Leptanthuridae sp. A	148628	Poore, 2001		1				1				2		1				
	Aspidoniscus sp. A	248462	Menzies & Schultz, 1968										1					1	
	Chandraniscus?	248603	George, 2004										1						
	Haploniscus	118351	Richardson, 1908					1											
	Ischnomesus	118358	Richardson, 1908			1		2	1	1				1					
	Nannoniscidae sp. A	118265	Hansen, 1916					1	2										
	Nannoniscidae sp. B	118265	Hansen, 1916		1														
	Paramunnidae? sp. A	118266	Vanhöffen, 1914											1					
	Paramunnidae sp. B	118266	Vanhöffen, 1914						1										
	Paramunnidae sp. C	118266	Vanhöffen, 1914	1															

Group	Taxon	Aphia ID	Authority	Sample															
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
	Desmosomatidae	**118250**	**G. O. Sars, 1897**	**4**		**2**	**1**	**2**	**2**	**2**	**1**		**1**	**1**					**1**
	Macrostylis	118371	G. O. Sars, 1864	1	1														
	Baeonectes	118335	Wilson, 1982												1				
	Disconectes	118339	Wilson & Hessler, 1981						1										
	Bathybadistes	248504	Hessler & Thistle, 1975	1			1												
	Pseudarachna	118355	G. O. Sars, 1897	1				1	1										
	Arcturidae sp. A	118280	Dana, 1849					2			2		1						
	TANAIDOMORPHA male	136152	Sieg, 1980	1									1						
	TANAIDOMORPHA sp. A	136152	Sieg, 1980	1		2						1						1	1
	TANAIDOMORPHA sp. B	136152	Sieg, 1980									1							
	Parafilitanais	246987	Kudinova-Pasternak, 1989	2	2			1				1							
	Paranarthrura	136225	Hansen, 1913				2						1					1	
	Akanthophoreidae? sp. A	599405	Sieg, 1986					1											
	Typhlotanais	136256	Sars, 1882		2				2	3				5			1		2
	Pseudotanais	136246	Sars, 1882					1	1										
	Neotanais	136204	Beddard, 1886	1															
	Apseudes sp. A	136185	Leach, 1814		2		2		1				1	1					
	Apseudes sp. B	136185	Leach, 1814	2	3			1											
	Pectinapseudes	246993	Bacescu & Williams, 1988						3										
	Sphyrapus?	136201	Sars, 1882																1
	Eudorella	110412	Norman, 1867														1		
	Leucon (*Leucon*)	110436	-												1				
	Nannastacidae sp. A	110383	Bate, 1866	2															
	Campylaspis sp. A	110415	G.O. Sars, 1865													1			
	Campylaspis sp. B	110415	G.O. Sars, 1865	1	1							1		1					
	Campylaspis sp. C	110415	G.O. Sars, 1865									1							
	Campylaspis sp. D	110415	G.O. Sars, 1865	1	1														
	Diastylidae? sp. A	110380	Bate, 1856												1				

Group	Taxon	Aphia ID	Authority	Sample															
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
	Makrokylindrus?	110404	Stebbing, 1912													1			
MOLLUSCA	CAUDOFOVEATA	151365	C. R. Boettger, 1956	4				2				1	1	1	1	1		1	
	GASTROPODA sp. A	101	Cuvier, 1795									1		1					
	Setia triangularis	533421	(R. B. Watson, 1886)	1										1					
	Eulimidae sp. A	135	Philippi, 1853															1	1
	Eulimidae sp. B	135	Philippi, 1853															1	
	Haliella?	137974	Monterosato, 1878															1	
	Acteonidae sp. A	155	d'Orbigny, 1842							1									
	PHILINOIDEA	196322	Gray, 1850 (1815)	1															
	Dentaliidae sp. A	202	Children, 1834				3			1	1	1		1					
	Dentalium	137886	Linnaeus, 1758				1												1
	Cadulus	138024	Philippi, 1844														1		
	Ennucula	138261	Iredale, 1931								1		1		1	4	2	5	8
	Neilonella?	138246	Dall, 1881													4	4		
	Ledella pustulosa	182796	(Jeffreys, 1876)													1	2	1	
	Pristigloma	138375	Dall, 1900		1						1								
	Microgloma mirmidina	506520	(Dautzenberg & H. Fischer, 1897)	2	1	1			2			2	1		1		1		
	Yoldiella	138673	A. E. Verrill & Bush, 1897		1	1	1	1				1	1	1			1		
	Bathyarca	137673	Kobelt, 1891											1		1			
	Limopsis	138132	Sassi, 1827			1			1	1	1			1	2				
	Dacrydium	138217	Torell, 1859	1	1			1	3					1	1				
	Limatula	138127	S. V. Wood, 1839													2	1		
	PECTINOIDEA dam.	151320	Rafinesque, 1815												1				
	Mendicula ferruginosa	152905	(Forbes, 1844)				1								1			1	
	Semelidae sp. A	1781	Stoliczka, 1870 (1825)		1												4		
	VENEROIDEA sp. A	14638	Rafinesque, 1815		1												2		3
	Cuspidariidae dam.	**1788**	**Dall, 1886**		**1**	**1**													

Group	Taxon	Aphia ID	Authority	Sample															
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
ECHINODERMATA	CRINOIDEA dam.	123081	-					1											
	Ophiotholia	242434	Lyman, 1880	4		1	1				1		1	2	4				1
	HOLOTHUROIDEA sp. A	123083	-											1					
	Labidoplax	123448	Östergren, 1898									1	1	1					
	Rynkatorpa?	241390	Rowe & Pawson, 1967			1												1	
Number of taxa				**31**	**28**	**24**	**15**	**25**	**26**	**11**	**11**	**21**	**27**	**28**	**26**	**15**	**21**	**21**	**17**
Number of individuals				**44**	**33**	**29**	**22**	**33**	**43**	**15**	**12**	**23**	**31**	**38**	**34**	**23**	**39**	**29**	**29**
The following taxa were merged for analysis																			
	Spionidae	**913**	**Grube, 1850**	**1**	**1**	**1**	**1**		**1**	**1**				**1**	**1**		**1**	**1**	
	Spionidae dam.	913	Grube, 1850	1	1		1		1	1					1		1		
	Spiophanes	129626	Grube, 1860			1								1				1	
	Terebellinae	**322588**	**Johnston, 1846**									**1**			**2**				
	Terebellinae dam.	322588	Johnston, 1846									1			1				
	Pista	129708	Malmgren, 1866												1				
	LYSIANASSOIDEA	**176788**	**Dana, 1849**	**1**		**1**													
	LYSIANASSOIDEA dam.	176788	Dana, 1849			1													
	LYSIANASSOIDEA sp. A	176788	Dana, 1849	1															
	Desmosomatidae	**118250**	**G. O. Sars, 1897**	**4**		**2**	**1**	**2**	**2**	**2**	**1**		**1**	**1**					**1**
	Desmosomatidae dam.	118250	G. O. Sars, 1897	4		1	1	2	2	2	1		1	1					1
	Mirabilicoxa	118325	Hessler, 1970			1													
	Cuspidariidae dam.	**1788**	**Dall, 1886**		**1**	**1**													
	Cuspidariidae dam.	1788	Dall, 1886			1													
	Myonera	137860	Dall & E. A. Smith, 1886		1														
Number of taxa				**3**	**2**	**4**	**2**	**1**	**2**	**2**	**1**	**0**	**1**	**2**	**1**	**0**	**1**	**1**	**1**
Number of individuals				**6**	**2**	**5**	**2**	**2**	**3**	**3**	**1**	**0**	**1**	**2**	**1**	**0**	**1**	**1**	**1**
The following taxa were removed from the analysis																			
Damaged																			
	SIPUNCULA dam.	1268	-	2	1		1					1		1		1	2		

Group	Taxon	Aphia ID	Authority	Sample															
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
	Onuphidae dam.	965	Kinberg, 1865				1							1		1			
	Cirratulidae dam.	919	Ryckholt, 1851	1		1			1								1		
	Flabelligeridae dam.	976	de Saint-Joseph, 1894														1		
	Ampharetidae dam.	981	Malmgren, 1866												2				
	Ampharetinae dam.	152252	Malmgren, 1866			2									1		3		
	AMPHIPODA dam.	1135	Latreille, 1816	3	1	2	2								1	1			1
	Oedicerotidae dam.	101400	Lilljeborg, 1865						1										
	Phoxocephalidae dam.	101403	G.O. Sars, 1891																1
	Ampeliscidae dam.	101364	Krøyer, 1842	1									1						
	ISOPODA dam.	1131	Latreille, 1817				1												
	JANIROIDEA dam.	155716	G. O. Sars, 1897																1
	Ischnomesidae dam.	118256	Hansen, 1916					1											
	TANAIDOMORPHA dam.	136152	Sieg, 1980	1	1														
	APSEUDOMORPHA dam.	136150	Sieg, 1980									1							
	CUMACEA dam.	1137	Krøyer, 1846	2															
	Campylaspis dam.	110415	G.O. Sars, 1865	1															
	BIVALVIA dam.	105	Linnaeus, 1758			1											2		
	OPHIUROIDEA dam.	123084	Gray, 1840	1					2	1		1							
	HOLOTHUROIDEA dam.	123083	-				1												
Juvenile																			
	ANIMALIA eggs	2	-			P			P										P
	SIPUNCULA juv.	1268	-		4	1							1			1	2		3
	Onuphidae juv.	965	Kinberg, 1865			1													1
	Spionidae juv.	913	Grube, 1850									1							
	Maldanidae juv.	923	Malmgren, 1867											1			1		
	Maldaninae juv.	154938	Malmgren, 1867								1								
	Ampharetidae juv.	981	Malmgren, 1866														1		

Group	Taxon	Aphia ID	Authority	Sample															
				EBSHH_01FA	EBSHH_01FB	EBSHH_02FA	EBSHH_02FB	EBSHH_03FA	EBSHH_03FB	EBSHH_04FA	EBSHH_04FB	EBSHH_05FA	EBSHH_05FB	EBSHH-06FA	EBSHH-06FB	EBSHH_07FA	EBSHH_07FB	EBSHH_08FA	EBSHH_08FB
	Ampharetinae juv.	152252	Malmgren, 1866														1		
	Terebellinae juv.	322588	Johnston, 1846														1		
	Sabellidae juv.	985	Latreille, 1825						2	1				1			1		
	CUMACEA juv.	1137	Krøyer, 1846			1													
	DECAPODA larva	1130	Latreille, 1802					1	1										
	GASTROPODA eggs	101	Cuvier, 1795															P	
	Eulimidae juv.	135	Philippi, 1853										1						
	SCAPHOPODA juv.	104	Bronn, 1862				1								1				
	BIVALVIA juv.	105	Linnaeus, 1758						1	1			1		1				2
	Nuculidae juv.	204	Gray, 1824		1				1										
	Semelidae juv.	1781	Stoliczka, 1870 (1825)		1												1		
	VENEROIDEA juv.	14638	Rafinesque, 1815													1			
	TEREBRATULIDA juv.	104023	Waagen, 1883										1						
	OPHIUROIDEA juv.	123084	Gray, 1840		1			3			1	2		1	2	1	3	3	3
	SPATANGOIDA juv.	123106	L. Agassiz, 1840			1	1							1	2				
	HOLOTHUROIDEA juv.	123083	-											1		1			1
	Actinopterygii eggs	10194	-	P							P								
Parasitic																			
	COPEPODA (parasitic)	1080	Milne Edwards, 1840														1		
Number of taxa				**9**	**7**	**9**	**7**	**3**	**8**	**3**	**3**	**5**	**5**	**7**	**7**	**7**	**14**	**2**	**9**
Number of individuals				**12**	**10**	**10**	**8**	**5**	**9**	**3**	**2**	**6**	**5**	**7**	**10**	**7**	**21**	**3**	**13**

I. CORRELATIONS-SEDIMENTS

	Depth [m BSL]	Median [µm]	Mean [µm]	SD [phi]	Gravel [%]	Sand [%]	Fines [%]	Silt [%]	Clay [%]	TOC [%]	THC [µg/g]	UCM [µg/g]	n-Alkanes (nC_{12-36}) [µg/g]	CPI (nC_{12-36})	Pristane [µg/g]	Phytane [µg/g]	Total 2 to 6 Ring PAH [µg/g]	Total US EPA 16 PAH [µg/g]	NPD [µg/g]	Al [µg/g]	As [µg/g]	Ba [µg/g]	Cd [µg/g]	Cr [µg/g]	Cu [µg/g]	Fe [µg/g]	Hg [µg/g]	Ni [µg/g]	Pb [µg/g]	Zn [µg/g]	No. Taxa	No. individuals	Shannon-Wiener ($H'Log_2$)	Brillouin (Hb)	Pielou (J)
Median [µm]	-0.626																																	
Mean [µm]	-0.577	0.961																																
SD [phi]	-0.190	0.639	0.761																															
Gravel [%]	0.098	0.236	0.352	0.610																														
Sand [%]	-0.357	0.779	0.847	0.952	0.390																													
Fines [%]	0.357	-0.779	-0.847	-0.952	-0.390	-1.000																												
Silt [%]	0.167	-0.281	-0.430	-0.833	-0.610	-0.738	0.738																											
Clay [%]	0.571	-0.907	-0.847	-0.405	-0.073	-0.548	0.548	-0.071																										
TOC [%]	-0.216	0.276	0.370	0.084	-0.380	0.204	-0.204	0.060	-0.287																									
THC [µg/g]	-0.180	-0.051	-0.179	-0.503	-0.785	-0.299	0.299	0.587	-0.108	0.482																								
UCM [µg/g]	-0.072	0.110	-0.062	-0.374	-0.778	-0.133	0.133	0.578	-0.241	0.406	0.915																							
n-Alkanes (nC_{12-36}) [µg/g]	-0.144	0.026	-0.117	-0.503	-0.785	-0.287	0.287	0.671	-0.216	0.494	0.982	0.952																						
CPI (nC_{12-36})	0.095	0.013	-0.098	0.071	0.586	-0.024	0.024	-0.190	0.119	-0.850	-0.455	-0.361	-0.455																					
Pristane [µg/g]	-0.156	0.225	0.185	0.383	-0.110	0.479	-0.479	-0.359	-0.072	0.145	0.434	0.455	0.349	-0.024																				
Phytane [µg/g]	-0.512	0.510	0.377	-0.146	-0.225	0.000	0.000	0.537	-0.781	0.147	0.491	0.482	0.565	-0.098	0.049																			
Total 2 to 6 Ring PAH [µg/g]	-0.214	-0.166	-0.270	-0.548	-0.756	-0.381	0.381	0.571	-0.024	0.407	0.970	0.807	0.922	-0.452	0.407	0.488																		
Total US EPA 16 PAH [µg/g]	-0.214	-0.166	-0.270	-0.548	-0.756	-0.381	0.381	0.571	-0.024	0.407	0.970	0.807	0.922	-0.452	0.407	0.488	1.000																	
NPD [µg/g]	0.096	-0.516	-0.595	-0.577	-0.690	-0.481	0.481	0.385	0.440	0.201	0.823	0.661	0.726	-0.289	0.484	0.028	0.866	0.866																
Al [µg/g]	0.410	-0.750	-0.826	-0.868	-0.605	-0.843	0.843	0.627	0.615	-0.121	0.242	0.213	0.248	-0.120	-0.467	-0.259	0.253	0.253	0.438															
As [µg/g]	0.810	-0.702	-0.786	-0.595	-0.317	-0.643	0.643	0.524	0.571	-0.371	0.060	0.193	0.108	0.143	-0.275	-0.317	0.024	0.024	0.289	0.783														
Ba [µg/g]	0.590	-0.659	-0.752	-0.735	-0.444	-0.735	0.735	0.602	0.530	-0.273	0.061	0.159	0.115	0.048	-0.515	-0.284	0.024	0.024	0.223	0.933	0.916													
Cd [µg/g]	0.289	-0.452	-0.460	-0.530	-0.210	-0.530	0.530	0.205	0.566	0.236	0.194	0.104	0.170	-0.036	-0.242	-0.444	0.133	0.133	0.348	0.598	0.349	0.494												
Cr [µg/g]	0.868	-0.633	-0.658	-0.422	-0.259	-0.482	0.482	0.374	0.554	-0.212	-0.067	0.104	-0.006	0.000	-0.315	-0.469	-0.133	-0.133	0.146	0.720	0.952	0.878	0.372											
Cu [µg/g]	0.795	-0.633	-0.733	-0.602	-0.333	-0.627	0.627	0.554	0.518	-0.303	0.115	0.268	0.176	0.145	-0.261	-0.284	0.048	0.048	0.292	0.774	0.988	0.915	0.427	0.945										
Fe [µg/g]	0.464	-0.798	-0.868	-0.903	-0.500	-0.927	0.927	0.708	0.586	-0.233	0.196	0.136	0.209	-0.049	-0.540	-0.150	0.244	0.244	0.394	0.963	0.805	0.914	0.482	0.704	0.778									
Hg [µg/g]	0.614	-0.764	-0.741	-0.638	-0.377	-0.712	0.712	0.491	0.589	-0.123	-0.068	-0.068	-0.037	-0.221	-0.630	-0.377	-0.037	-0.037	0.149	0.876	0.798	0.888	0.385	0.826	0.752	0.893								
Ni [µg/g]	0.843	-0.788	-0.832	-0.482	-0.272	-0.554	0.554	0.301	0.747	-0.358	0.030	0.128	0.030	0.133	-0.091	-0.531	0.012	0.012	0.390	0.726	0.952	0.823	0.390	0.927	0.927	0.716	0.739							
Pb [µg/g]	0.737	-0.724	-0.785	-0.651	-0.403	-0.687	0.687	0.552	0.577	-0.278	0.037	0.143	0.086	0.000	-0.426	-0.340	0.012	0.012	0.248	0.876	0.970	0.969	0.391	0.950	0.950	0.881	0.911	0.907						
Zn [µg/g]	0.738	-0.626	-0.724	-0.619	-0.415	-0.619	0.619	0.548	0.524	-0.252	0.120	0.277	0.180	0.071	-0.299	-0.317	0.048	0.048	0.289	0.831	0.976	0.952	0.458	0.952	0.988	0.805	0.798	0.916	0.970					
No. Taxa	0.571	-0.089	0.000	0.143	0.195	0.071	-0.071	-0.143	0.238	0.419	0.012	0.072	0.036	-0.119	0.120	-0.439	-0.119	-0.119	0.055	-0.024	0.190	0.060	0.578	0.349	0.277	-0.098	0.037	0.277	0.123	0.238				
No. Individuals	0.333	0.089	0.246	0.714	0.512	0.595	-0.595	-0.786	0.214	0.144	-0.371	-0.301	-0.419	0.048	0.455	-0.634	-0.429	-0.429	-0.165	-0.482	-0.167	-0.386	0.048	0.024	-0.157	-0.561	-0.307	0.060	-0.258	-0.190	0.667			
Shannon-Wiener ($H'Log_2$)	0.548	-0.089	0.000	0.095	0.268	0.000	0.000	-0.071	0.190	0.395	0.036	0.048	0.060	-0.071	0.084	-0.317	-0.071	-0.071	0.055	-0.072	0.143	0.000	0.554	0.265	0.229	-0.098	-0.012	0.205	0.061	0.167	0.976	0.595		
Brillouin (Hb)	0.683	-0.180	-0.068	0.275	0.417	0.132	-0.132	-0.347	0.383	0.133	-0.271	-0.188	-0.265	0.108	0.108	-0.638	-0.371	-0.371	-0.083	-0.073	0.252	0.067	0.467	0.412	0.303	-0.123	0.062	0.382	0.161	0.252	0.934	0.802	0.898	
Pielou (J)	0.476	-0.600	-0.651	-0.762	0.000	-0.881	0.881	0.667	0.381	-0.299	0.048	-0.060	0.084	0.262	-0.599	0.049	0.095	0.095	0.151	0.615	0.595	0.627	0.482	0.458	0.602	0.756	0.577	0.458	0.589	0.548	0.119	-0.452	0.238	0.096
Simpson (1 - λ)	0.619	-0.447	-0.381	-0.238	0.317	-0.405	0.405	0.071	0.500	0.048	-0.048	-0.145	-0.060	0.190	-0.144	-0.390	-0.071	-0.071	0.151	0.205	0.333	0.229	0.699	0.349	0.386	0.244	0.209	0.386	0.258	0.310	0.786	0.357	0.857	0.778

Notes:
Correlations based on n = 8

Significance

- Positive correlations (≥ 95 % significant where $0.738 \leq r_s \leq 0.881$)
- Strong positive correlations (≥ 99 % significant where $r_s \geq 0.881$)
- Negative correlations (≥ 95 % significant where $-0.738 \geq r_s \geq -0.881$)
- Strong negative correlations (≥ 99 % significant where $r_s \leq -0.881$)

Shallow Sampling Program—Environmental Baseline Field Report: Continental Slope AUV Survey, Hammerhead Development, Offshore Guyana

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Volume 4: Shallow Sampling Program - Environmental Baseline Field Report

Continental Slope AUV Survey
Hammerhead Development, Offshore Guyana

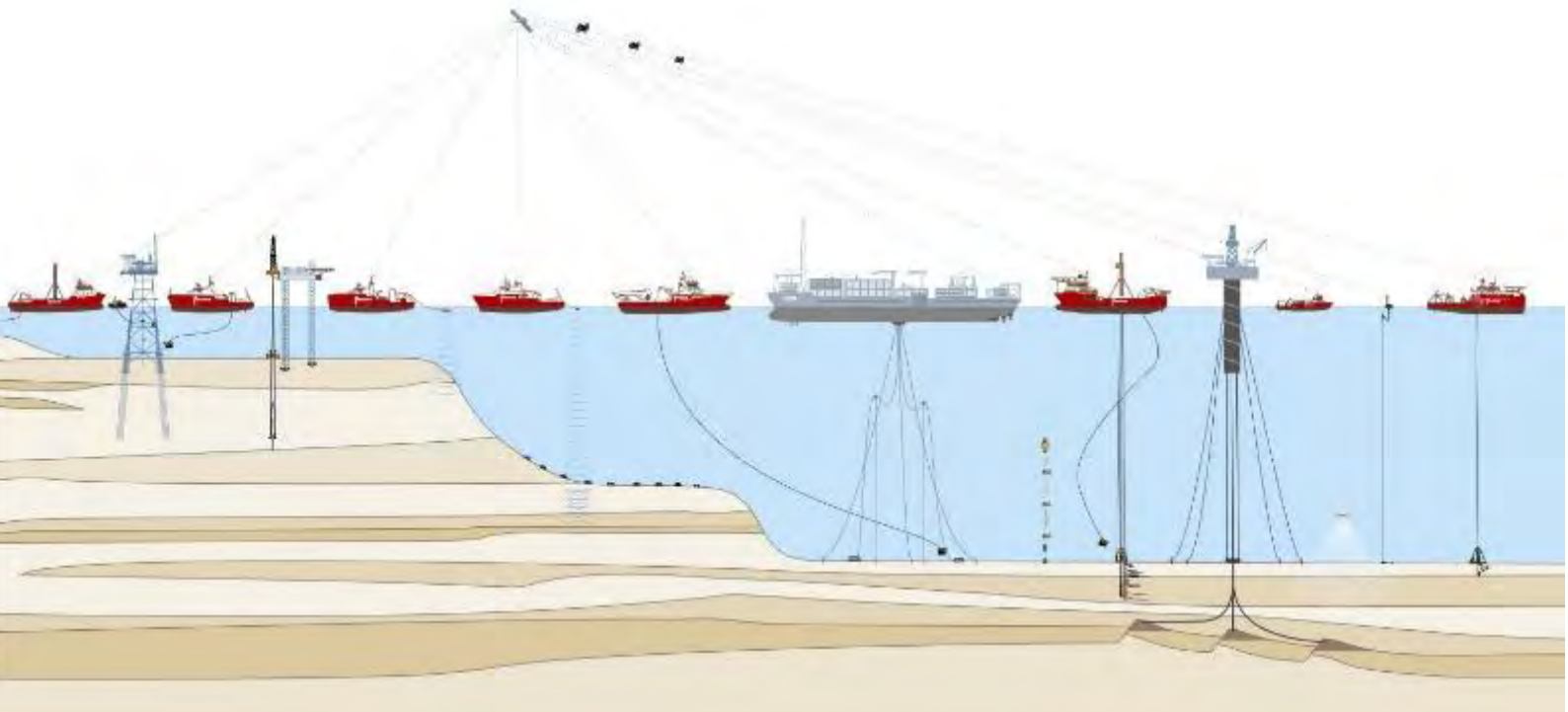
Date of Report: 8 August 2019
Date of Field Work: 22 April to 27 May 2019

Fugro Document No.: 1903-1507-V4-FIELDEBS

Esso Exploration and Production Guyana Limited

EEPGL

Final



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Continental Slope AUV Survey
Hammerhead Development, Offshore Guyana

Date of Report: 8 August 2019
Date of Field Work: 22 April to 27 May 2019

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Final

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Attention: Mr Patrick Lee

Volume 4: Environmental Baseline Field Report
Continental Slope AUV Survey
Hammerhead Development, Offshore Guyana

As a subcontractor to Fugro Canada Corp., Fugro GB Marine Limited has the pleasure of submitting the Shallow Sampling Program - Environmental Baseline Field Report for the integrated site investigation programme within the Hammerhead Development survey area, offshore Guyana. This report presents a summary of the survey operations and the preliminary results from the environmental survey. These results are subject to change after full interpretation and analysis undertaken in the office has been completed.

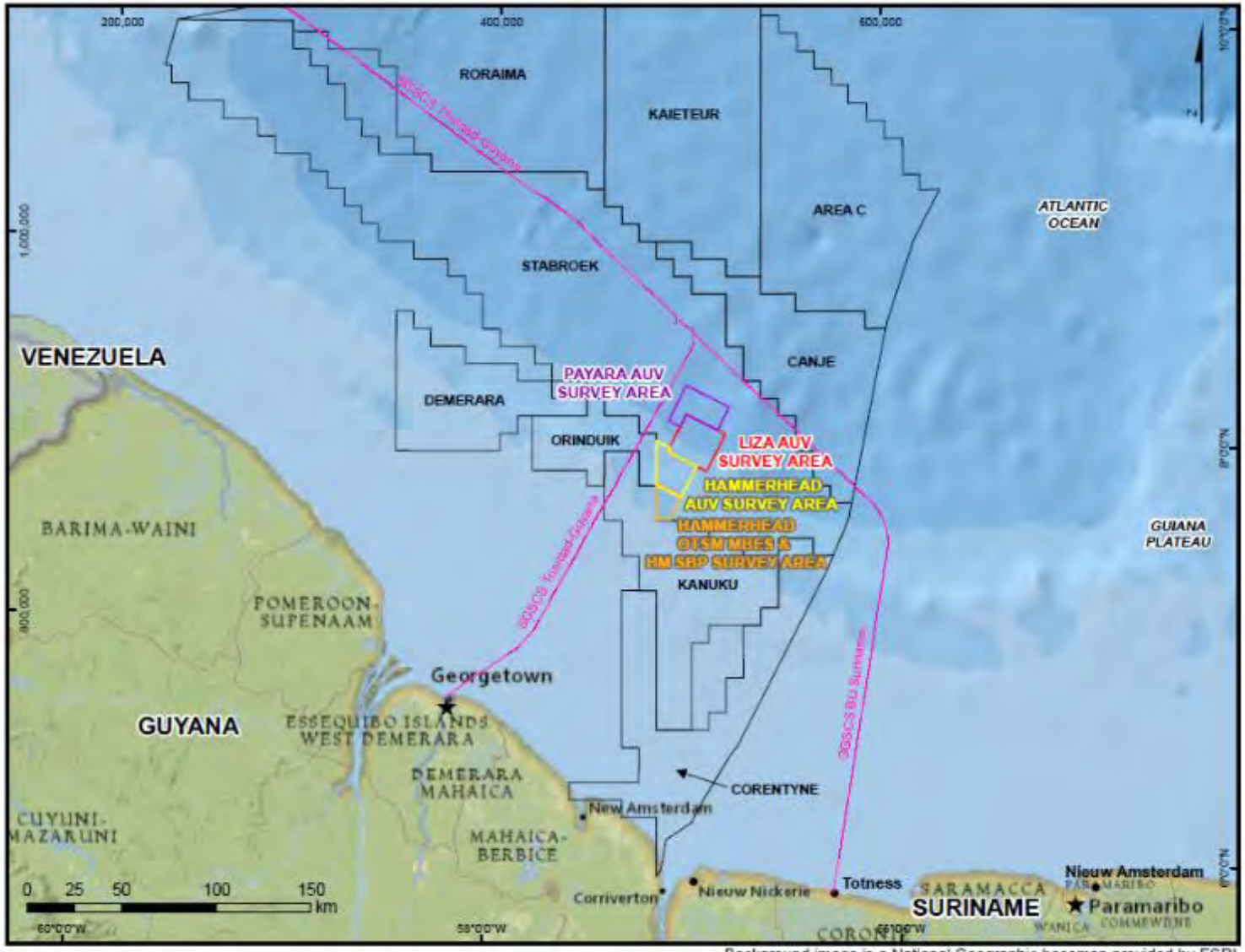
This work was carried out as authorised by Master Marine Survey Order A4000457, dated 16 August 2018 and under Master Marine Survey Agreement A4001077 dated 8 November 2018, and under Master Marine Survey Agreement A1998840 and Marine Survey SubAgreement A2002836 with EEPGL, both dated effective as of 14 February 2006 (contract reference Schedule E—Onshore Reporting, item 5.3). Work was done in general accordance with EEPGL's project work scope, Fugro proposal PL18-036 dated 8 June 2018, and as otherwise agreed with the EEPGL representative, Patrick Lee. This report is also in general accordance with "ExxonMobil, Geophysical Operations - Shallow Seabed Group, Generic Specification, Field Development Project, Site Investigation Reports, GS.93, REV 03" dated October 2012.

We hope that you find this report to your satisfaction; should you have any queries, please do not hesitate to contact us.

Yours faithfully
Fugro GB Marine Limited

D. Watson
Environmental Project Manager

Distribution: One electronic copy to **Mr Patrick Lee**



Background image is a National Geographic basemap provided by ESRI.
Coordinate Grid: WGS 1984 UTM Zone 21N, meters

GENERAL LOCATION MAP

EXECUTIVE SUMMARY

Introduction

On the instruction of Esso Exploration and Production Guyana Limited (EEPGL), Fugro performed an integrated site investigation program within the Hammerhead Field, offshore Guyana. The integrated program consisted of geophysical, geotechnical and environmental surveys. This field report describes the field operations of the environmental baseline survey (EBS), which was undertaken between 22 April and 24 May 2019.

Environmental Survey

Seabed video and photographic data collection was performed at fifteen locations to establish and identify the seabed habitat and epifaunal species within the survey area. Sediment box core sampling was performed at eight pre-determined locations to establish the physico-chemical and biological properties of the sediment. Water quality was assessed through in-situ collection of water column profiles and acquisition of water samples at eight locations.

Seabed Habitats and Epifauna

Box core sampling identified similar sediments across the Hammerhead field, with the sediment type described as mud with minimal shell material. Large irregular bedrock or possible carbonate reef structures were observed on the shelf area in water depths of between approximately 95 m and 112 m.

Benthic epifauna was generally sparse associated with the soft sediment with fauna including bryozoans (Bryozoa) and sponges (Porifera) present. Faunal tubes and burrows were also recorded. The faunal and floral community associated with the hard substrate in the shallower waters was dominated by crustose coralline algae (Corallinaceae), black corals (Antipatharia), and sponges (Porifera), faunal turf (Hydrozoa/Bryozoa), shrimps (Caridea), brittlestars (Ophiuroidea) and various fish species.

Potentially Sensitive Habitats

The reef areas observed with the Hammerhead shelf area may constitute a potentially sensitive habitat, due to the associated epifauna.

Water Column Profiles

Water column profiles obtained within the Hammerhead field were typical of the oceanic water column within the region. There was a distinct thermocline, extending between approximately 20 m and 200 m depth below surface, over which the majority of the parameters measured exhibited rapid change. The exception to this was turbidity, which remained constantly low throughout the water column.

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ABBREVIATIONS

AUV	Autonomous underwater vehicle
BC	Box core
BIO	Biodiversity DNA sample
BSL	Below sea level
CTD	Conductivity, temperature, density (sonde)
DNA	Deoxyribonucleic acid (sample)
DO	Dissolved oxygen
EBS	Environmental baseline survey
EEPGL	Esso Exploration and Production Guyana Limited
EOL	End of line
FA/FB	Fauna sample A/B
HC	Hydrocarbon (sample)
HM	Heavy metal (sample)
MBES	Multibeam echo sounder
OTSM	Over the side mounted
PC	Physico-chemical (core subsample)
PSD	Particle size distribution (sample)
RV	Research vessel
SBP	Sub-bottom profiler
SOL	Start of line
SSS	Sidescan sonar
TOC	Total organic carbon (sample)
TSS	Total suspended solids (sample)
UHF	Ultra high frequency
USBL	Ultra short baseline
USNEL	United States Naval Electronics Laboratory
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984
WP	Water profile
WS	Water sample

1. INTRODUCTION

1.1 Background

On the instruction of Esso Exploration and Production Guyana Limited (EEPGL), Fugro performed an integrated site investigation programme in support of the Hammerhead Development, offshore Guyana. Geophysical operations, comprising automated underwater vehicle (AUV) based multibeam echosounder (MBES), sidescan sonar (SSS), and sub-bottom profiler (SBP) data collection, were undertaken during the first phase of survey operations. The second phase of the site investigation comprised over the side mounted (OTSM) multibeam echosounder (MBES) and hull-mounted sub-bottom profiler (SBP) data collection upslope of the AUV survey area, geotechnical sampling and an environmental baseline survey (EBS).

This report details the field operations undertaken as part of the Hammerhead Field EBS, which was conducted onboard the RV Fugro Brasilis during the survey period 22 April to 25 May 2019.

Appendix A outlines the guidelines for use of this report.

1.2 Coordinate Reference System

All coordinates detailed in this report are referenced to World Geodetic System 1984 (WGS84) datum, Universal Transverse Mercator (UTM) projection Zone 21 N . Table 1.1 provided the detailed geodetic and projection parameters.

Table 1.1: Project Geodetic and Projection Parameters

Global Positioning System Geodetic Parameters *	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Reciprocal flattening:	1/f = 298.257 223 563
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator (UTM)
UTM Zone:	21 N
Central Meridian:	57° 00’ 00.0” West
Latitude of Origin:	00° 00′ 00″ North
False Easting:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	Metre
Notes: * = Fugro Starfix navigation software always uses WGS84 geodetic parameters as a primary datum for any geodetic calculations. † = This is the right-hand coordinate frame rotation used by the Fugro Starfix navigation software	

2. SURVEY STRATEGY

The objectives of the EBS were to provide data to establish the baseline physico-chemical and biological characteristics of the seabed and water column environment, by undertaking water column and seabed sampling. Seabed photographic data were also collected to identify the habitats and epifaunal communities present within the survey area.

The EBS sampling stations were pre-determined by the client. Following the acquisition of the shelf and shelf break geophysical data, camera transects were selected to investigate areas of elevated rough hard substrate which had reduced or near zero signal penetration on the SBP data.

Table 2.1 provide the coordinates, data to be acquired and rationale for each location. The orientation of the camera transects was subject to change to accommodate vessel manoeuvrability at the time of survey operations. provides a spatial display of the proposed camera transects within the OTSM data acquisition area. Figure 2.2 provides a spatial display of the proposed environmental sampling and drop-down camera locations.

Table 2.1: Proposed Environmental Survey Sampling Stations, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N					
Station		**Easting [m]**	**Northing [m]**	**Rationale**	**Sample/Data Acquisition**
Camera Transects					
TR01	SOL	484 524	858 728	2 m high rugged undulations	Video and stills
	EOL	484 667	858 890		
TR02	SOL	483 162	856 229	Raised seabed (5 m in height), possible reef	Video and stills
	EOL	483 243	856 113		
TR03	SOL	487 107	856 901	Uneven seabed in the centre of the site	Video and stills
	EOL	486 987	856 855		
TR04	SOL	489 761	852 259	A 5 m high and 30 m wide seabed elevation in the west of site	Video and stills
	EOL	489 824	852 332		
TR05	SOL	486 588	853 927	Scouring next to an elevated seabed	Video and stills
	EOL	486 637	853 891		
TR06	SOL	490 673	853 927	Client requested. Possible active seep	Video and stills
	EOL	490 545	855 798		
Drop-down camera					
EBSHHDD_01		483 890.61	880 797.50	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_02		488 361.44	878 558.84	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_03		492 832.28	876 320.17	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_04		484 335.09	876 101.50	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_05		488 805.93	873 862.83	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_06		493 622.33	871 760.78	Client predetermined for site spatial coverage	Video and stills

Geodetic Parameters: WGS84 UTM Zone 21 N				
Station	**Easting [m]**	**Northing [m]**	**Rationale**	**Sample/Data Acquisition**
EBSHHDD_07	484 779.57	871 405.50	Client predetermined for site spatial coverage	Video and stills
EBSHHDD_08	489 250.41	869 166.83	Client predetermined for site spatial coverage	Video and stills
GEOPC010DD	487 687.90	873 555.90	Client requested, pockmark investigation	Video and stills
Sediment Sampling				
EBSHH_01	483 890.61	880 797.50	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_02	488 361.44	878 558.84	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_03	492 832.28	876 320.17	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_04	484 335.09	876 101.50	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_05	488 805.93	873 862.83	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_06	493 622.33	871 760.78	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_07	484 779.57	871 405.50	Client predetermined for site spatial coverage	PC, FA, FB, BIO
EBSHH_08	489 250.41	869 166.83	Client predetermined for site spatial coverage	PC, FA, FB, BIO
Water Sampling				
EBSHHW_01	483 890.61	880 797.50	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_02	488 361.44	878 558.84	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_03	492 832.28	876 320.17	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_04	484 335.09	876 101.50	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_05	488 805.93	873 862.83	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_06	493 622.33	871 760.78	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_07	484 779.57	871 405.50	Client predetermined for site spatial coverage	WS, WP, BIO
EBSHHW_08	489 250.41	869 166.83	Client predetermined for site spatial coverage	WS, WP, BIO

Notes:
PC = Physico-chemical sediment sample
FA/FB = Faunal samples A/B
WS = Physico-chemical water sample
WP = Water profile
BIO = Biodiversity DNA sample

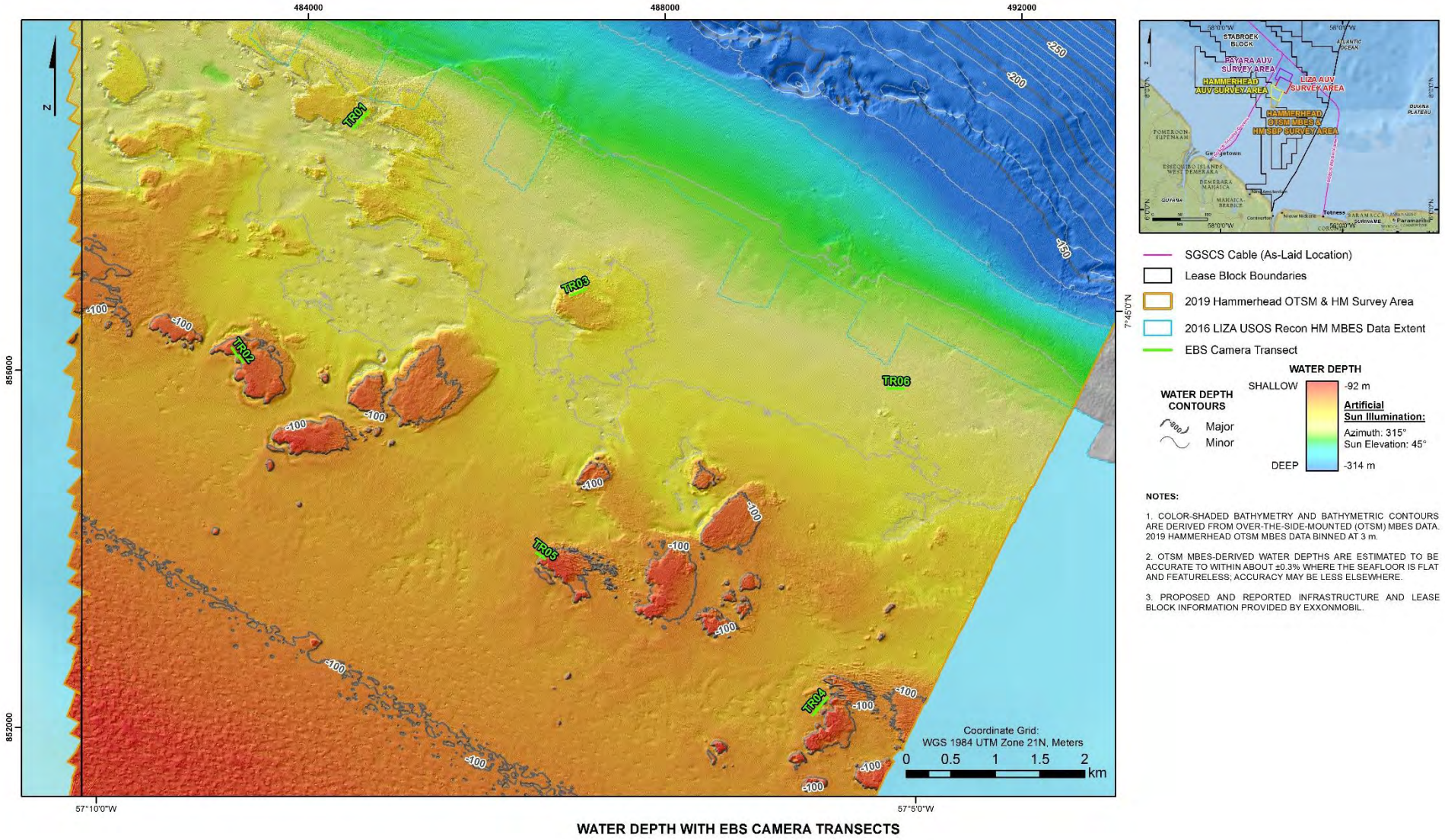


Figure 2.1: OTSM survey area proposed environmental camera transects overlain on bathymetry

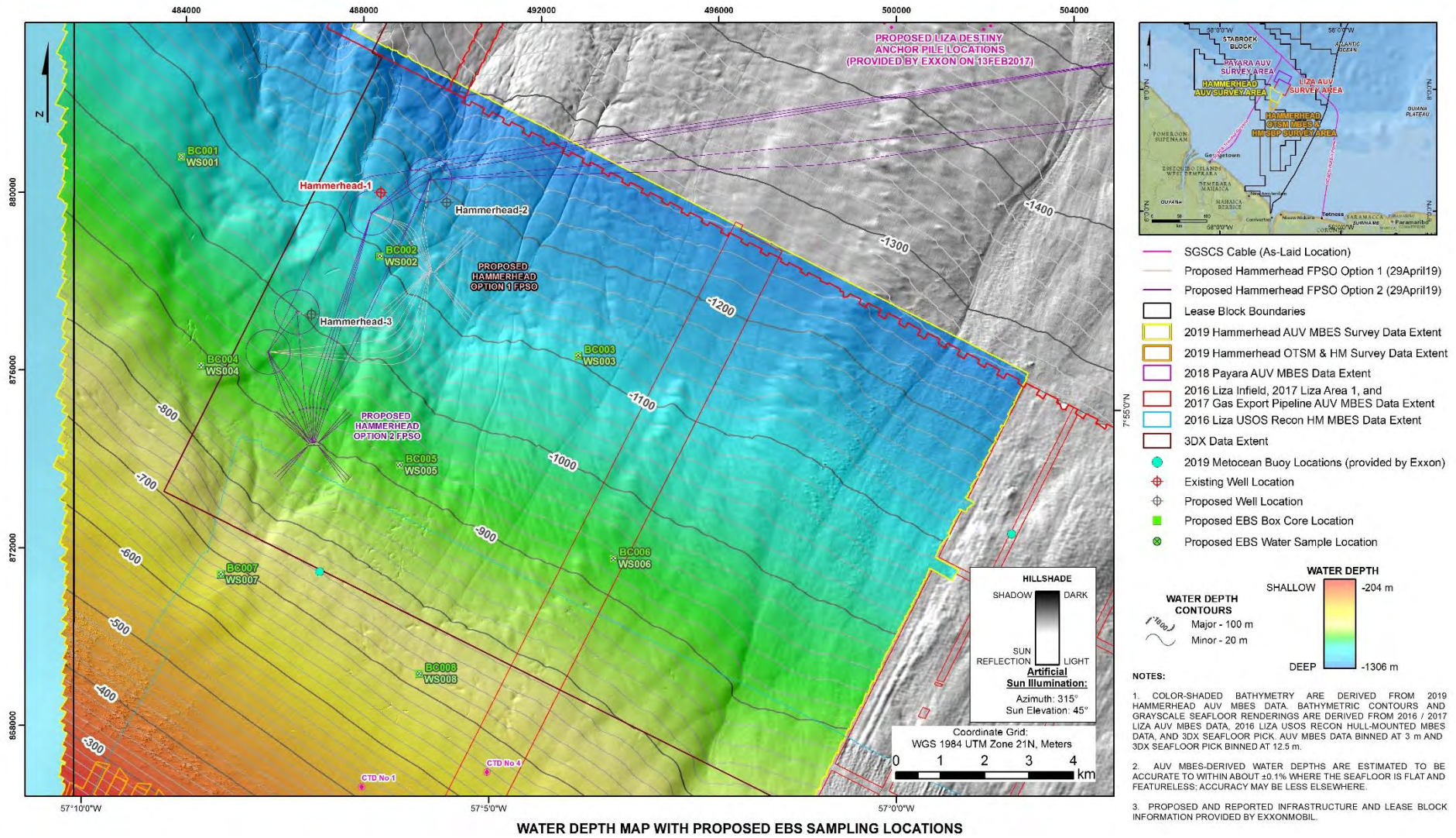


Figure 2.2: AUV survey area proposed environmental sampling locations overlain on bathymetry

3. METHODS

3.1 Survey Methods

3.1.1 Seabed Video/Photography

Seabed photography was acquired using a Sonar Equipment Services deep-sea camera system mounted within a purpose-built camera frame complete with one high resolution video camera, one stills camera, a separate strobe and four light emitting diode lights.

Seabed video footage was displayed on a computer monitor and recorded directly onto a hard drive. A video overlay was used to overlay a navigation string from an attached ultra short baseline (USBL) beacon, including the time, date, depth and location (easting and northing). The survey location and station number were also displayed (manually updated). The stills camera imagery was visible on a second window of the computer. Footage was viewed in real time via a co-axial cable, assisting in the control of the camera in the water. Two lasers were set up 9 cm apart to provide image scaling.

Operational procedures for seabed photography were as follows:

- The camera was setup on deck prior to deployment and a test photograph taken;
- The camera was deployed into the water just below the sea surface, at which point the system was switched on;
- The camera was lowered to the seabed using the SSS winch and when the seabed was visible recording started;
- At each drop-down station the camera was lowered to the seabed outside a 50 m diameter circle centred on the target location. The vessel was then manoeuvred across the circle so that a minimum of 5 minutes of good quality video and a minimum of 5 good quality camera stills were acquired;
- If a transect was required, the vessel manoeuvred along the line with the winch adjusted to keep the seabed visible on the live feed;
- Still photography commenced with the environmental scientist manually triggering the camera while the camera moved over the seabed. Whenever a photograph was taken the surveyor captured a positional fix;
- The camera system was switched off just beneath the surface and then recovered to the deck;
- On completion, photographs were downloaded and backed up onto the ships system and an external hard drive.

3.1.2 Sediment Grab Sampling

Seabed samples were acquired using a United States Naval Electronics Laboratory (USNEL) 0.25 m^2 box corer.

Operational procedures for grab sampling were as follows:

- The USNEL box corer was prepared for operations prior to arrival on station. A USBL beacon was attached to the box core frame. The Bridge communicated to the deck via an ultra high frequency (UHF) radio when the vessel was steady and on location, and the box core was deployed from the stern A-frame and lowered to the seabed using the coring winch;

- When the engineer operating the winch observed that the box core had reached the seabed (evidenced through a distinct slackening of the lifting rope and snatch block), the on-line surveyor was informed (via UHF radio) and a fix was taken;
- On recovery to the deck, the sample was inspected and judged acceptable or otherwise (see below for rejection criteria);
- The sample was subsampled into two 0.1 m^2 macrofauna samples, with the remaining material subsampled for physico-chemical analysis;
- Deck logs were completed for each sample acquired (including no samples) recording: date, time, sample number, fix number, sediment type, depth and colour of strata in the sediment (if any) using Munsell colour codes, odour (i.e. hydrogen sulphide), bioturbation or debris.

Samples were considered unacceptable in the following instances:

- Evidence of sediment washout caused through improperly closed scoop or inspection hatch;
- Sediment sample taken on an angle; where the box was not parallel to the seabed when it fired;
- Disruption of the sample through striking the side of the vessel;
- Sample represented less than 20 % of the box corer's capacity (unless deemed acceptable by the client representative);
- Sample was more than 50 m from the target location, unless deemed acceptable by the client representative, particularly in deeper waters;
- Presence of hagfish within the sample, as this species of fish produces mucilaginous slime which renders a sample unusable. Presence of other sessile organisms or fish would not lead to discarding a sample unless exhibiting similar characteristics;
- Deemed unacceptable by the client representative for any other reason.

3.1.2.1 Physico-chemical Sample Processing

Sub-samples were taken from the surface of the sample while retained in the box core as follows:

- Prior to any subsampling metal scoops was pre-cleaned using acetone;
- Hydrocarbon samples were collected using a metal scoop to a nominal depth of 3 cm. Samples collected were HCA1 and HCA2. The samples were preserved in glass jars at - 20 ºC;
- Heavy metal samples were collected using a plastic scoop to a nominal depth of 3 cm. Samples collected were HMA1 and HMA2. The samples were preserved in polythene bags at – 20 ºC;
- Particle size samples were collected using a plastic scoop to a nominal depth of 3 cm. Samples collected were PSDA1 and PSDA2. The samples were preserved in polythene bags at -20 ºC;
- Biodiversity DNA samples were collected using a sterile plastic spatula to collect approximately 5 g of sediment in six Whirl-pak(R) bags to collect BIOA1, BIOA2, BIOB1, BIOB2, BIOC1 and BIOC2.

3.1.2.2 Macrofauna Sample Processing

Macrofauna samples were processed as follows:

- After the sediment had been described and photographed the top 10 cm to 20 cm was transferred into a 0.5 mm mesh sieve along with the remaining supernatant water;
- The sample was then transferred to the Wilson autosiever for washing;

- Once the sediment had been removed the sample was transferred to containers labelled with the job number, station code, and fauna code (FA or FB depending on replicate) and fixed in 10 % formal saline (a buffered 4 % formaldehyde solution in seawater). The sample containers were then sealed, hazard labelled and stored securely on deck.

3.1.3 Combined Water Sampling and Profiling

The following procedure describes the deployment and recovery of the Valeport 606+ deepwater conductivity temperature depth (CTD) and simultaneous deployment and recovery of 5 litre Niskin water samplers. The CTD profiles were acquired simultaneously with the collection of near-seabed (bottom) water samples. Mid-depth and near-surface samples were then acquired in two subsequent deployments of Niskin sampler only. This section also describes the subsequent uploading and processing of water profile data and handling of water samples.

3.1.3.1 Deployment and Recovery

The CTD and Niskin water samplers were deployed using the following methodology:

- The CTD was set up to record conductivity, temperature, depth, turbidity, pH and dissolved oxygen (DO). Both the pH and DO sensors were calibrated onboard prior to survey operations;
- After calibration the data output from the CTD underwent a visual check to ensure that the readings were accurate and the pH and DO sensors had not drifted after calibration;
- At each station the initial drop had a clump weight, beacon, CTD and two 5 litre Niskin water samplers attached to the lifting wire 1 m apart.
- The Niskin bottles were armed and a messenger weight suspended under the top sampler. The messenger weights were rigged so that once the first Niskin was triggered a domino effect would take place triggering that suspended below;
- The equipment was deployed over the starboard side using the A-frame;
- Once deployed the CTD was held at the surface for a period of approximately five minutes to allow the profiler to acclimatise to environmental conditions;
- The equipment was then lowered to the desired depth at a rate of 0.5 m/s to 1.0 m/s. When at the desired depth deployment stopped and a messenger weight was attached to the lift wire. The weight was then released to trigger the samplers;
- A conservative fall rate was used to determine release time after which a positional fix for the bottom sample was taken by the surveyor;
- The equipment was then recovered to deck with each item of equipment being removed from the wire as it paid in;
- The Niskin samplers were set to sample at three depths the surface (5 m), below the thermocline and 10 m above the seabed.

3.1.3.2 Water Profile Processing

The CTD was rinsed with clean water immediately after deployment – the plug area was dried after rinsing. Data were uploaded from the unit (.dat format) and translated into a text file (.000 format) with the pressure tare applied. These raw data were backed up to hard drive immediately.

The translated data were copied into Water Profile QA.xls and data quality checked. The following acceptance criteria applied:

- All data must be within expected values for seawater (e.g. pH = 7.8 to 8.5; DO = approximately 100 % at surface and declines with depth);
- Data should be collected for the duration of both the down and up casts;
- Data should be consistent between down and up casts.

Occasional spikes in data (due to sensor interference) are acceptable as is some variation in readings at depths where profiler is stationary (i.e. where Niskin water samplers fitted or samples taken); this occurs due to mixing effects, which the fast response DO meter is particularly susceptible to.

3.1.3.3 Water Sample Processing

The Niskin water samplers were cleaned after each deployment, after the following subsamples were collected:

- One heavy and trace metal sample (HMA1) was collected at each depth and stored in 500 mL plastic bottle at between 4 ºC and 6 ºC;
- One total suspended solid (TSSA1) sample was collected at each depth and stored in 1 L plastic bottle between 4 ºC and 6 ºC;
- One total organic carbon (TOCA1) sample was collected at each depth and stored in glass vials at between 4 ºC and 6 ºC;
- Two hydrocarbon samples (HCA1 and HCA2) were collected at each depth and stored in amber glass bottles at -20 ºC;
- Six biodiversity DNA samples (BIOA1, BIOA2, BIOB1, BIOB2, BIOC1 and BIOC2) were collected at each depth, filtered and stored in Whirl-pak® bags at -20 ºC;
- One spare sample was collected at each depth and stored in 1 L plastic bottle.

Figure 3.1 presents operational photographs of the equipment used during the environmental survey.

Figure 3.1: Operational photographs showing the box corer (left), water sampling (centre) and macrofaunal processing using a Wilson autosiever (right)

4. RESULTS

4.1 Field Operations

Appendix C provides details of all survey locations and sample and data acquired.

4.1.1 Sediment Sampling

Grab sampling was successfully conducted at all eight proposed sediment stations. Table 4.1 presents the samples acquired and actual sampling coordinates. Figure 4.1 presents a spatial display of the actual sampling and drop-down camera locaitons.

Table 4.1: Completed Environmental Survey Sampling Stations, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N				
Station	**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Sample Acquisition**
EBSHH_01	483 901.7	880 800.3	1039.0	FA, FB, BIO
EBSHH_01	483 880.6	880 796.5	1037.0	PC
EBSHH_02	488 359.2	878 553.6	1098.1	PC, FA, FB, BIO
EBSHH_03	492 842.9	876 316.2	1110.1	PC, FA, FB, BIO
EBSHH_04	484 335.6	876 094.4	887.9	PC, FA, FB, BIO
EBSHH_05	488 811.0	873 870.1	926.1	PC, FA, FB, BIO
EBSHH_06	493 624.9	871 760.4	938.0	PC, FA, FB, BIO
EBSHH_07	484 789.1	871 407.7	673.2	PC, FA, FB, BIO
EBSHH_08	489 254.6	869 170.5	722.1	PC, FA, FB, BIO

Notes:
BSL = Below sea level
FA/FB = Faunal sample A/B
BIO = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample

4.1.2 Seabed Video/Photography

Photographic stills and video data were successfully acquired at all nine proposed drop-down camera stations and at the six proposed camera transects. Stations EBSHH03 and EBSHH06 were repeated due to technical issues. Acquisition of video and photographic data was successful on the second attempt at station EBSHH05DD, due to marginal sea conditions affected the vessel manoeuvrability on the first attempt. Poor sea conditions prevented acquisition of good quality stills at station EBSHH01DD, this station was repeated and on the fourth attempt, stills images were accepted by the onboard client representative. Table 4.2 presents the acquired video and photographic data.

Table 4.2: Completed Environmental Survey Camera Transects, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N						
Transect		**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
TR01_part1	SOL	483 267.6	856 086.6	111	42	7 min 47 sec, 10 stills
	EOL	484 500.2	858 711.5	109		
TR01_part2	SOL	484 534.7	858 748.6	103	200	20 min 39 sec, 41 stills
	EOL	484 669.0	858 896.4	103		
TR02_part1	SOL	483 136.9	856 254.5	95	148	16 min 48 sec, 33 stills
	EOL	483 230.1	856 139.4	96		
TR02_part2	SOL	483 232.7	856 135.9	94	60	8 min 3 sec, 13 stills
	EOL	483 267.6	856 086.6	96		
TR03	SOL	486 939.4	856 840.3	104	183	21 min 19 sec, 38 stills
	EOL	487 108.9	856 909.6	105		
TR04	SOL	489 648.0	852 133.1	100	266	29 min, 59 sec 63 stills
	EOL	489 821.7	852 334.2	99		
TR05_part1	SOL	486 551.3	853 954.9	99	50	6 min, 56 sec 12 stills
	EOL	486 592.7	853 927.6	101		
TR05_part2	SOL	486 600.0	853 923.6	100	62	8 min, 58 sec 22 stills
	EOL	486 648.6	853 885.2	95		
TR06_part1	SOL	490 481.3	855 793.1	112	101	12 min, 17 sec 22 stills
	EOL	490 582.6	855 798.4	109		
TR06_part2	SOL	490 594.7	855 799.2	110	83	14 min, 58 sec 23 stills
	EOL	490 677.0	855 792.8	111		
Drop-down camera						
EBSHH01DD	SOL	483 850.9	880 790.1	1031	75	13 min, 44 sec 14 stills
	EOL	483 925.7	880 796.7	1031		
EBSHH01DDa	SOL	483 854.2	880 795.2	1033	66	12 min, 17 sec 19 stills
	EOL	483 919.2	880 805.9	1034		
EBSHH01DDb	SOL	483 843.4	880 804.1	1034	45	10 min, 47 sec 8 stills
	EOL	483 887.9	880 801.7	1035		
EBSHH01DDc	SOL	483 849.5	880 792.5	1034	85	19 min, 16 sec 26 stills
	EOL	483 934.5	880 799.0	1036		
EBSHH02DD	SOL	488 296.6	878 534.7	1094	104	17 min 49 sec 21 stills
	EOL	488 392.2	878 576.4	1097		
EBSHH03DD	SOL	492 803.0	876 326.8	1107	61	7 min, 43 sec 10 stills
	EOL	492 863.4	876 332.1	1107		
EBSHH03DDa	SOL	492 781.4	876 327.3	1106	77	15 min, 3 sec 30 stills
	EOL	492 857.4	876 317.2	1108		
EBSHH04DD	SOL	484 267.2	876 107.1	880	93	15 min, 21 sec 26 stills
	EOL	484 360.0	876 103.3	883		
EBSHH05DD	SOL	488 753.3	873 859.9	921	71	14 min, 49 sec 13 stills
	EOL	488 821.0	873 882.7	922		
EBSHH05DDa	SOL	488 761.6	873 859.7	917	70	10 min, 57 sec 17 stills
	EOL	488 832.0	873 857.8	922		
EBSHH06DD	SOL	493 608.0	871 754.2	933	21	

Geodetic Parameters: WGS84 UTM Zone 21 N						
Transect		**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
	EOL	493 628.0	871 759.5	933		13 min 27 sec 19 stills
EBSHH06DDa	SOL	493 622.7	871 738.0	935	106	20 min, 56 sec 21 stills
	EOL	493 611.4	871 843.3	932		
EBSHH07DD	SOL	484 722.1	871 373.5	663	96	15 min 42 sec 25 stills
	EOL	484 808.6	871 414.7	663		
EBSHH08DD	SOL	489 191.7	869 161.8	716	112	27 min 10 sec 39 stills
	EOL	489 301.6	869 181.5	723.6		
GEOPC010DD	SOL	487 652.4	873 544.8	879.2	66	14 min 0 sec, 15 stills
	EOL	487 711.2	873 574.6	880.9		

Notes:
BSL = Below sea level
SOL = Start of line
EOL = End of line

4.1.3 Water Sampling and Profiling

A complete suite of water samples was successfully collected at all the eight water stations. Two water profiles were collected at all stations except stations EBSHHW04 and EBSHHW07. At station EBSHHW04 the Valeport CTD failed during the first deployment. At station EBSHHW07 one profile was accepted by the onboard client representative. Table 4.3 provides details of sample and water profile data acquisition. Appendix D presents the water profile data.

Table 4.3: Completed Environmental Water Sampling Stations, Hammerhead Development

Geodetic Parameters: WGS84 UTM Zone 21 N						
Station	Easting [m]	Northing [m]	Sample Depth [m BSL]			Sample/Data Acquisition
			Top	Mid	Bottom	
EBSHHW01	483 889.8	880 797.8	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW01	483 890.6	880 799.7	5			BIOC1, BIOC2
EBSHHW01	483 895.6	880 798.9		202		BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW01	483 895.9	880 799.0		202		BIOC1, BIOC2
EBSHHW01	483 877.2	880 811.0			1027	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW01	483 888.0	880 797.3			1030	BIOC1, BIOC2, WP
EBSHHW02	488 356.8	878 557.8	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW02	488 356.4	878 560.4	5			BIOC1, BIOC2
EBSHHW02	488 359.3	878 562.1		205		BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW02	488 358.7	878 561.2		198		BIOC1, BIOC2
EBSHHW02	488 357.6	878 569.3			1090	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW02	488 359.9	878 565.3			1090	BIOC1, BIOC2, WP
EBSHHW03	492 832.5	876 320.2	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW03	492 831.7	876 321.6	5			BIOC1, BIOC2
EBSHHW03	492 833.5	876 319.9		200		BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW03	492 834.1	876 319.4		203		BIOC1, BIOC2
EBSHHW03	492 838.1	876 298.4			1100	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW03	492 829.9	876 310.3			1101	BIOC1, BIOC2, WP
EBSHHW04	484 336.4	876 108.0	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW04	484 335.0	876 107.3	5			BIOC1, BIOC2
EBSHHW04	484 334.2	876 106.9		237		BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW04	484 340.9	876 104.6		239		BIOC1, BIOC2
EBSHHW04	484 336.8	876 100.8			880	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW04	484 332.0	876 108.9			895	BIOC1, BIOC2, WP
EBSHHW05	488 797.4	873 860.8	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW05	488 797.5	873 862.0	5			BIOC1, BIOC2
EBSHHW05	488 799.8	873 869.1		204		BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW05	488 802.4	873 862.1		203		BIOC1, BIOC2
EBSHHW05	488 820.3	873 846.7			918	WP
EBSHHW05	488 814.9	873 854.3			916	WP
EBSHHW05	488 806.8	873 865.4			918	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW05	488 815.9	873 852.7			918	BIOC1, BIOC2
EBSHHW06	493 623.3	871 765.8	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW06	493 623.6	871 767.1	5			BIOC1, BIOC2
EBSHHW06	493 626.6	871 769.1		199		BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW06	493 626.7	871 762.8		201		BIOC1, BIOC2
EBSHHW06	493 645.0	871 752.0			931	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW06	493 629.8	871 745.7			933	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW07	484 779.9	871 406.7	5			BIOC1, BIOC2

Geodetic Parameters: WGS84 UTM Zone 21 N						
Station	Easting [m]	Northing [m]	Sample Depth [m BSL]			Sample/Data Acquisition
			Top	Mid	Bottom	
EBSHHW07	484 779.1	871 394.9	5			BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW07	484 780.5	871 401.0		198		BIOC1, BIOC2
EBSHHW07	484 778.1	871 401.9		200		BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW07	484 797.9	871 391.3			662	BIOA1, BIOA2, BIOB1, BIOB2, WS
EBSHHW07	484 794.3	871 392.2			663	BIOC1, BIOC2
EBSHHW08	489 251.3	869 172.1	5			BIOA1, BIOA2, WS
EBSHHW08	489 252.2	869 171.6	5			BIOB1, BIOB2
EBSHHW08	489 252.1	869 170.3	5			BIOC1, BIOC2
EBSHHW08	489 255.1	869 174.8		203		BIOA1, BIOA2, BIOB1, BIOB2, WS, WP
EBSHHW08	489 261.6	869 164.2		201		BIOC1, BIOC2
EBSHHW08	489 264.4	869 157.1			711	BIOA1, BIOA2, WS, WP
EBSHHW08	489 257.7	869 163.3			716	BIOB1, BIOB2
EBSHHW08	489 262.3	869 162.4			717	BIOC1, BIOC2, WP

Notes:
BSL = Below sea level
WS = Physico-chemical water sample
WP = Water profile
BIO = Biodiversity DNA sample

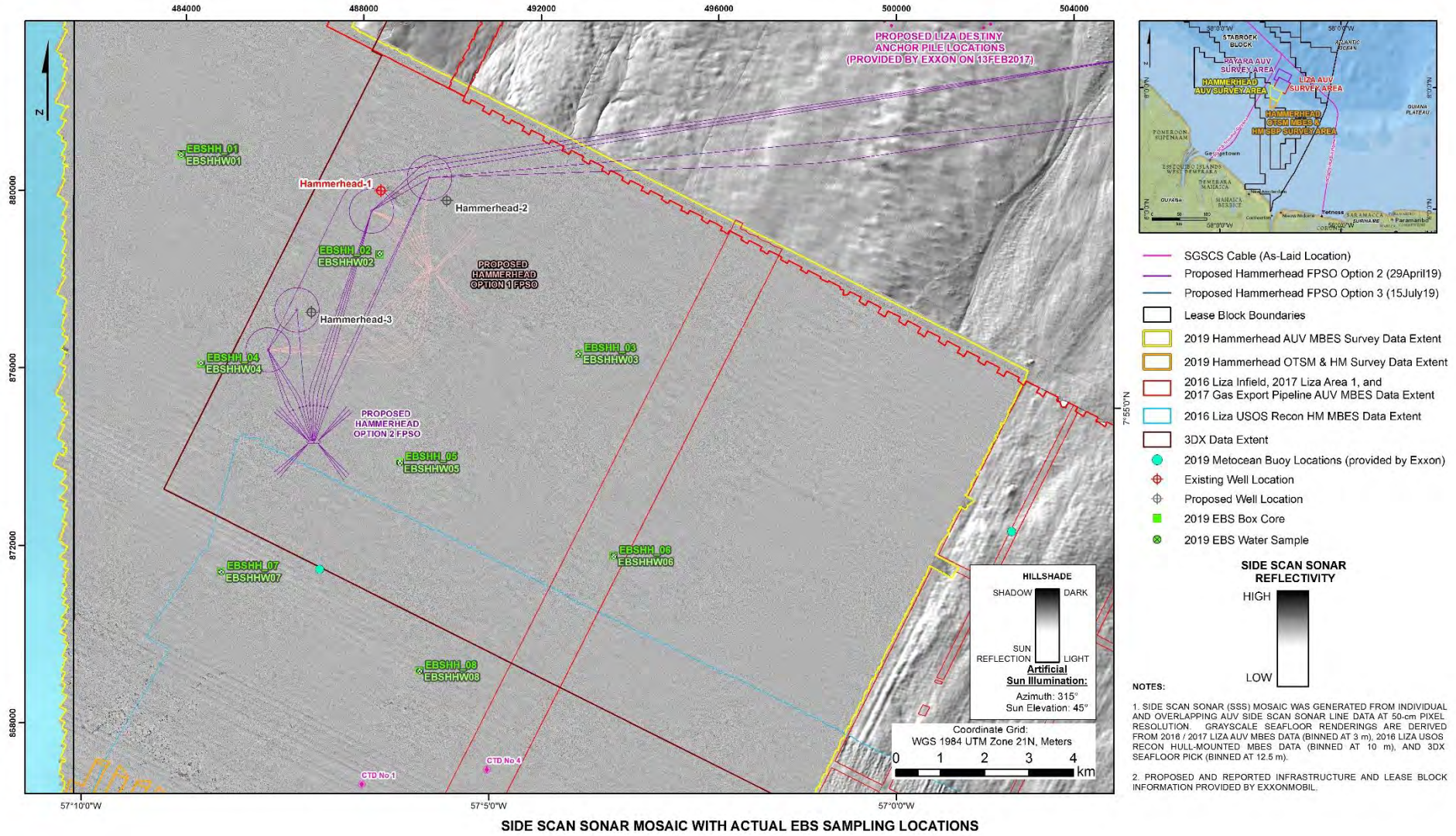


Figure 4.1: AUV survey area actual environmental sampling locations overlain on side scan sonar mosaic

4.2 Seabed Habitats and Fauna

These results are preliminary and subject to change following a full analysis completed in the office.

4.2.1 Seabed Sediments

Seabed sediment within the AUV survey area consisted of fine mud with a minimal amount of shell material. Higher relief structures were recorded on the upper shelf slope in water depths ranging between approximately 95 m and 112 m. These structures were seen across the whole survey area running parallel to the shelf break. They comprised of widely spaced irregular patches with lengths varying from 20 m to more than 100 m, with heights of up to 6 m. The general bedrock or possible carbonate reef morphology appeared to consist of two types; ridge-like features (in general 5 m in height) orientated perpendicular to the shelf break interspersed by patches of sandy mud, and low relief patch reefs.

4.2.2 Benthic Fauna

Benthic fauna was sparse within the AUV survey area, with fauna including bryozoans (Bryozoa) and sponges (Porifera). Faunal tubes and burrows were also recorded.

The faunal and floral community associated with the hard substrate in the shallower waters was dominated by crustose coralline algae (Corallinaceae), black corals (Antipatharia), and sponges (Porifera), faunal turf (Hydrozoa/Bryozoa), shrimps (Caridea), brittlestars (Ophiuroidea) and various fish species.

Figure 4.2 presents example photographs of observed benthic communities.

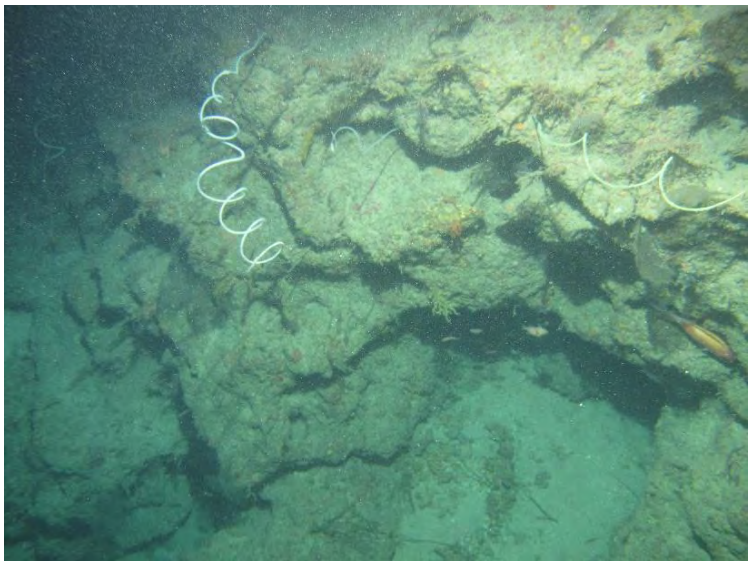
4.2.3 Potentially Sensitive Habitats or Species

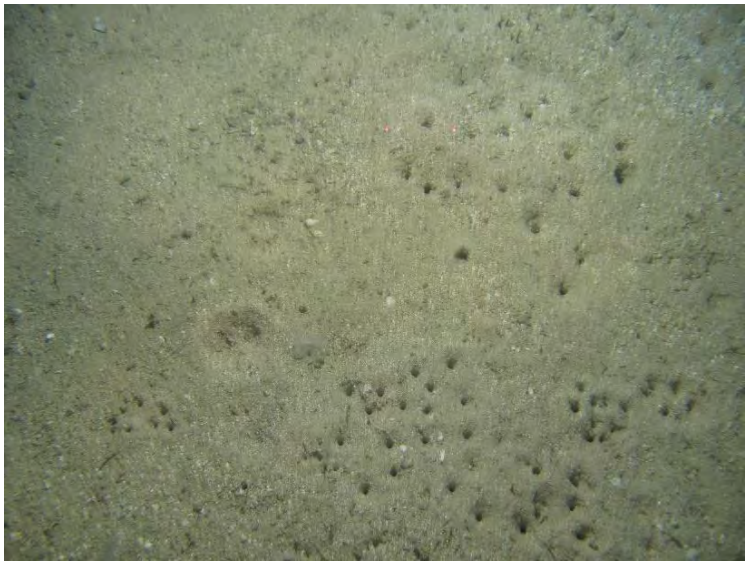
The bedrock or possible carbonate reef areas observed with the Hammerhead shelf area may constitute a potentially sensitive habitat due to the presence of possible sensitive species. These areas will be further assessed in the Environmental Baseline Results report (Volume 8).

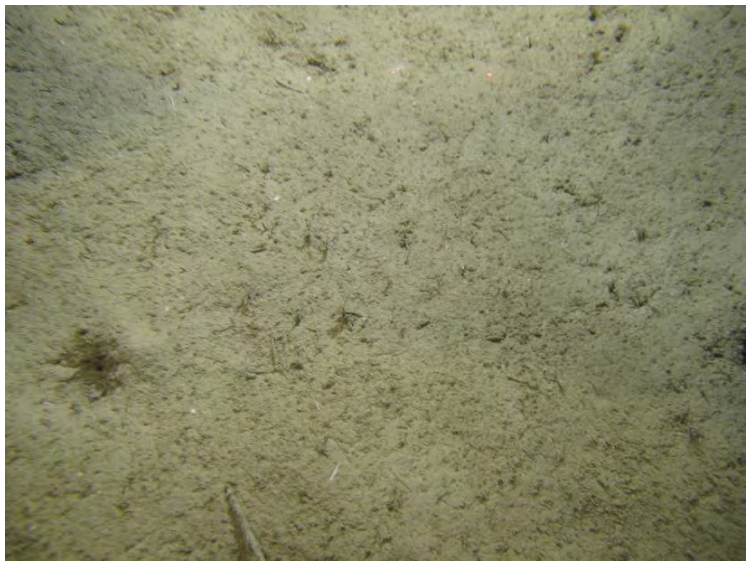
4.3 Water Profile Data

The water profiles obtained at all stations (Appendix D) were typical of the oceanic water column within the region. There was an upper layer of wave-mixed water, extending to approximately 20 m depth, where all parameters remained relatively constant. Beyond this there was a distinct thermocline, extending to approximately 200 m depth, over which temperature and dissolved oxygen concentration decreased rapidly, salinity and conductivity showed an initial trend of increase, followed by decrease and pH decreased slightly. Turbidity was consistently low throughout the water column.

These results will be discussed in detail in the Environmental Baseline Results Report (Volume 8).







A: Photograph TR05_23

Whip coral (Antipatharia)
Sponges (Porifera)
Faunal turf (Hydrozoa/Bryozoa)
Soft coral (Alcyonacea)

B: Photography TR03_13

Black coral (Antipatharia)
Crustose coralline algae (Corallinaceae)
Brittlestar (Ophiuroidea)
Sponge (Porifera)

C: Photograph TR04_16

Faunal burrows

D: Photograph EBSHHDD01c_05

Faunal burrows

Figure 4.2: Example seabed sediment photographs , Hammerhead Development

APPENDICES

A. GUIDELINES ON USE OF REPORT

B. WORK INSTRUCTIONS

B.1 SES DEEPWATER CAMERA

B.2 BOX CORING

B.3 SEDIMENT SAMPLE ACCEPTANCE AND PROCESSING

B.4 WATER SAMPLING AND PROFILING

C. LOGS

C.1 SURVEY LOG

C.2 SEDIMENT LOG

D. WATER PROFILES

A. GUIDELINES ON USE OF REPORT

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B. WORK INSTRUCTIONS

B.1 SES DEEPWATER CAMERA

B.1.1 Purpose, Definitions and References

This procedure has been prepared in order to provide for the safe deployment and recovery of the SES camera system.

NB: The procedure for all lifting operations on the vessel remain the responsibility of the Party Chief and Technical Coordinator (if present) or Master.

B.1.2 Instructions

B.1.2.1 General

Seabed photography (digital stills) and video footage are routinely conducted as part of ecology surveys and/or to investigate selected anomalous seabed features, identified from geophysical data.

Seabed photography is undertaken using a frame mounted, Mulitport Subsea Unit attached to an STR underwater camera, and separate STR flash unit and LED lamps. The seabed video footage is displayed through the topside unit onto monitors and recorded. A navigational data string from a USBL beacon attached to the camera frame prior to deployment is overlain onto the video footage, supplying the following information; time, date, easting, northing and depth. The client name, contractor name, job number and job description are also displayed in addition to station transect number (manually updated).

B.1.2.2 Personnel

A minimum team of four personnel is required during the launch and recovery of the camera system. All team members shall be appropriately qualified and adequately trained to carry out their delegated tasks and responsibilities safely. The camera system handlers will be responsible for deployment as normal practice, assisted by a winch/A frame operator. At least two persons will be required for manual handling of the video during the deployment and recovery phase.

The team will comprise:

- 1 × operator: will be clearly identified and will be in charge of the winch and A-frame or controls when deploying and recovering the system;
- 2 × camera system handlers: assisting with recovery and deployment of the video and monitoring of the video footage;
- 1 × surveyor: recording date, time, depth, position and other data during deployment, sampling and retrieval.

B.1.2.3 General Handling and Set Up

- The vessel will set up at the proposed deployment location, as advised by the online surveyor, on an appropriate heading with respect to prevailing environmental conditions;
- The shift engineer will ensure that hydraulic power is available to the deck equipment to be used;
- The online surveyor will ensure the HiPAP pole is deployed and the correct beacon code selected on the HiPAP console;

- Prepare the STR camera for deployment;
- Ensure electrical power to the camera is switched off before deployment;
- Manually move the camera from its stowage position to the deployment position. Four people will be required for this task and manual handling procedures are to be adhered to;
- If not already installed, spool out sufficient wire from the winch to connect the cable counter block;
- A safety rope should be fitted between the winch cable and the camera; this is to prevent loss of the equipment;
- Ensure a beacon is attached to the camera frame and check the correct channel is set;
- Reset the cable counter to zero.

B.1.2.4 Deployment

- The surveyor will communicate to the deployment team that the vessel is in position and that they are clear to deploy the camera;
- The winch is carefully hauled in, raising the camera above the deck and positioned over the stern of the vessel. If deemed necessary, a tag line can be attached to help stabilise the deployment and recovery operation;
- The camera will be manoeuvred clear of the vessel and lowered until fully submerged;
- One of the video handlers should return to the video system monitor. The camera lamps and laser scaling lights are then switched on, the video overlay unit checked for correct operation (i.e. ensure it is updating regularly) and the video recording software set to record;
- The winch control will be switched to remote and spooling gear confirmed as operating correctly;
- The online surveyor will check that the beacon position is being received;
- Ensure the instrument room observation monitors are configured to observe the block and winch spooling. This is a safety requirement and must be observed at all times when the winch is being remotely operated.

B.1.2.5 Recovery

- When photographic/video sampling has been completed, the online surveyor should be informed that the system will be raised to the sea surface;
- The lamps and recording systems should be switched off;
- The video handlers should prepare on deck for recovery of the video system. The winch operator will switch control to local and start to recover the camera. The video handlers will indicate when the camera is just below the sea surface;
- Once at the sea surface, the online surveyor and bridge will be informed;
- When recovering the system to the deck, care must be taken to avoid the equipment striking the ship's hull and from swinging out of control;
- The A-frame/winch operator will then slowly raise the camera clear of the water until it is just above the gunwhale;
- It is important the camera is steadied as soon as possible;
- With the camera inboard, carefully pay out winch cable to lower the camera onto the deck;

- At the end of all video operations, four people should then manually lift the camera frame to its stowed position where it will be secured;
- The beacon should be switched off;
- When recovery has been completed and all personnel are clear of the deck, inform bridge crew and stop hydraulic pumps locally on the back deck.

B.1.3 Records

Documents and files generated by this work instruction are:

Title	Document No.	Holder	Retention Period
Field logbook	TP25_006	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Video log	FM25_011	Project Manager	4 years from job close out date unless otherwise stated within the client contract

B.2 BOX CORING

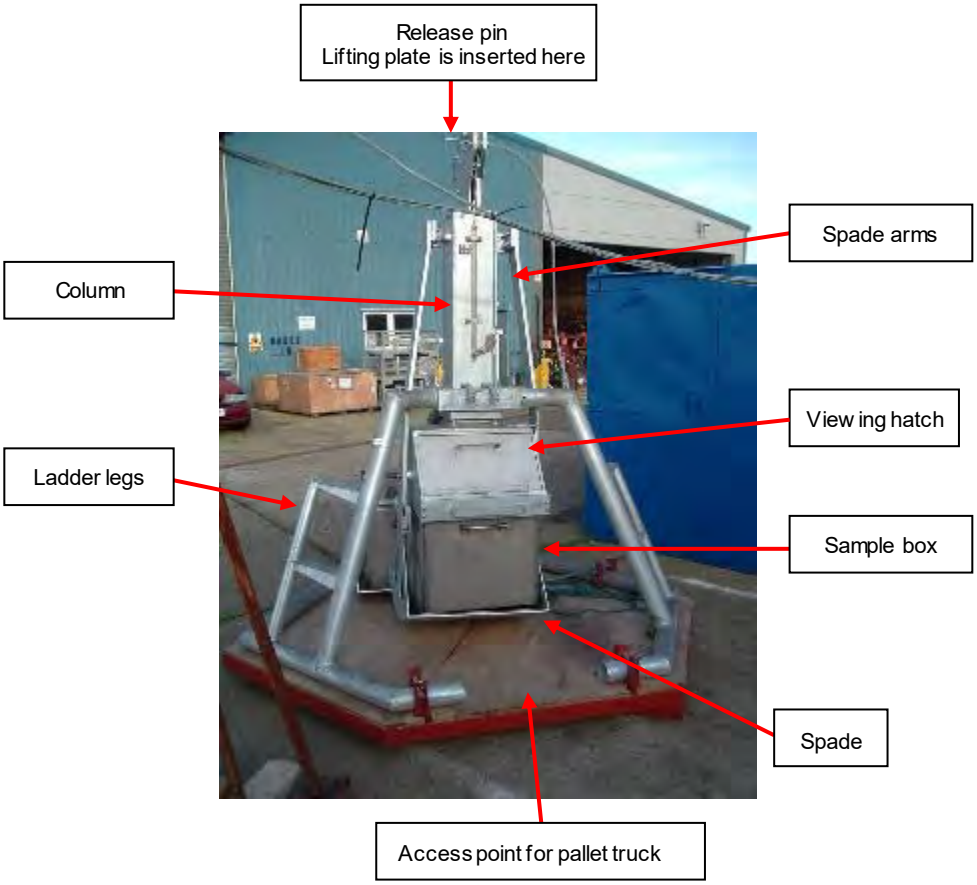
The purpose of this work instruction is to describe the safe deployment and recovery of USNEL type box corers, when used for acquisition of biological and chemical sediment samples, and who shall be responsible for the process.

NB: The procedure for all lifting operations on the vessel remain the responsibility of the Technical Coordinator (if present) or Master.

B.2.1 Background

USNEL box corers are routinely used as part of deepwater environmental surveys and in shallower water surveys where investigation of subsurface strata is required (e.g. cuttings piles surveys).

The diagram below shows the key parts of the 0.25 m^2 USNEL corer.



B.2.2 Personnel

A minimum team of four personnel is required during the launch and recovery of the USNEL box corer. All team members shall be appropriately qualified and adequately trained to carry out their delegated tasks and responsibilities safely. At least two persons will be required for manual handling of the corer during the deployment and recovery phase. They will be assisted by one winch/A frame operator.

The team will comprise:

- 1 × operator: will be in charge of the winch and A-frame controls when deploying and recovering the corer;
- 2 × deck handlers: assisting with recovery and deployment of the corer At least one of these must be an environmental scientist/ecologist, who will be responsible for subsequent sample processing;
- 1 × surveyor: recording date, time, depth, position and other data during deployment, sampling and retrieval. These details will be logged in either the field logbook (TP25_006).

B.2.3 Operational Protocol

B.2.3.1 General Handling

- Due to the box corer's size and weight, lift the box corer with a mechanical lifting device;
- Check that the safety pin is in place to avoid incidental firing;

- During mobilisation, and lifting operations, heavy duty gloves, safety footwear and hard hats must be worn;
- Check the corer deployment/landing position to ensure that handlers can move freely around the corer, and if necessary be able to move out of the way in case it swings;
- Ensure the corer deployment/landing position is within clear line of site of the winch and A-frame operator;
- Check there are adequate fixed points to secure the corer while not in use must also be present adjacent to the landing position. When not in use, secure the corer to the deck/gunwale by means of an appropriately rated ratchet strap.

B.2.3.2 Set Up

- If a beacon is to be used (as defined within the Scope of Works), secure to the corer by means of jubilee clips. House the beacon within a protective tube to prevent damage if the corer swings against the vessel.

B.2.3.3 Loading/Arming the Corer

- The main lifting wire will pass over a suitable diameter, suitably load tested block (minimum SWL of 5 t);
- Manoeuvre the corer into its deployment position with the safety pins in place;
- Attach the main lift wire to the corer wire;
- Lock the lifting plate in the corer head by the release pin (release the trigger column locking mechanism during this process);
- Swing the spade open;
- Lodge the inspection hatches open by securing the lugs in the hatch closure mechanism, rotating to the open position;
- Inform the bridge and the surveyor that the corer is ready to deploy.

B.2.3.4 Deploying

- Loop two 5 m to 10 m tag lines around the corer legs. Secure the end of each tag line, and pass the other end through a pad eye / shackle to be handled by the deck personnel;
- The surveyor: check the proximity of the vessel to the intended sampling location. When satisfied that the vessel is in the correct position, request permission from the bridge to deploy the corer. If the vessel is a distance from the intended sampling location, inform the deck to standby;
- Once permission is given from the bridge, inform the deck to deploy the corer;
- The winch and A-frame operator: manoeuvre the block so it is directly over the corer. Lift up on the winch wire so that the weight of the corer is taken off the safety pins. Remove the safety pin;
- Deploy the corer by simultaneously extending the A-frame or manoeuvring the crane and paying out from the winch. The base of the corer should not be lifted above knee height;
- Once outboard, lower the corer to the surface, and remove the tag lines;
- Lower the corer at maximum speed until the corer is approximately 20 m from the seabed (as defined by the beacon or winch wire markings);

- Once the corer is 20 m above the seabed, pause the descent to allow the beacon to steady. Once the depth indicated by the beacon is steady and the corer is seen to be within acceptable proximity to the target position, slowly lower the corer to the seabed. Monitor the beacon depth during the final stage of deployment to ensure that deployment is slow to prevent 'bow wave' displacement of superficial sediment;
- Surveyor: notify the deck personnel when the corer has stopped descending;
- Stop the winch. Take a positional fix of the sampling location, before the corer is recovered.

B.2.3.5 Retrieval

- Recover the corer at a speed of approximately 1 ms^{-1} or less;
- When the corer reaches the surface, stop the recovery. Retract the A-frame so that the corer rests against the stern of the vessel. Slowly winch up so that the landing frame is just above the deck level;
- Loop the tag lines around the landing frame legs and run the end back through the pad eye/shackle;
- Recover the corer to the deck by simultaneously using the winch and A-frame.
- The two deck handlers: steady the corer on retrieval using the tag lines;
- Place the corer on deck with the spade resting on the deck;
- Lift the corer until just a few centimetres above deck level and rotate so that the access point in its base faces forward. Lower the corer so it is just on deck. Place chocks under the edges of the spade;
- Release the spade by undoing the two clamps on each side and free the box by removing the front plate;
- Remove the box and spade and secure out of the deployment area for subsequent sample processing;
- Fit the replacement box and spade to the corer so that it is ready for redeployment;
- A pallet truck can be used to assist in moving the sample and fitting the replacement box and spade;
- Inform the bridge that sampling has been completed.

Sample acceptance and processing (WI25_007) should be referred to for the subsequent process.

B.2.4 Records

Documents and files generated by this work instruction are:

Title	Document No.	Holder	Retention Period
Field logbook	TP25_006	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Sediment sample log	FM25_008	Project Manager	4 years from job close out date unless otherwise stated within the client contract

B.3 SEDIMENT SAMPLE ACCEPTANCE AND PROCESSING

B.3.1 Acceptance

Once the box corer has been recovered and is secure, the inspection doors can be lifted, (if present), or the sampler contents otherwise inspected and a decision made by the environmental scientist/ecologist as to whether to accept or reject the sample. The sample is considered unacceptable in the following instances (and is classified as a no sample):

- Evidence of surface sediment washout caused through the jaws not closing properly;
- Inspection hatches open or not closed properly allowing sediment washout;
- Sediment sample taken on an angle i.e. where the corer has not struck the seabed true;
- Disruption of the sample through striking the side of the vessel;
- All box core samples to be a minimum of approximately 10 cm deep. Sample depth is measured by a steel ruler;
- Sample is more than the accepted range from the target location (the sample tolerance for each project should be defined by the Scope of Works);
- The presence of a Hag Fish (*Myxine glutinosa*) and/or other mucous coagulants;
- The sample is unacceptable to the environmental scientist/ecologist or client representative for any other reason.

If the sample is deemed acceptable, it is retained for either macrofaunal analysis or physico-chemical analysis.

Under exceptional circumstances, where sampling success is limited by substrate type, samples that do not meet the acceptance requirements may be retained for analysis. This must be recorded in the field logbook (Template TP25_006), or sample log (Form FM25_008) or deck sample details (Template TP25_011) and a client concession form (Form FM25_007) completed and signed off by the client representative.

B.3.2 Sample Logging

- Ensure all samples are logged to client specifications;
- Sample details should be recorded within the field logbook (Template TP25_006). Details which must be recorded for all samples acquired are:
  - Date and time of collection;
  - Personnel undertaking sample processing;
  - Site/station code and individual sample identifier (describing analysis and replicate);
  - Sampling equipment;
  - Sieve aperture (for screening of faunal samples only);
  - Number and type of container(s) used;
  - Acquisition coordinates;
  - Water depth;
  - Approximate sample volume (litres) or bite depth (cm);

- Visual sediment description, including stratification, if applicable (see Section B.3.3);
- Colour, including stratification, if applicable (see Section B.3.4);
- Presence of conspicuous fauna/bioturbation;
- Other sediment characteristics (e.g. smell of H_2S, anthropogenic debris, indicators of sewage contamination etc.);
- Weather conditions and sea state at time of sampling. As a minimum this should be recorded for each day of operations, with significant changes over the course of a day also recorded.

- In box core samples sample depth is determined by measuring from the top of the corer's box to the sediment surface and subtracting this measurement from the total box depth. As a minimum the rulers used must be cleaned with seawater between samples; if samples are to be subsampled for chemical analyses, only acetone cleaned etched stainless steel rulers may be used;
- Where clients require sample size to be determined in litres, graduated sample collection hoppers are to be used. The sediment should be levelled within the hopper, and the sample size ascertained from the graduations (I litre increments) from the side of the hopper;
- Where pH, temperature or redox data are required these data must be obtained as specified in WI25_017 Calibration and Use of Hanna HI98121 Redox Probes and recorded within the field logbook (Template TP25_006);
- As a minimum a sample from each location should be photographed with a label or site card clearly showing the job number, station number, and a scale bar (ruler). A macro (close-up) photograph of the sample may also be required within the scope of works. Photographs must be in focus and well-lit, with the camera lens kept free of dirt and water droplets. To allow consistent presentation of reports and electronic deliverables the label or site card should always be located in the top left corner of the photograph;
- Photographs of the residues retained on the sieve from the biological samples may be required within the scope of works. Care must be taken to ensure that the macro (close-up) photographs are in focus.

B.3.3 Sediment Composition Description

The sediment composition of samples needs to be described and recorded on the field logbook (Template TP25_007).

Sediments be visually classified in accordance with the Folk (1954) sediment classification. The particle size classes within this are shown in Table B.1 and the means by which the proportions of these classes are combined to create a sediment description is shown Figure B.1.

If cobbles or boulders are present within the samples, these should be noted, but will not form part of the Folk classification. The description will be subjective and will only be used to inform preliminary project reporting and interpretation; these descriptions will be superseded by quantitative data provided by particle size distribution (PSD) analysis.

It is important to mention the shell content of the sample, if present, as this is not differentiated from gravel in the PSD analysis. Any cobbles or boulders (>64 mm on any axis) present in the sample should be measured along both axes (to the nearest cm rounded up or down) and should not be included in the sample for PSD analysis.

Table B.1: Sediment Particle Sizes and Classification Terms

Particle Size	Wentworth (1922) Classification	Corresponding Folk Class Used in Long (2006) Classification
> 256 mm	Boulder	NA
> 64 to 256 mm	Cobble	
> 2 to 64 mm	Gravel/pebble	Gravel
> 62.5 µm to 2 mm	Sand	Sand
> 4 to 62.5 µm	Silt	Mud
> 1 to 4 µm	Clay	

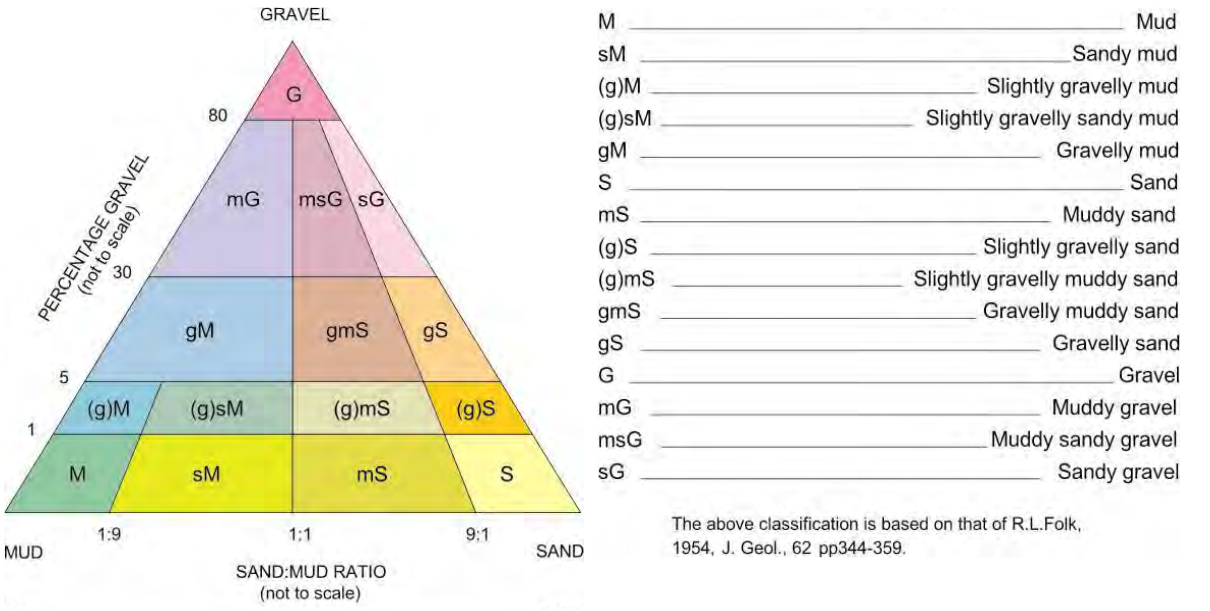


Figure B.1: The BGS modified Folk classification (source: Long, 2006)

Example sample photographs are presented in Figure B.2 along with descriptions and actual proportions of sediment fractions (quantified from PSD data).

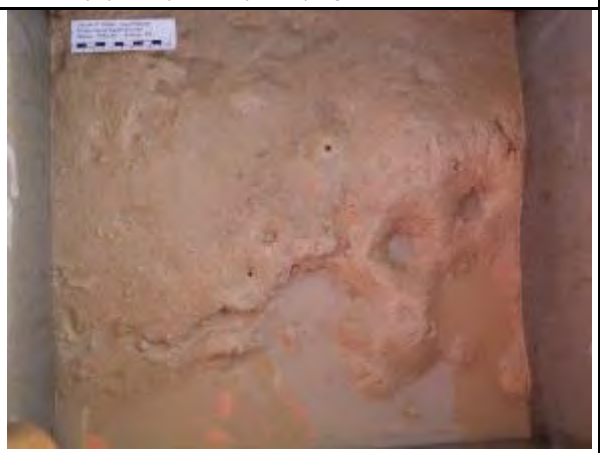
<table>
<tr><td> </td><td> </td></tr>
<tr><td>Sandy (22 %) gravel (71 %) with shell and cobble -sG</td><td>Sandy (47 %) gravel (50 %) with shell</td></tr>
<tr><td> </td><td> </td></tr>
<tr><td>Sand (99 %) - S</td><td>Gravelly (17 %) sand (79 %) - gS</td></tr>
<tr><td>
</td><td>  </td></tr>
<tr><td>Mud (100 %) - M</td><td>Sandy (21 %) mud (79 %) - sM</td></tr>
</table>

Figure B.2: Example photographs of different sediment types with accompanying descriptions and PSD data

B.3.4 Munsell Colour Classification

Munsell colour charts should be used to describe sediment colour. It may not be appropriate to use Munsell colour to describe particularly heterogeneously coloured samples (e.g. gravels, shell hash) but the sediment matrix of muddy/sandy mixed sediments can be described.

The description of colour using Munsell colour charts should be undertaken after any physico-chemical subsamples have been taken, or before processing of macrofaunal samples.

Before using the charts the environmental scientist/ecologist must ensure that they are intact, with no missing pages or colour panels and are in a legible state (the charts are waterproof and can be gently washed if they are excessively dirty). A brief procedure of the use of Munsell colour charts follows; further details of their use are also provided within the books of charts themselves.

- Assessment of sediment colour at the samples surface must be made for all samples. If differently colour underlying strata are present the colour of these, and their depth below surface, must also be recorded. While description of the sediment surface must be conducted immediately after sample collection, it will generally be better to characterise underlying layers after all subsampling has been completed (to minimise disturbance of the sample);
- Allow water film to drain away from the sample;
- Collect a small amount of the sediment to be assessed;
- Flatten the sediment onto a clean fingertip or onto a small piece of paper. Accurate classification can be made easier by putting a dark sample on black background or light sample on a white background;
- Place the sample as close to the colour chart as possible and ensure they are under an adequate light source. Daylight or fluorescent artificial light sources are preferable to incandescent light sources;
- Compare the sample to the colour chart by first selecting the chart of appropriate hue and then selecting the colour chip that most closely matches the sediment colour;
- The selected colour should be recorded using the following notation: 'Hue Value/Chroma', with the colour description also noted e.g. sediment of hue 2.5YR, value 5 and chroma 3, should be recorded as '2.5YR 5/3 Reddish Brown'.

B.3.5 Box Core Sample Processing

After sample logging and photography (using standard procedures from WI25_007), each of the box core samples will be subdivided, processed and stored as detailed in Table B.2.

Table B.2: Sediment Sample Processing and Storage

Subsample (subsample Code(s))	Sample Codes	Treatment	Storage
Temperature; Redox/ORP	NA	In situ testing with sensor inserted to 2 cm, 5 cm and 10 cm depth (3 measurements per sample). Record on logbook TP25_006.	NA
Grain size Distribution, TOM	PSDA1, PSDA2	Collect 250 g sample from 0-3 cm sediment surface using plastic scoop and place into bag.	Ziplock bag (double bagged). Freeze at -20 ºC (±5 ºC)
Hydrocarbons	HCA1, HCA2	Collect 250 g sample from 0-3 cm from surface of sediment using stainless steel scoop, place into glass jar.	500 ml glass jar, Freeze at -20 ºC (±5 ºC)
Metals, TOC	HMA1, HMA2	Collect 250 g sample from 0-3 cm from sediment surface using plastic scoop, place into bag.	Ziplock bag (double bagged). Freeze at -20 ºC (±5 ºC)
Macrofauna	FA1, FB1	Subdivide 0.1 m^2 of the sample, sieve over 0.5 mm mesh and decant to 1 litre plastic pot, add 10 % formalin/seawater solution.	1 litre plastic pot (5 litre buckets available if required). Ambient temperature
Biodiversity	BIOA1, BIOB1, BIOC1, BIOA2, BIOB2, BIOC2	Sample an aliquot (approximately 5 g) of sediment into a ziplock bag using a sterile, single use spatula.	Ziplock bag (3 samples placed into ziplock bag). Freeze at -20 ºC (±5 ºC)

Notes:

i. All sampling must be undertaken while wearing **clean** nitrile gloves. Equipment will be appropriately cleaned prior to use (metal scoops cleaned with acetone, plastic scoops with fresh seawater); single use sterile spatulas will be used for biodiversity samples;
ii. The sample may be left to drain naturally or drained using a siphon. The siphon must be rinsed with seawater after use and decontaminated with DNAse Displace and rinsed with deionized water immediately before use;
iii. The redox potential of each physicochemical sample will be measured using a Hanna HI 98121 handheld sensor; this will be tested prior to the sample being fully drained. Redox potential will be measured at depths of 2 cm, 5 cm and 10 cm below the sediment surface from an area of the sample where macrofauna samples will be extracted (not area used for physico-chemical/DNA sampling). The sensor must be cleaned with seawater after use and decontaminated with DNAse Displace and rinsed with deionized water immediately before use. Accompanying temperature measurement will also be taken to allow standardization to the potential of a hydrogen electrode (Eh). Results will be recorded on form TP25_006;
iv. To minimize the risk of sample contamination, biodiversity (DNA) samples will be extracted before other sample types (immediately after sample fully drained);
v. Macrofauna inserts can then be inserted into the core and the physico-chemical samples taken;
vi. Finally, macrofauna samples should be extracted (to 10 cm depth) and processed.

B.3.5.1 Macrofaunal Processing

Samples retained for macrofaunal analysis are thoroughly washed from the box corer insert into a sediment collection tray. All collection trays, sieves and sieving apparatus must be thoroughly cleaned with a seawater hose (and nylon brush, if necessary) between samples to minimise likelihood of cross-sample contamination.

Samples will be sieved using a 0.5 mm mesh sieve in a Wilson autosiever (WAS) as follows:

- The WAS is connected to a seawater hose (often the ships fire pumps via a standard UK sector fire hose). The Bridge is then requested to turn the pumps on. Due to the intermittent use of the

WAS an additional hose may have to be run off in order to alleviate the pressure built up in the pump system, check if this is required with the bridge and the technical coordinator;

- Ensure that the main valve to the WAS is turned off. The sediment collection tray should then be washed into the WAS sieve using a gentle spray of water from the attached seawater hose. Care should be taken to ensure the entire sample is transferred as some of the animals may be too small to be obvious at this stage;
- If the sieve clogs before the entire sample has been transferred, the sample should be transferred in stages;
- Securely place the lid on the WAS sieve and turn on the main valve on the WAS to start the flow of water. Ensure that water flow is sufficient to remove sediment, but not so high as to displace/damage any animals;
- Once sieving has been completed the WAS main valve should be turned off and the sieving residue (which will include retained fauna) washed to one side of the sieve;
- The animals and remaining sediment are then back-washed into an appropriately labelled container using the seawater hose;
- The samples are fixed by adding an approximately 1:1 ratio mixture of ~20 to 25 % formal saline stock solution and seawater to the samples. Mixing instructions to make these stock solutions are detailed in WI25_018 Formalin Mixing Instructions;
- If undissolved lumps of clay are evident after sieving sodium hexametaphospahate can be added at an approximate concentration of 0.2 % w/v. As over addition of sodium hexametaphospahate will not have detrimental effect on samples, this can be added in approximate quantities of 0.5 level teaspoons per litre of sample/fixative.

B.3.5.2 Sieve Types, Certification and Inspection

All sieves used for macrofauna processing must hold certificates of conformity to BS410 or ISO 3310-1 (woven wire sieves) or ISO 3310-2 (perforated plate sieves). Sieves with a diameter of 30 cm or less will be calibrated in house, in accordance with Fugro GB Marine's sediment laboratory test method (TM08_004 – Calibration of test sieves). Sieves of a diameter of greater than 30 cm will be calibrated by an accredited subcontractor. Copies of the performance check record must be kept, and relevant certificates are to be saved in the job folder. Compiled records of manufacture/performance check dates will also be maintained.

All sieves must be visually inspected before use and if any of the following is noted their use must be discontinued, with the equipment 'red tagged' to indicate that it is faulty:

- Broken wire mesh/visibly damaged perforations;
- Bent wire mesh/perforated plate – this may distort sieve apertures;
- Distorted sieve frames – this may prevent correct sealing of lids in the WAS;
- Damaged/detached seals between the mesh and frame – this may lead to fauna being trapped under seals.

The visual inspection of each sieve when in use must be carried out at least weekly (during extended periods of use) or once per project (for projects of less than 1 week duration). The results of this inspection must be documented in Form FM25_017 Macrofaunal Sieves Visual Examination. The completed forms should be saved on the network in the appropriate job folder.

B.3.6 Sample Labelling

All samples must be at least double labelled in the following way:

- Glass jars/plastic pots used for physico-chemical analysis – labelled on side and lid;
- Glass vials (BTEX) – labelled on side, station and sample identifier written on lid;
- Plastic bags – labelled both inner and outer bag;
- Faunal sample pots and buckets – labelled on side/lid and internal label (waterproof paper).

Each sample's label(s) must include the following information:

- Project number;
- Site/station number;
- Sample identifier;
- Date sampling undertaken;
- Positional fix number (which is a digital log of date, time and position);
- If single macrofaunal samples have been stored in multiple containers, the container number and total number of containers should be noted (e.g. 1 of 2).

B.3.7 Sample Storage

B.3.7.1 Fridge/Freezer Temperature Monitoring

Monitoring of the temperature of fridges and freezers (onboard survey vessels) used to store samples for physico-chemical analysis is key in control of deviating samples.

All sample storage fridges/freezers will be monitored during their period of use by dedicated verified thermometers. These will be identifiable by unique asset numbers and will have labels showing the expanded uncertainty of measurement range for the fridge/freezer temperature required. Thermometers will be verified against a UKAS accredited (NPL) thermometer annually; this verification will be undertaken by Fugro GB Marine's Sediment Laboratory. Verification expiry dates will be recorded on the thermometer label and tracked centrally.

Daily temperature checks of all fridges/freezers will be undertaken while they are being used to store samples. Temperature recording forms (Form FM25_018) will be attached to each fridge/freezer and filled out by hand. Hard copies of the forms will remain with the fridges/freezers in question, but scans or photocopies of the records pertinent to individual projects should be made as proof of adequate performance for the duration of the project. These records should then be saved on the network in the appropriate job folder.

USB temperature loggers are to be used to monitor the temperature within the coolboxes during transit to the laboratories. USB temperature loggers should be placed in a plastic bag labelled with the job number and job title. Once these have been received at the laboratories, the USB temperature loggers should be returned to the Environmental Technician at Portchester. The data will then be downloaded and saved on the network in the appropriate job folder.

B.3.8 Records

Documents and files generated by this work instruction are:

Title	Document No.	Holder	Retention Period
Sample details	FM25_005	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Field logbook (multiple OPCO)	TP25_006	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Field logbook (single OPCO)	TP25_007	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Client concession	FM25_007	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Grab sample log	FM25_008	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Sediment chemistry log	FM25_009	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Deck sample details form	TP25_011	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Macrofaunal sieves visual examination	FM25_017	Project Manager	4 years from job close out date unless otherwise stated within the client contract
Fridge/freezer temperature recording form	FM25_018	Original maintained with equipment/copies passed to Project Manager	4 years from job close out date unless otherwise stated within the client contract

B.4 WATER SAMPLING AND PROFILING

B.4.1 Purpose

The purpose of this work instruction is to describe the process of environmental water sampling and profiling using Valeport Midas CTD+ and Niskin water samplers.

B.4.2 Responsibilities

The master retains overall responsibility for the safety of the vessel. The senior shift engineer and senior environmental scientist (from here on referred to as shift supervisor) will be responsible for the safe deployment and recovery of the equipment. Operation of the water samplers and profilers and processing of water samples is the responsibility of the onboard environmental scientists.

B.4.3 Operational Protocol

It will be necessary to deploy the water profiler twice at each station, to ensure consistency in the water column data collected. As three samples (at surface, mid-depth and near bottom) are required at each station, the mid-depth and bottom samples will be collected individually on each of the two profiler

deployments. The surface samples will be acquired by briefly redeploying the system so that the sampler is approximately 1 m below the surface (or deeper if sea conditions are marginal).

B.4.3.1 Predeployment

- The water profiler will be checked against calibration standards (pH probe) and in oxygen saturated water (DO probe) prior to deployment;
- Logging will be initiated in the profiler and the blanking plug attached. The water profiler will be set up to record as per Manual;
- The profiler will be shackled to the end of the lift wire, with a beacon above it;
- The water samplers will be fitted (using large diameter cable clamps) a few metres above the beacon.

B.4.3.2 Deployment and Recovery

- The vessel will settle on location and the equipment will be deployed;
- The equipment will be lowered to the desired sampling depth at a low speed (0.5 $m.s^{-1}$ to 1 $m.s^{1}$);
- For mid depth and near-bottom samples depth will be determined by the beacon;
- When the equipment is at the desired depth a messenger weight is attached to the lift wire and sent to trip the sampler. Sufficient time should be allowed for this to travel to the sampler. Winch speed for continuation of deployment or recovery should again be slow (0.5 $m.s^{-1}$ to 1 $m.s^{-1}$);
- When the equipment is at the surface it should be recovered to deck and the sampler removed, with water decanted into various laboratory sample containers.

B.4.3.3 Post Recovery

- The vessel should not leave the site until the quality of the water profile data has been checked;
- Data will be uploaded from the water profiler using the Valeport Datalog Pro software. Data will be exported in a '000' file format which can be pasted into an excel QC spreadsheet.

B.4.4 Water Sample Processing

Each of the 10 litre samples will be pre-treated (if necessary), packaged and stored as detailed below. Sufficient spare samples will be acquired to allow analysis of all target analytes, should primary samples be lost/damaged during transit.

Table B.3: Water Sample Processing and Storage

Subsample (Subsample Code)	Sample Codes	Treatment	Storage
Metals	HMA1	Fill 500 ml plastic bottle to neck and add nitric acid (quantity tbc)	Refrigerate at 4 ºC (±2 ºC)
Total suspended solids	TSS1	Fill 1000 ml plastic bottle to neck	Refrigerate at 4 ºC (±2 ºC)
TOC	TOCA1, TOCA2	Fill 2 × 40 ml glass vials to shoulder and add dihydrogen phosphate	Refrigerate at 4 ºC (±2 ºC)
Hydrocarbons A - THC, n-alkanes, PAH	HCA1, HCA2	Fill 1 litre amber glass bottle to shoulder	Freeze at -20 ºC (±5 ºC)
Spare (SPARE)	SPAREA1	Fill with remaining water	Freeze at -20 ºC (±5 ºC)
Total Sample Volume required from each depth			**10 litres**

Notes:

i. All sampling must be undertaken while wearing **clean** nitrile gloves. Prior to sampling the Niskin bottles and any reusable components associated with biodiversity sampling will be cleaned with Fisherbrand DNAse Displace decontaminant and rinsed with deionized water;
ii. To minimize the risk of sample contamination, biodiversity (DNA) samples will be taken before other sample types;
iii. Collect all other sample types before collecting spare sample – it is not anticipated that 1 litre of sample water will remain after all other samples collected;
iv. Add fixates to metals and TOC samples after filling with water (to prevent splashing of neat fixative). Do this in a safe environment (isolate other personnel) as soon as possible after collection;
v. Filter DNA samples as soon as possible after collection. Following instructions provided by CEGA.

C. LOGS

C.1 SURVEY LOG

Geodetic Parameters: WGS84 UTM Zone 21 N

Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
14/05/2019	21:28:51	Mid water Test	Video	SOL			489 761.0	852 259.0	488 434.4	877 250.6	25026.8	
14/05/2019	21:30:35	Mid water Test	Video	EOL			489 761.0	852 259.0	488 434.4	877 251.7	25027.8	
15/05/2019	18:24:03	GEOPC010DD	Video	SOL	1	879.2	487 687.9	873 555.9	487 652.4	873 544.8	37.2	Camera too light, added ~70kg of weight
15/05/2019	18:26:58	GEOPC010DD	Still	GEOPC010DD_01	1	878.1	487 687.9	873 555.9	487 651.8	873 543.4	38.2	
15/05/2019	18:30:47	GEOPC010DD	Still	GEOPC010DD_02	2	878.7	487 687.9	873 555.9	487 666.8	873 552.7	21.3	
15/05/2019	18:32:30	GEOPC010DD	Still	GEOPC010DD_03	3	879.6	487 687.9	873 555.9	487 676.3	873 555.4	11.6	
15/05/2019	18:33:34	GEOPC010DD	Still	GEOPC010DD_04	4	879.2	487 687.9	873 555.9	487 673.1	873 558.1	15.0	
15/05/2019	18:33:46	GEOPC010DD	Still	GEOPC010DD_05	5	880.4	487 687.9	873 555.9	487 681.6	873 561.4	8.3	
15/05/2019	18:33:59	GEOPC010DD	Still	GEOPC010DD_06	6	880.3	487 687.9	873 555.9	487 683.7	873 559.8	5.7	
15/05/2019	18:34:14	GEOPC010DD	Still	GEOPC010DD_07	7	880.0	487 687.9	873 555.9	487 685.6	873 559.1	3.9	
15/05/2019	18:35:11	GEOPC010DD	Still	GEOPC010DD_08	8	880.1	487 687.9	873 555.9	487 690.8	873 563.3	8.0	
15/05/2019	18:34:44	GEOPC010DD	Still	GEOPC010DD_09	9	879.8	487 687.9	873 555.9	487 690.8	873 563.3	8.0	
15/05/2019	18:35:30	GEOPC010DD	Still	GEOPC010DD_10	10	880.0	487 687.9	873 555.9	487 693.6	873 564.1	9.9	
15/05/2019	18:35:51	GEOPC010DD	Still	GEOPC010DD_11	11	880.0	487 687.9	873 555.9	487 695.6	873 565.4	12.2	
15/05/2019	18:36:21	GEOPC010DD	Still	GEOPC010DD_12	12	880.5	487 687.9	873 555.9	487 698.4	873 568.2	16.1	
15/05/2019	18:36:32	GEOPC010DD	Still	GEOPC010DD_13	13	880.7	487 687.9	873 555.9	487 700.4	873 568.1	17.5	
15/05/2019	18:37:43	GEOPC010DD	Still	GEOPC010DD_14	14	880.8	487 687.9	873 555.9	487 709.0	873 571.7	26.4	
15/05/2019	18:37:55	GEOPC010DD	Still	GEOPC010DD_15	15	881.4	487 687.9	873 555.9	487 710.9	873 573.4	28.8	
15/05/2019	18:38:03	GEOPC010DD	Video	EOL	1	880.9	487 687.9	873 555.9	487 711.2	873 574.6	29.8	
17/05/2019	14:08:14	EBSHH01DD	Video	SOL	1	1031.4	483 890.6	880 797.5	483 850.9	880 790.1	40.4	Photographs not acceptable, seabed not in view
17/05/2019	14:10:15	EBSHH01DD	Still	EBSHH01DD_01	1	1031.7	483 890.6	880 797.5	483 854.2	880 794.4	36.5	
17/05/2019	14:12:16	EBSHH01DD	Still	EBSHH01DD_02	2	1032.4	483 890.6	880 797.5	483 861.1	880 795.1	29.7	
17/05/2019	14:12:37	EBSHH01DD	Still	EBSHH01DD_03	3	1032.1	483 890.6	880 797.5	483 862.6	880 795.9	28.1	
17/05/2019	14:15:03	EBSHH01DD	Still	EBSHH01DD_04	4	1032.1	483 890.6	880 797.5	483 878.5	880 795.6	12.3	
17/05/2019	14:15:49	EBSHH01DD	Still	EBSHH01DD_05	5	1032.4	483 890.6	880 797.5	483 881.6	880 794.3	9.6	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
17/05/2019	14:16:57	EBSHH01DD	Still	EBSHH01DD_06	6	1035.5	483 890.6	880 797.5	483 890.4	880 794.9	2.6	
17/05/2019	14:19:27	EBSHH01DD	Still	EBSHH01DD_07	7	1035.1	483 890.6	880 797.5	483 906.8	880 796.3	16.2	
17/05/2019	14:19:39	EBSHH01DD	Still	EBSHH01DD_08	8	1035.7	483 890.6	880 797.5	483 908.4	880 796.0	17.9	
17/05/2019	14:19:56	EBSHH01DD	Still	EBSHH01DD_09	9	1034.9	483 890.6	880 797.5	483 909.8	880 796.8	19.2	
17/05/2019	14:20:09	EBSHH01DD	Still	EBSHH01DD_10	10	1034.5	483 890.6	880 797.5	483 911.9	880 796.8	21.3	
17/05/2019	14:20:25	EBSHH01DD	Still	EBSHH01DD_11	11	1034.6	483 890.6	880 797.5	483 913.8	880 796.4	23.2	
17/05/2019	14:20:41	EBSHH01DD	Still	EBSHH01DD_12	12	1034.3	483 890.6	880 797.5	483 915.7	880 796.5	25.1	
17/05/2019	14:20:56	EBSHH01DD	Still	EBSHH01DD_13	13	1034.1	483 890.6	880 797.5	483 917.8	880 795.7	27.2	
17/05/2019	14:21:21	EBSHH01DD	Still	EBSHH01DD_14	14	1036.2	483 890.6	880 797.5	483 921.3	880 796.6	30.8	
17/05/2019	14:21:57	EBSHH01DD	Video	EOL	1	1031.4	483 890.6	880 797.5	483 925.7	880 796.7	35.1	
17/05/2019	16:39:27	EBSHH01DDa	Video	SOL	1	1032.9	483 890.6	880 797.5	483 854.2	880 795.2	36.5	Weight removed from back of the camera
17/05/2019	16:39:40	EBSHH01DDa	Still	EBSHH01DDa_01	1	1032.4	483 890.6	880 797.5	483 854.7	880 796.5	35.9	
17/05/2019	16:40:57	EBSHH01DDa	Still	EBSHH01DDa_02	2	1033.3	483 890.6	880 797.5	483 857.5	880 797.2	33.1	
17/05/2019	16:41:29	EBSHH01DDa	Still	EBSHH01DDa_03	3	1031.7	483 890.6	880 797.5	483 859.5	880 797.8	31.1	
17/05/2019	16:41:55	EBSHH01DDa	Still	EBSHH01DDa_04	4	1032.9	483 890.6	880 797.5	483 861.0	880 798.6	29.7	
17/05/2019	16:42:32	EBSHH01DDa	Still	EBSHH01DDa_05	5	1033.3	483 890.6	880 797.5	483 862.9	880 799.7	27.8	
17/05/2019	16:43:00	EBSHH01DDa	Still	EBSHH01DDa_06	6	1034.2	483 890.6	880 797.5	483 863.6	880 799.7	27.1	
17/05/2019	16:43:37	EBSHH01DDa	Still	EBSHH01DDa_07	7	1033.6	483 890.6	880 797.5	483 866.7	880 800.0	24.1	
17/05/2019	16:44:03	EBSHH01DDa	Still	EBSHH01DDa_08	8	1034.6	483 890.6	880 797.5	483 866.9	880 801.0	23.9	
17/05/2019	16:44:21	EBSHH01DDa	Still	EBSHH01DDa_09	9	1033.8	483 890.6	880 797.5	483 867.7	880 800.1	23.0	
17/05/2019	16:44:52	EBSHH01DDa	Still	EBSHH01DDa_10	10	1034.5	483 890.6	880 797.5	483 872.0	880 800.2	18.8	
17/05/2019	16:45:27	EBSHH01DDa	Still	EBSHH01DDa_11	11	1033.6	483 890.6	880 797.5	483 874.4	880 799.9	16.4	
17/05/2019	16:46:18	EBSHH01DDa	Still	EBSHH01DDa_12	12	1033.1	483 890.6	880 797.5	483 879.6	880 801.2	11.6	
17/05/2019	16:46:38	EBSHH01DDa	Still	EBSHH01DDa_13	13	1035.0	483 890.6	880 797.5	483 881.9	880 801.0	9.4	
17/05/2019	16:47:27	EBSHH01DDa	Still	EBSHH01DDa_14	14	1034.2	483 890.6	880 797.5	483 887.2	880 801.7	5.4	
17/05/2019	16:47:44	EBSHH01DDa	Still	EBSHH01DDa_15	15	1035.3	483 890.6	880 797.5	483 889.2	880 802.1	4.8	
17/05/2019	16:48:09	EBSHH01DDa	Still	EBSHH01DDa_16	16	1034.2	483 890.6	880 797.5	483 892.3	880 802.5	5.3	
17/05/2019	16:49:12	EBSHH01DDa	Still	EBSHH01DDa_17	17	1034.6	483 890.6	880 797.5	483 900.3	880 803.9	11.6	
17/05/2019	16:49:34	EBSHH01DDa	Still	EBSHH01DDa_18	18	1036.2	483 890.6	880 797.5	483 902.1	880 804.5	13.5	
17/05/2019	16:50:04	EBSHH01DDa	Still	EBSHH01DDa_19	19	1036.3	483 890.6	880 797.5	483 904.9	880 804.6	15.9	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
17/05/2019	16:51:42	EBSHH01DDa	Video	EOL	1	1033.8	483 890.6	880 797.5	483 919.2	880 805.9	29.8	Camera spinning in the water column, photographs not accepted
17/05/2019	18:14:00	EBSHH01	BC	FA/FB	1	1038.9	483 890.6	880 797.5	483 901.7	880 800.3	11.5	
17/05/2019	20:30:17	EBSHH01DDb	Video	SOL	-	1033.6	483 890.6	880 797.5	483 845.0	880 804.7	46.2	Weight added to the back of the camera and to the front
17/05/2019	20:34:03	EBSHH01DDb	Still	EBSHH01DDb_01	1	1033.4	483 890.6	880 797.5	483 851.2	880 805.5	40.3	
17/05/2019	20:34:28	EBSHH01DDb	Still	EBSHH01DDb_02	2	1033.5	483 890.6	880 797.5	483 852.2	880 805.1	39.2	
17/05/2019	20:35:29	EBSHH01DDb	Still	EBSHH01DDb_03	3	1034.6	483 890.6	880 797.5	483 856.1	880 803.9	35.1	
17/05/2019	20:35:42	EBSHH01DDb	Still	EBSHH01DDb_04	4	1035.2	483 890.6	880 797.5	483 857.6	880 804.2	33.7	
17/05/2019	20:35:53	EBSHH01DDb	Still	EBSHH01DDb_05	5	1033.5	483 890.6	880 797.5	483 858.1	880 803.7	33.1	
17/05/2019	20:36:02	EBSHH01DDb	Still	EBSHH01DDb_06	6	1034.8	483 890.6	880 797.5	483 859.0	880 804.7	32.4	
17/05/2019	20:36:22	EBSHH01DDb	Still	EBSHH01DDb_07	7	1034.9	483 890.6	880 797.5	483 860.3	880 804.4	31.0	
17/05/2019	20:36:41	EBSHH01DDb	Still	EBSHH01DDb_08	8	1034.1	483 890.6	880 797.5	483 862.3	880 804.2	29.1	
17/05/2019	20:41:02	EBSHH01DDb	Video	EOL	-	1034.7	483 890.6	880 797.5	483 887.9	880 801.7	5.0	Camera drop down aborted due to poor stills images
17/05/2019	21:56:41	EBSHH01	BC	PC	2	1037.0	483 890.6	880 797.5	483 880.6	880 796.5	10.0	
18/05/2019	00:20:31	EBSHH02	BC	PC, FA, FB	1	1098.1	488 361.4	878 558.8	488 359.2	878 553.6	5.7	
18/05/2019	02:23:14	EBSHH03	BC	PC, FA, FB	1	1110.1	492 832.3	876 320.2	492 842.9	876 316.2	11.3	
18/05/2019	04:02:17	EBSHH06	BC	PC, FA, FB	1	938.0	493 622.3	871 760.8	493 624.9	871 760.4	2.6	
18/05/2019	05:49:50	EBSHH05	BC	PC, FA, FB	1	926.1	488 805.9	873 862.8	488 811.0	873 870.1	8.9	
18/05/2019	07:36:31	EBSHH04	BC	PC, FA, FB	1	887.9	484 335.1	876 101.5	484 335.6	876 094.4	7.1	
18/05/2019	09:25:36	EBSHH07	BC	PC, FA, FB	1	673.2	484 779.6	871 405.5	484 789.1	871 407.7	9.8	
18/05/2019	10:03:02	EBSHH08	BC	PC, FA, FB	1	722.1	489 250.4	869 166.8	489 254.6	869 170.5	5.5	
18/05/2019	14:59:16	TR04	Video	SOL	1	99.5	489 761.0	852 259.0	489 648.0	852 133.1	169.2	
18/05/2019	15:01:23	TR04	Still	TR04_01	1	99.7	489 761.0	852 259.0	489 653.7	852 134.8	164.2	
18/05/2019	15:01:39	TR04	Still	TR04_02	2	99.1	489 761.0	852 259.0	489 655.7	852 136.5	161.5	
18/05/2019	15:01:51	TR04	Still	TR04_03	3	99.9	489 761.0	852 259.0	489 657.2	852 137.9	159.5	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	15:02:03	TR04	Still	TR04_04	4	100.4	489 761.0	852 259.0	489 658.6	852 138.8	157.9	
18/05/2019	15:02:09	TR04	Still	TR04_05	5	100.6	489 761.0	852 259.0	489 659.4	852 139.5	156.9	
18/05/2019	15:02:24	TR04	Still	TR04_06	6	99.7	489 761.0	852 259.0	489 660.8	852 140.5	155.2	
18/05/2019	15:02:43	TR04	Still	TR04_07	7	99.4	489 761.0	852 259.0	489 663.0	852 142.6	152.2	
18/05/2019	15:03:01	TR04	Still	TR04_08	8	100.5	489 761.0	852 259.0	489 664.6	852 144.2	149.9	
18/05/2019	15:03:41	TR04	Still	TR04_09	9	100.3	489 761.0	852 259.0	489 667.6	852 148.8	144.4	
18/05/2019	15:04:04	TR04	Still	TR04_10	10	101.1	489 761.0	852 259.0	489 669.7	852 151.5	141.1	
18/05/2019	15:04:18	TR04	Still	TR04_11	11	98.9	489 761.0	852 259.0	489 670.3	852 152.7	139.8	
18/05/2019	15:04:38	TR04	Still	TR04_12	12	100.7	489 761.0	852 259.0	489 671.9	852 155.5	136.6	
18/05/2019	15:04:50	TR04	Still	TR04_13	13	100.3	489 761.0	852 259.0	489 673.2	852 157.2	134.4	
18/05/2019	15:05:06	TR04	Still	TR04_14	14	101.1	489 761.0	852 259.0	489 674.3	852 158.9	132.4	
18/05/2019	15:05:27	TR04	Still	TR04_15	15	100.8	489 761.0	852 259.0	489 675.8	852 161.8	129.2	
18/05/2019	15:05:59	TR04	Still	TR04_16	16	101.6	489 761.0	852 259.0	489 678.5	852 165.9	124.4	
18/05/2019	15:06:45	TR04	Still	TR04_17	17	100.9	489 761.0	852 259.0	489 683.4	852 172.5	116.2	
18/05/2019	15:07:12	TR04	Still	TR04_18	18	101.3	489 761.0	852 259.0	489 686.9	852 175.5	111.6	
18/05/2019	15:07:25	TR04	Still	TR04_19	19	101.3	489 761.0	852 259.0	489 688.1	852 176.8	109.9	
18/05/2019	15:07:40	TR04	Still	TR04_20	20	101.1	489 761.0	852 259.0	489 689.8	852 179.3	106.8	
18/05/2019	15:07:55	TR04	Still	TR04_21	21	100.5	489 761.0	852 259.0	489 691.7	852 181.6	103.8	
18/05/2019	15:08:15	TR04	Still	TR04_22	22	101.0	489 761.0	852 259.0	489 694.6	852 184.2	100.0	
18/05/2019	15:08:48	TR04	Still	TR04_23	23	100.7	489 761.0	852 259.0	489 698.1	852 187.4	95.3	
18/05/2019	15:08:59	TR04	Still	TR04_24	24	101.7	489 761.0	852 259.0	489 699.0	852 188.4	93.9	
18/05/2019	15:09:40	TR04	Still	TR04_25	25	90.2	489 761.0	852 259.0	489 688.9	852 205.8	89.6	
18/05/2019	15:09:53	TR04	Still	TR04_26	26	101.1	489 761.0	852 259.0	489 705.0	852 196.5	83.9	
18/05/2019	15:10:16	TR04	Still	TR04_27	27	101.0	489 761.0	852 259.0	489 708.1	852 200.7	78.7	
18/05/2019	15:10:31	TR04	Still	TR04_28	28	100.7	489 761.0	852 259.0	489 709.9	852 203.1	75.7	
18/05/2019	15:10:46	TR04	Still	TR04_29	29	101.8	489 761.0	852 259.0	489 711.8	852 205.7	72.5	
18/05/2019	15:11:06	TR04	Still	TR04_30	30	100.6	489 761.0	852 259.0	489 714.0	852 208.8	68.7	
18/05/2019	15:11:37	TR04	Still	TR04_31	32	101.2	489 761.0	852 259.0	489 717.4	852 214.0	62.7	
18/05/2019	15:11:51	TR04	Still	TR04_32	33	101.7	489 761.0	852 259.0	489 718.6	852 215.7	60.6	
18/05/2019	15:12:35	TR04	Still	TR04_33	34	100.1	489 761.0	852 259.0	489 722.1	852 221.0	54.3	
18/05/2019	15:13:05	TR04	Still	TR04_34	35	101.5	489 761.0	852 259.0	489 725.3	852 223.7	50.2	
18/05/2019	15:13:32	TR04	Still	TR04_35	36	101.8	489 761.0	852 259.0	489 727.2	852 226.0	47.2	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	15:14:59	TR04	Still	TR04_36	37	101.8	489 761.0	852 259.0	489 733.6	852 233.2	37.6	
18/05/2019	15:15:24	TR04	Still	TR04_37	38	102.5	489 761.0	852 259.0	489 736.0	852 235.7	34.2	
18/05/2019	15:15:49	TR04	Still	TR04_38	39	102.5	489 761.0	852 259.0	489 738.1	852 237.6	31.3	
18/05/2019	15:17:42	TR04	Still	TR04_39	40	99.7	489 761.0	852 259.0	489 749.3	852 251.4	13.9	
18/05/2019	15:18:22	TR04	Still	TR04_40	41	100.9	489 761.0	852 259.0	489 753.6	852 256.7	7.8	
18/05/2019	15:18:41	TR04	Still	TR04_41	42	100.2	489 761.0	852 259.0	489 755.7	852 259.6	5.3	
18/05/2019	15:19:31	TR04	Still	TR04_42	45	95.6	489 761.0	852 259.0	489 761.4	852 269.7	10.7	
18/05/2019	15:20:07	TR04	Still	TR04_43	47	94.1	489 761.0	852 259.0	489 766.0	852 273.9	15.8	
18/05/2019	15:20:34	TR04	Still	TR04_44	48	94.7	489 761.0	852 259.0	489 769.1	852 277.7	20.4	
18/05/2019	15:21:29	TR04	Still	TR04_45	51	93.9	489 761.0	852 259.0	489 775.4	852 284.0	28.8	
18/05/2019	15:21:46	TR04	Still	TR04_46	52	92.9	489 761.0	852 259.0	489 776.9	852 285.4	30.8	
18/05/2019	15:21:58	TR04	Still	TR04_47	53	94.4	489 761.0	852 259.0	489 777.8	852 286.4	32.1	
18/05/2019	15:22:20	TR04	Still	TR04_48	54	94.0	489 761.0	852 259.0	489 780.1	852 289.5	35.9	
18/05/2019	15:22:34	TR04	Still	TR04_49	55	93.7	489 824.0	852 332.0	489 781.5	852 290.8	59.2	
18/05/2019	15:23:03	TR04	Still	TR04_50	57	94.3	489 824.0	852 332.0	489 784.9	852 293.7	54.8	
18/05/2019	15:24:15	TR04	Still	TR04_51	58	97.5	489 824.0	852 332.0	489 792.4	852 298.9	45.8	
18/05/2019	15:24:29	TR04	Still	TR04_52	59	96.8	489 824.0	852 332.0	489 793.9	852 300.0	43.9	
18/05/2019	15:24:49	TR04	Still	TR04_53	60	100.0	489 824.0	852 332.0	489 796.8	852 303.1	39.7	
18/05/2019	15:25:14	TR04	Still	TR04_54	61	99.3	489 824.0	852 332.0	489 799.1	852 305.8	36.1	
18/05/2019	15:25:24	TR04	Still	TR04_55	62	99.8	489 824.0	852 332.0	489 800.1	852 307.0	34.6	
18/05/2019	15:26:30	TR04	Still	TR04_56	63	96.1	489 824.0	852 332.0	489 803.4	852 314.3	27.1	
18/05/2019	15:26:46	TR04	Still	TR04_57	64	99.4	489 824.0	852 332.0	489 805.0	852 316.9	24.3	
18/05/2019	15:26:56	TR04	Still	TR04_58	65	100.8	489 824.0	852 332.0	489 806.5	852 319.1	21.7	
18/05/2019	15:27:23	TR04	Still	TR04_59	66	100.0	489 824.0	852 332.0	489 809.6	852 322.6	17.2	
18/05/2019	15:27:48	TR04	Still	TR04_60	67	100.1	489 824.0	852 332.0	489 812.8	852 326.4	12.5	
18/05/2019	15:28:01	TR04	Still	TR04_61	68	100.3	489 824.0	852 332.0	489 813.9	852 327.7	11.0	
18/05/2019	15:28:26	TR04	Still	TR04_62	69	100.1	489 824.0	852 332.0	489 816.0	852 329.7	8.3	
18/05/2019	15:29:07	TR04	Still	TR04_63	70	99.6	489 824.0	852 332.0	489 821.2	852 334.0	3.4	
18/05/2019	15:29:15	TR04	Video	EOL	1	99.4	489 824.0	852 332.0	489 821.7	852 334.2	3.2	
18/05/2019	16:37:16	TR05_part1	Video	SOL	1	99.2	486 554.7	853 954.2	486 551.3	853 954.9	3.4	
18/05/2019	16:38:34	TR05_part1	Still	TR05_01	1	101.6	486 554.7	853 954.2	486 554.7	853 954.2	0.0	
18/05/2019	16:39:57	TR05_part1	Still	TR05_02	2	100.0	486 554.7	853 954.2	486 562.5	853 948.3	9.8	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	16:40:21	TR05_part1	Still	TR05_03	3	101.1	486 554.7	853 954.2	486 564.7	853 945.9	13.0	
18/05/2019	16:40:31	TR05_part1	Still	TR05_04	4	101.3	486 554.7	853 954.2	486 566.5	853 944.8	15.1	
18/05/2019	16:40:47	TR05_part1	Still	TR05_05	5	100.8	486 554.7	853 954.2	486 569.0	853 943.1	18.2	
18/05/2019	16:40:59	TR05_part1	Still	TR05_06	6	99.3	486 554.7	853 954.2	486 570.0	853 941.5	19.9	
18/05/2019	16:41:27	TR05_part1	Still	TR05_07	7	100.0	486 554.7	853 954.2	486 571.8	853 940.2	22.1	
18/05/2019	16:41:52	TR05_part1	Still	TR05_08	8	100.5	486 554.7	853 954.2	486 575.2	853 938.6	25.8	
18/05/2019	16:42:08	TR05_part1	Still	TR05_09	9	103.1	486 554.7	853 954.2	486 578.7	853 937.4	29.4	
18/05/2019	16:42:26	TR05_part1	Still	TR05_10	10	102.4	486 554.7	853 954.2	486 581.4	853 936.5	32.1	
18/05/2019	16:42:53	TR05_part1	Still	TR05_11	11	102.0	486 554.7	853 954.2	486 585.7	853 934.5	36.8	
18/05/2019	16:43:08	TR05_part1	Still	TR05_12	12	102.7	486 554.7	853 954.2	486 587.3	853 933.8	38.5	
18/05/2019	16:44:11	TR05_part1	Video	EOL	1	100.7	486 554.7	853 954.2	486 592.7	853 927.6	46.4	Camera malfunction, vessel stopped and the system rebooted
18/05/2019	16:46:44	TR05_part2	Video	SOL	2	100.0	486 554.7	853 954.2	486 600.0	853 923.6	54.7	
18/05/2019	16:47:48	TR05_part2	Still	TR05_13	13	103.6	486 554.7	853 954.2	486 602.6	853 925.7	55.8	
18/05/2019	16:48:06	TR05_part2	Still	TR05_14	14	103.0	486 554.7	853 954.2	486 602.9	853 926.5	55.7	
18/05/2019	16:48:53	TR05_part2	Still	TR05_15	15	102.7	486 554.7	853 954.2	486 604.3	853 925.2	57.5	
18/05/2019	16:49:05	TR05_part2	Still	TR05_16	16	103.0	486 554.7	853 954.2	486 606.0	853 924.6	59.2	
18/05/2019	16:49:30	TR05_part2	Still	TR05_17	17	102.7	486 554.7	853 954.2	486 608.4	853 922.6	62.3	
18/05/2019	16:49:52	TR05_part2	Still	TR05_18	18	103.4	486 554.7	853 954.2	486 611.0	853 921.6	65.1	
18/05/2019	16:50:20	TR05_part2	Still	TR05_19	19	101.6	486 554.7	853 954.2	486 612.3	853 919.6	67.2	
18/05/2019	16:50:32	TR05_part2	Still	TR05_20	20	102.1	486 554.7	853 954.2	486 614.3	853 918.4	69.6	
18/05/2019	16:51:05	TR05_part2	Still	TR05_21	21	101.7	486 554.7	853 954.2	486 616.4	853 916.0	72.6	
18/05/2019	16:51:48	TR05_part2	Still	TR05_22	22	102.0	486 554.7	853 954.2	486 620.9	853 911.6	78.8	
18/05/2019	16:52:25	TR05_part2	Still	TR05_23	23	98.5	486 554.7	853 954.2	486 625.2	853 908.0	84.3	
18/05/2019	16:52:39	TR05_part2	Still	TR05_24	24	95.9	486 554.7	853 954.2	486 626.8	853 906.5	86.5	
18/05/2019	16:52:52	TR05_part2	Still	TR05_25	25	95.4	486 554.7	853 954.2	486 629.7	853 904.5	90.0	
18/05/2019	16:53:09	TR05_part2	Still	TR05_26	26	94.8	486 554.7	853 954.2	486 631.1	853 902.3	92.5	
18/05/2019	16:53:21	TR05_part2	Still	TR05_27	27	94.2	486 554.7	853 954.2	486 632.5	853 900.9	94.3	
18/05/2019	16:53:40	TR05_part2	Still	TR05_28	28	94.0	486 554.7	853 954.2	486 634.9	853 898.4	97.8	
18/05/2019	16:53:52	TR05_part2	Still	TR05_29	29	93.2	486 554.7	853 954.2	486 636.2	853 896.4	99.9	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	16:54:11	TR05_part2	Still	TR05_30	30	95.2	486 554.7	853 954.2	486 639.0	853 893.8	103.7	
18/05/2019	16:54:29	TR05_part2	Still	TR05_31	31	95.4	486 554.7	853 954.2	486 641.3	853 892.8	106.2	
18/05/2019	16:54:59	TR05_part2	Still	TR05_32	32	94.3	486 554.7	853 954.2	486 643.6	853 889.1	110.2	
18/05/2019	16:55:15	TR05_part2	Still	TR05_33	33	94.5	486 554.7	853 954.2	486 645.9	853 887.5	113.1	
18/05/2019	16:55:32	TR05_part2	Still	TR05_34	34	93.0	486 554.7	853 954.2	486 648.1	853 886.0	115.7	
18/05/2019	16:55:39	TR05_part2	Video	EOL	2	94.5	486 554.7	853 954.2	486 648.6	853 885.2	116.5	
18/05/2019	18:09:45	TR06_part1	Video	SOL	1	112.1	490 481.3	855 793.2	490 481.3	855 793.1	0.1	
18/05/2019	18:10:13	TR06_part1	Still	TR06_01	1	112.3	490 481.3	855 793.2	490 481.3	855 793.2	0.0	
18/05/2019	18:11:35	TR06_part1	Still	TR06_02	2	112.6	490 481.3	855 793.2	490 490.1	855 796.0	9.2	
18/05/2019	18:11:49	TR06_part1	Still	TR06_03	3	111.5	490 481.3	855 793.2	490 492.1	855 796.7	11.3	
18/05/2019	18:12:08	TR06_part1	Still	TR06_04	4	110.2	490 481.3	855 793.2	490 494.6	855 796.8	13.8	
18/05/2019	18:12:26	TR06_part1	Still	TR06_05	5	112.6	490 481.3	855 793.2	490 497.6	855 796.9	16.7	
18/05/2019	18:12:45	TR06_part1	Still	TR06_06	6	112.4	490 481.3	855 793.2	490 499.5	855 797.2	18.7	
18/05/2019	18:13:34	TR06_part1	Still	TR06_07	7	112.8	490 481.3	855 793.2	490 506.0	855 796.5	24.9	
18/05/2019	18:14:17	TR06_part1	Still	TR06_08	8	113.1	490 481.3	855 793.2	490 514.8	855 797.1	33.7	
18/05/2019	18:15:18	TR06_part1	Still	TR06_09	9	111.1	490 481.3	855 793.2	490 521.7	855 795.8	40.5	
18/05/2019	18:15:37	TR06_part1	Still	TR06_10	10	112.3	490 481.3	855 793.2	490 525.0	855 796.2	43.8	
18/05/2019	18:15:54	TR06_part1	Still	TR06_11	11	111.7	490 481.3	855 793.2	490 527.6	855 796.2	46.4	
18/05/2019	18:16:06	TR06_part1	Still	TR06_12	12	112.1	490 481.3	855 793.2	490 529.4	855 796.0	48.2	
18/05/2019	18:16:26	TR06_part1	Still	TR06_13	13	110.6	490 481.3	855 793.2	490 532.6	855 795.6	51.3	
18/05/2019	18:16:45	TR06_part1	Still	TR06_14	14	112.1	490 481.3	855 793.2	490 536.0	855 795.8	54.7	
18/05/2019	18:17:07	TR06_part1	Still	TR06_15	15	113.1	490 481.3	855 793.2	490 540.2	855 795.9	58.9	
18/05/2019	18:17:32	TR06_part1	Still	TR06_16	16	112.5	490 481.3	855 793.2	490 544.6	855 796.5	63.3	
18/05/2019	18:17:56	TR06_part1	Still	TR06_17	17	111.9	490 481.3	855 793.2	490 548.7	855 797.8	67.5	
18/05/2019	18:18:26	TR06_part1	Still	TR06_18	18	112.6	490 481.3	855 793.2	490 553.1	855 799.2	72.1	
18/05/2019	18:19:09	TR06_part1	Still	TR06_19	19	113.6	490 481.3	855 793.2	490 559.3	855 799.4	78.3	
18/05/2019	18:20:08	TR06_part1	Still	TR06_20	20	111.2	490 481.3	855 793.2	490 566.3	855 799.0	85.2	
18/05/2019	18:20:20	TR06_part1	Still	TR06_21	21	111.9	490 481.3	855 793.2	490 567.7	855 798.8	86.5	
18/05/2019	18:20:37	TR06_part1	Still	TR06_22	22	111.8	490 481.3	855 793.2	490 570.0	855 798.6	88.9	
18/05/2019	18:22:00	TR06_part1	Still	EOL	1	108.8	490 481.3	855 793.2	490 582.6	855 798.4	101.4	
18/05/2019	18:24:08	TR06_part2	Still	SOL	2	109.6	490 481.3	855 793.2	490 594.7	855 799.2	113.5	
18/05/2019	18:24:23	TR06_part2	Still	TR06_23	24	106.3	490 481.3	855 793.2	490 595.0	855 798.9	113.8	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	18:26:28	TR06_part2	Still	TR06_24	25	106.7	490 481.3	855 793.2	490 596.6	855 799.8	115.4	
18/05/2019	18:26:47	TR06_part2	Still	TR06_25	26	107.5	490 481.3	855 793.2	490 599.3	855 800.5	118.2	
18/05/2019	18:27:21	TR06_part2	Still	TR06_26	27	109.6	490 481.3	855 793.2	490 604.5	855 801.0	123.4	
18/05/2019	18:27:35	TR06_part2	Still	TR06_27	28	111.3	490 481.3	855 793.2	490 605.5	855 801.1	124.4	
18/05/2019	18:27:48	TR06_part2	Still	TR06_28	29	111.9	490 481.3	855 793.2	490 605.7	855 801.1	124.6	
18/05/2019	18:30:46	TR06_part2	Still	TR06_29	30	112.8	490 481.3	855 793.2	490 605.2	855 798.2	124.0	
18/05/2019	18:31:16	TR06_part2	Still	TR06_30	31	112.5	490 481.3	855 793.2	490 606.6	855 798.9	125.4	
18/05/2019	18:31:29	TR06_part2	Still	TR06_31	32	112.4	490 481.3	855 793.2	490 608.0	855 799.7	126.9	
18/05/2019	18:31:45	TR06_part2	Still	TR06_32	33	112.1	490 481.3	855 793.2	490 610.9	855 800.0	129.8	
18/05/2019	18:32:54	TR06_part2	Still	TR06_33	34	113.6	490 481.3	855 793.2	490 620.2	855 799.6	139.1	
18/05/2019	18:33:14	TR06_part2	Still	TR06_34	35	111.5	490 481.3	855 793.2	490 622.6	855 800.5	141.5	
18/05/2019	18:33:32	TR06_part2	Still	TR06_35	36	107.8	490 481.3	855 793.2	490 626.6	855 800.4	145.5	
18/05/2019	18:33:57	TR06_part2	Still	TR06_36	37	105.6	490 481.3	855 793.2	490 631.1	855 799.3	149.9	
18/05/2019	18:34:16	TR06_part2	Still	TR06_37	38	104.5	490 481.3	855 793.2	490 633.9	855 798.5	152.7	
18/05/2019	18:34:42	TR06_part2	Still	TR06_38	39	105.7	490 481.3	855 793.2	490 637.5	855 797.2	156.2	
18/05/2019	18:35:06	TR06_part2	Still	TR06_39	40	108.8	490 481.3	855 793.2	490 641.2	855 796.1	159.9	
18/05/2019	18:35:53	TR06_part2	Still	TR06_40	41	110.2	490 481.3	855 793.2	490 646.7	855 795.5	165.4	
18/05/2019	18:36:04	TR06_part2	Still	TR06_41	42	111.2	490 481.3	855 793.2	490 648.5	855 796.0	167.2	
18/05/2019	18:36:26	TR06_part2	Still	TR06_42	43	112.2	490 481.3	855 793.2	490 652.4	855 796.2	171.1	
18/05/2019	18:36:53	TR06_part2	Still	TR06_43	44	111.2	490 481.3	855 793.2	490 657.6	855 795.3	176.3	
18/05/2019	18:37:07	TR06_part2	Still	TR06_44	45	110.8	490 481.3	855 793.2	490 659.7	855 794.5	178.4	
18/05/2019	18:38:54	TR06_part2	Still	TR06_45		111.1	490 481.3	855 793.2	490 675.1	855 793.1	193.8	
18/05/2019	18:39:06	TR06_part2	Still	EOL	2	110.9	490 481.3	855 793.2	490 677.0	855 792.8	195.7	
18/05/2019	20:19:26	TR03	Video	SOL	1	103.7	486 938.8	856 841.0	486 939.4	856 840.3	1.0	
18/05/2019	20:19:50	TR03	Still	TR03_01	1	104.7	486 938.8	856 841.0	486 938.8	856 841.0	0.0	
18/05/2019	20:22:16	TR03	Still	TR03_02	2	102.7	486 938.8	856 841.0	486 951.4	856 847.5	14.1	
18/05/2019	20:23:36	TR03	Still	TR03_03	3	103.5	486 938.8	856 841.0	486 963.6	856 852.8	27.5	
18/05/2019	20:24:31	TR03	Still	TR03_04	4	103.6	486 938.8	856 841.0	486 971.1	856 855.3	35.3	
18/05/2019	20:24:50	TR03	Still	TR03_05	5	104.8	486 938.8	856 841.0	486 973.7	856 855.8	38.0	
18/05/2019	20:25:41	TR03	Still	TR03_06	6	104.4	486 938.8	856 841.0	486 981.3	856 855.5	44.9	
18/05/2019	20:26:04	TR03	Still	TR03_07	7	103.5	486 938.8	856 841.0	486 983.7	856 856.9	47.6	
18/05/2019	20:26:17	TR03	Still	TR03_08	8	103.3	486 938.8	856 841.0	486 985.1	856 857.5	49.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	20:26:44	TR03	Still	TR03_09	9	102.5	486 938.8	856 841.0	486 989.3	856 858.6	53.5	
18/05/2019	20:26:55	TR03	Still	TR03_10	10	103.9	486 938.8	856 841.0	486 990.7	856 859.4	55.1	
18/05/2019	20:27:48	TR03	Still	TR03_11	11	102.4	486 938.8	856 841.0	486 996.2	856 862.8	61.4	
18/05/2019	20:28:32	TR03	Still	TR03_12	12	103.3	486 938.8	856 841.0	487 003.0	856 864.3	68.3	
18/05/2019	20:29:04	TR03	Still	TR03_13	13	103.2	486 938.8	856 841.0	487 007.0	856 866.3	72.8	
18/05/2019	20:29:38	TR03	Still	TR03_14	14	103.7	486 938.8	856 841.0	487 012.1	856 867.6	78.0	
18/05/2019	20:30:30	TR03	Still	TR03_15	15	104.9	486 938.8	856 841.0	487 020.1	856 872.1	87.0	
18/05/2019	20:30:57	TR03	Still	TR03_16	16	104.1	486 938.8	856 841.0	487 024.3	856 874.6	91.9	
18/05/2019	20:31:30	TR03	Still	TR03_17	17	104.2	486 938.8	856 841.0	487 029.4	856 877.3	97.6	
18/05/2019	20:32:02	TR03	Still	TR03_18	18	105.6	486 938.8	856 841.0	487 033.7	856 880.0	102.6	
18/05/2019	20:32:15	TR03	Still	TR03_19	19	104.3	486 938.8	856 841.0	487 035.0	856 880.9	104.2	
18/05/2019	20:32:28	TR03	Still	TR03_20	20	105.3	486 938.8	856 841.0	487 037.4	856 882.8	107.1	
18/05/2019	20:33:19	TR03	Still	TR03_21	21	104.4	486 938.8	856 841.0	487 045.9	856 885.7	116.0	
18/05/2019	20:34:02	TR03	Still	TR03_22	22	102.6	486 938.8	856 841.0	487 051.1	856 886.8	121.3	
18/05/2019	20:34:44	TR03	Still	TR03_23	23	103.4	486 938.8	856 841.0	487 057.5	856 887.2	127.3	
18/05/2019	20:34:55	TR03	Still	TR03_24	24	103.9	486 938.8	856 841.0	487 058.9	856 888.3	129.1	
18/05/2019	20:35:11	TR03	Still	TR03_25	25	104.5	486 938.8	856 841.0	487 061.5	856 888.6	131.6	
18/05/2019	20:35:23	TR03	Still	TR03_26	26	104.5	486 938.8	856 841.0	487 063.1	856 889.8	133.5	
18/05/2019	20:35:44	TR03	Still	TR03_27	27	105.6	486 938.8	856 841.0	487 065.8	856 891.4	136.6	
18/05/2019	20:35:55	TR03	Still	TR03_28	28	103.7	486 938.8	856 841.0	487 067.5	856 892.3	138.5	
18/05/2019	20:36:14	TR03	Still	TR03_29	29	105.1	486 938.8	856 841.0	487 070.7	856 894.0	142.2	
18/05/2019	20:36:49	TR03	Still	TR03_30	30	103.6	486 938.8	856 841.0	487 075.9	856 895.2	147.4	
18/05/2019	20:37:07	TR03	Still	TR03_31	31	103.5	486 938.8	856 841.0	487 078.0	856 895.9	149.7	
18/05/2019	20:37:22	TR03	Still	TR03_32	32	103.9	486 938.8	856 841.0	487 080.2	856 896.7	152.0	
18/05/2019	20:37:32	TR03	Still	TR03_33	33	104.9	486 938.8	856 841.0	487 081.1	856 897.2	153.1	
18/05/2019	20:38:23	TR03	Still	TR03_34	34	103.9	486 938.8	856 841.0	487 088.7	856 899.6	161.0	
18/05/2019	20:38:37	TR03	Still	TR03_35	35	103.9	486 938.8	856 841.0	487 091.4	856 900.8	163.9	
18/05/2019	20:39:39	TR03	Still	TR03_36	36	104.1	486 938.8	856 841.0	487 101.1	856 904.0	174.1	
18/05/2019	20:40:08	TR03	Still	TR03_37	37	106.7	486 938.8	856 841.0	487 104.7	856 907.3	178.6	
18/05/2019	20:40:25	TR03	Still	TR03_38	38	106.6	486 938.8	856 841.0	487 106.5	856 908.7	180.8	
18/05/2019	20:40:42	TR03	Video	EOL	1	104.9	486 938.8	856 841.0	487 108.9	856 909.6	183.4	
18/5/2019	21:57:28	TR02_part1	Video	SOL	1	94.5	483 243.0	856 113.0	483 136.9	856 254.5	176.9	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/5/2019	21:57:58	TR02_part1	Still	TR02_01	2	94.7	483 243.0	856 113.0	483 137.9	856 254.3	176.1	
18/5/2019	21:58:34	TR02_part1	Still	TR02_02	3	94.1	483 243.0	856 113.0	483 140.4	856 251.3	172.2	
18/5/2019	21:58:57	TR02_part1	Still	TR02_03	4	95.7	483 243.0	856 113.0	483 143.8	856 249.3	168.6	
18/5/2019	21:59:36	TR02_part1	Still	TR02_04	5	95.8	483 243.0	856 113.0	483 146.5	856 245.1	163.6	
18/5/2019	21:59:54	TR02_part1	Still	TR02_05	6	93.8	483 243.0	856 113.0	483 146.9	856 243.1	161.7	
18/5/2019	22:00:15	TR02_part1	Still	TR02_06	7	93.3	483 243.0	856 113.0	483 147.8	856 240.4	159.0	
18/5/2019	22:00:49	TR02_part1	Still	TR02_07	8	94.8	483 243.0	856 113.0	483 150.1	856 236.5	154.6	
18/5/2019	22:01:30	TR02_part1	Still	TR02_08	9	94.3	483 243.0	856 113.0	483 153.2	856 230.5	147.9	
18/5/2019	22:01:46	TR02_part1	Still	TR02_09	10	93.0	483 243.0	856 113.0	483 155.0	856 228.2	145.0	
18/5/2019	22:01:58	TR02_part1	Still	TR02_10	11	94.9	483 243.0	856 113.0	483 156.8	856 227.6	143.4	
18/5/2019	22:02:34	TR02_part1	Still	TR02_11	12	94.3	483 243.0	856 113.0	483 160.4	856 222.4	137.1	
18/5/2019	22:02:55	TR02_part1	Still	TR02_12	13	93.3	483 243.0	856 113.0	483 162.3	856 219.2	133.3	
18/5/2019	22:03:34	TR02_part1	Still	TR02_13	14	94.8	483 243.0	856 113.0	483 166.8	856 213.2	125.9	
18/5/2019	22:03:56	TR02_part1	Still	TR02_14	15	95.0	483 243.0	856 113.0	483 168.3	856 209.0	121.6	
18/5/2019	22:04:27	TR02_part1	Still	TR02_15	16	95.2	483 243.0	856 113.0	483 170.6	856 204.6	116.8	
18/5/2019	22:04:41	TR02_part1	Still	TR02_16	17	94.7	483 243.0	856 113.0	483 172.2	856 202.9	114.4	
18/5/2019	22:05:02	TR02_part1	Still	TR02_17	18	95.5	483 243.0	856 113.0	483 173.6	856 200.2	111.4	
18/5/2019	22:05:27	TR02_part1	Still	TR02_18	19	96.3	483 243.0	856 113.0	483 175.5	856 196.5	107.4	
18/5/2019	22:06:10	TR02_part1	Still	TR02_19	20	97.5	483 243.0	856 113.0	483 179.5	856 191.2	100.7	
18/5/2019	22:07:21	TR02_part1	Still	TR02_20	21	98.7	483 243.0	856 113.0	483 185.7	856 183.1	90.6	
18/5/2019	22:07:50	TR02_part1	Still	TR02_21	22	100.6	483 243.0	856 113.0	483 189.8	856 178.6	84.5	
18/5/2019	22:08:09	TR02_part1	Still	TR02_22	23	100.7	483 243.0	856 113.0	483 191.8	856 175.3	80.7	
18/5/2019	22:08:28	TR02_part1	Still	TR02_23	24	101.5	483 243.0	856 113.0	483 193.1	856 173.0	78.0	
18/5/2019	22:08:41	TR02_part1	Still	TR02_24	25	100.5	483 243.0	856 113.0	483 194.5	856 171.4	75.9	
18/5/2019	22:08:52	TR02_part1	Still	TR02_25	26	99.9	483 243.0	856 113.0	483 195.3	856 170.8	74.9	
18/5/2019	22:09:13	TR02_part1	Still	TR02_26	27	99.0	483 243.0	856 113.0	483 197.5	856 168.2	71.5	
18/5/2019	22:09:34	TR02_part1	Still	TR02_27	28	99.8	483 243.0	856 113.0	483 200.5	856 165.1	67.2	
18/5/2019	22:10:02	TR02_part1	Still	TR02_28	29	98.1	483 243.0	856 113.0	483 204.7	856 162.8	62.8	
18/5/2019	22:10:21	TR02_part1	Still	TR02_29	30	98.9	483 243.0	856 113.0	483 207.2	856 160.6	59.6	
18/5/2019	22:11:39	TR02_part1	Still	TR02_30		97.4	483 243.0	856 113.0	483 215.8	856 154.3	49.4	
18/5/2019	22:12:02	TR02_part1	Still	TR02_31	31	97.1	483 243.0	856 113.0	483 217.8	856 151.2	45.7	
18/5/2019	22:12:34	TR02_part1	Still	TR02_32	32	95.6	483 243.0	856 113.0	483 221.8	856 149.7	42.4	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/5/2019	22:13:00	TR02_part1	Still	TR02_33	33	95.0	483 243.0	856 113.0	483 224.6	856 147.3	38.9	
18/5/2019	22:14:14	TR02_part1	Video	EOL	1	95.8	483 243.0	856 113.0	483 230.1	856 139.4	29.4	
18/5/2019	22:17:35	TR02_part2	Video	SOL	2	94.3	483 243.0	856 113.0	483 232.7	856 135.9	25.1	
18/5/2019	22:17:50	TR02_part2	Still	TR02_34	36	94.8	483 243.0	856 113.0	483 231.9	856 136.8	26.3	
18/5/2019	22:18:22	TR02_part2	Still	TR02_35	37	94.4	483 243.0	856 113.0	483 231.9	856 136.6	26.1	
18/5/2019	22:18:46	TR02_part2	Still	TR02_36	38	94.0	483 243.0	856 113.0	483 233.5	856 135.0	24.0	
18/5/2019	22:19:22	TR02_part2	Still	TR02_37	39	94.5	483 243.0	856 113.0	483 236.1	856 130.4	18.7	
18/5/2019	22:19:43	TR02_part2	Still	TR02_38	40	95.1	483 243.0	856 113.0	483 238.1	856 129.2	16.9	
18/5/2019	22:21:36	TR02_part2	Still	TR02_39	41	98.0	483 243.0	856 113.0	483 251.7	856 118.6	10.3	
18/5/2019	22:22:12	TR02_part2	Still	TR02_40	42	97.5	483 243.0	856 113.0	483 252.2	856 114.6	9.4	
18/5/2019	22:22:39	TR02_part2	Still	TR02_41	43	97.8	483 243.0	856 113.0	483 253.4	856 110.3	10.7	
18/5/2019	22:23:02	TR02_part2	Still	TR02_42		98.4	483 243.0	856 113.0	483 254.4	856 105.8	13.5	
18/5/2019	22:23:25	TR02_part2	Still	TR02_43	44	98.8	483 243.0	856 113.0	483 256.5	856 102.1	17.3	
18/5/2019	22:24:07	TR02_part2	Still	TR02_44		98.5	483 243.0	856 113.0	483 260.6	856 096.1	24.4	
18/5/2019	22:24:38	TR02_part2	Still	TR02_45	45	98.1	483 243.0	856 113.0	483 263.4	856 092.4	28.9	
18/5/2019	22:25:24	TR02_part2	Still	TR02_46	46	96.0	483 243.0	856 113.0	483 267.0	856 088.0	34.7	
18/5/2019	22:25:36	TR02_part2	Video	EOL	2	96.2	483 243.0	856 113.0	483 267.6	856 086.6	36.1	
18/05/2019	23:34:36	TR01_part1	Video	SOL	1	111.2	484 524.0	858 728.0	484 500.2	858 711.5	29.0	
18/05/2019	23:34:57	TR01_part1	Still	TR01_01	1	111.3	484 524.0	858 728.0	484 500.2	858 710.3	29.6	
18/05/2019	23:37:16	TR01_part1	Still	TR01_02	2	110.8	484 524.0	858 728.0	484 500.8	858 708.6	30.3	
18/05/2019	23:37:38	TR01_part1	Still	TR01_03	3	110.8	484 524.0	858 728.0	484 502.6	858 710.7	27.6	
18/05/2019	23:38:50	TR01_part1	Still	TR01_04	4	109.8	484 524.0	858 728.0	484 508.8	858 718.2	18.0	
18/05/2019	23:39:15	TR01_part1	Still	TR01_05	5	109.7	484 524.0	858 728.0	484 511.5	858 721.5	14.0	
18/05/2019	23:39:58	TR01_part1	Still	TR01_06	6	108.8	484 524.0	858 728.0	484 516.4	858 727.5	7.6	
18/05/2019	23:40:14	TR01_part1	Still	TR01_07	7	108.7	484 524.0	858 728.0	484 518.0	858 729.4	6.1	
18/05/2019	23:40:39	TR01_part1	Still	TR01_08	8	108.1	484 524.0	858 728.0	484 520.2	858 732.9	6.2	
18/05/2019	23:41:02	TR01_part1	Still	TR01_09	9	108.3	484 524.0	858 728.0	484 522.3	858 736.2	8.4	
18/05/2019	23:41:25	TR01_part1	Still	TR01_10	10	110.1	484 524.0	858 728.0	484 524.6	858 738.0	10.0	
18/05/2019	23:42:20	TR01_part1	Video	EOL	1	109.0	484 524.0	858 728.0	484 528.1	858 742.7	15.3	
18/05/2019	23:45:29	TR01_part2	Video	SOL	2	102.6	484 524.0	858 728.0	484 534.7	858 748.6	23.3	
18/05/2019	23:47:11	TR01_part2	Still	TR01_11	11	102.7	484 524.0	858 728.0	484 542.1	858 752.4	30.3	
18/05/2019	23:47:37	TR01_part2	Still	TR01_12	12	103.9	484 524.0	858 728.0	484 542.7	858 753.7	31.7	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
18/05/2019	23:47:58	TR01_part2	Still	TR01_13	13	103.4	484 524.0	858 728.0	484 544.3	858 755.2	33.9	
18/05/2019	23:48:26	TR01_part2	Still	TR01_14	14	105.4	484 524.0	858 728.0	484 546.3	858 757.4	36.9	
18/05/2019	23:48:44	TR01_part2	Still	TR01_15	15	103.2	484 524.0	858 728.0	484 547.9	858 758.6	38.8	
18/05/2019	23:49:07	TR01_part2	Still	TR01_16	16	103.1	484 524.0	858 728.0	484 551.8	858 761.9	43.8	
18/05/2019	23:49:31	TR01_part2	Still	TR01_17	17	103.6	484 524.0	858 728.0	484 554.5	858 764.7	47.7	
18/05/2019	23:50:05	TR01_part2	Still	TR01_18	18	104.0	484 524.0	858 728.0	484 557.7	858 769.1	53.1	
18/05/2019	23:50:27	TR01_part2	Still	TR01_19	19	104.5	484 524.0	858 728.0	484 560.7	858 771.6	57.0	
18/05/2019	23:51:09	TR01_part2	Still	TR01_20	20	105.8	484 524.0	858 728.0	484 564.6	858 776.8	63.5	
18/05/2019	23:51:27	TR01_part2	Still	TR01_21	21	106.0	484 524.0	858 728.0	484 566.6	858 778.3	65.9	
18/05/2019	23:52:05	TR01_part2	Still	TR01_22	22	106.6	484 524.0	858 728.0	484 568.2	858 783.5	71.0	
18/05/2019	23:52:27	TR01_part2	Still	TR01_23	23	106.6	484 524.0	858 728.0	484 569.9	858 786.0	74.0	
18/05/2019	23:53:13	TR01_part2	Still	TR01_24	24	107.3	484 524.0	858 728.0	484 574.9	858 791.4	81.3	
18/05/2019	23:54:09	TR01_part2	Still	TR01_25	25	108.4	484 524.0	858 728.0	484 580.5	858 794.8	87.5	
18/05/2019	23:54:34	TR01_part2	Still	TR01_26	26	109.4	484 524.0	858 728.0	484 582.9	858 797.8	91.3	
18/05/2019	23:55:07	TR01_part2	Still	TR01_27	27	108.3	484 524.0	858 728.0	484 585.2	858 801.5	95.6	
18/05/2019	23:56:30	TR01_part2	Still	TR01_28	28	106.5	484 524.0	858 728.0	484 592.7	858 810.4	107.3	
18/05/2019	23:57:06	TR01_part2	Still	TR01_29	29	106.9	484 524.0	858 728.0	484 596.7	858 815.6	113.9	
18/05/2019	23:57:24	TR01_part2	Still	TR01_30	30	106.6	484 524.0	858 728.0	484 599.0	858 817.9	117.1	
18/05/2019	23:58:14	TR01_part2	Still	TR01_31	31	106.4	484 524.0	858 728.0	484 604.4	858 823.3	124.7	
18/05/2019	23:58:38	TR01_part2	Still	TR01_32	32	106.5	484 524.0	858 728.0	484 606.7	858 825.4	127.7	
18/05/2019	23:58:52	TR01_part2	Still	TR01_33	33	106.1	484 524.0	858 728.0	484 607.5	858 827.7	130.0	
18/05/2019	23:59:16	TR01_part2	Still	TR01_34	34	106.6	484 524.0	858 728.0	484 610.1	858 830.5	133.9	
18/05/2019	23:59:40	TR01_part2	Still	TR01_35	35	106.2	484 524.0	858 728.0	484 612.2	858 833.3	137.4	
19/05/2019	00:00:17	TR01_part2	Still	TR01_36	36	106.2	484 524.0	858 728.0	484 615.8	858 837.3	142.8	
19/05/2019	00:00:35	TR01_part2	Still	TR01_37	37	107.0	484 524.0	858 728.0	484 617.5	858 839.1	145.2	
19/05/2019	00:00:59	TR01_part2	Still	TR01_38	38	106.2	484 524.0	858 728.0	484 620.3	858 840.9	148.4	
19/05/2019	00:01:20	TR01_part2	Still	TR01_39	39	102.9	484 524.0	858 728.0	484 623.7	858 843.3	152.4	
19/05/2019	00:02:02	TR01_part2	Still	TR01_40	40	104.9	484 524.0	858 728.0	484 629.9	858 850.2	161.7	
19/05/2019	00:02:33	TR01_part2	Still	TR01_41	41	104.4	484 524.0	858 728.0	484 632.4	858 854.4	166.5	
19/05/2019	00:03:04	TR01_part2	Still	TR01_42	42	104.5	484 524.0	858 728.0	484 635.3	858 857.0	170.3	
19/05/2019	00:03:31	TR01_part2	Still	TR01_43	43	104.2	484 524.0	858 728.0	484 639.0	858 859.9	175.0	
19/05/2019	00:04:18	TR01_part2	Still	TR01_44	44	105.2	484 524.0	858 728.0	484 643.2	858 867.3	183.4	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	00:04:54	TR01_part2	Still	TR01_45	45	105.9	484 524.0	858 728.0	484 647.6	858 871.4	189.3	
19/05/2019	00:05:38	TR01_part2	Still	TR01_46	46	104.4	484 524.0	858 728.0	484 651.4	858 874.7	194.3	
19/05/2019	00:05:56	TR01_part2	Still	TR01_47	47	106.9	484 524.0	858 728.0	484 654.0	858 877.2	197.9	
19/05/2019	00:06:34	TR01_part2	Still	TR01_48	48	105.3	484 524.0	858 728.0	484 658.6	858 882.2	204.6	
19/05/2019	00:07:36	TR01_part2	Still	TR01_49	49	106.2	484 524.0	858 728.0	484 666.2	858 890.2	215.7	
19/05/2019	00:07:56	TR01_part2	Still	TR01_50	50	108.3	484 524.0	858 728.0	484 666.6	858 892.3	217.5	
19/05/2019	00:08:24	TR01_part2	Still	TR01_51	51	104.0	484 524.0	858 728.0	484 667.7	858 894.8	220.2	
19/05/2019	00:08:00	TR01_part2	Video	EOL	2	102.8	484 524.0	858 728.0	484 669.0	858 896.4	222.3	
19/05/2019	02:46:23	EBSHH01DDc	Video	SOL	1	1033.5	483 865.5	880 797.2	483 849.5	880 792.5	16.8	
19/05/2019	02:48:51	EBSHH01DDc	Still	EBSHH01DDc_01	1	1031.8	483 865.5	880 797.2	483 851.5	880 798.6	14.1	
19/05/2019	02:49:26	EBSHH01DDc	Still	EBSHH01DDc_02	2	1032.6	483 865.5	880 797.2	483 851.3	880 799.4	14.4	
19/05/2019	02:50:13	EBSHH01DDc	Still	EBSHH01DDc_03	3	1030.4	483 865.5	880 797.2	483 851.0	880 800.7	15.0	
19/05/2019	02:51:46	EBSHH01DDc	Still	EBSHH01DDc_04	4	1033.4	483 865.5	880 797.2	483 851.8	880 801.3	14.4	
19/05/2019	02:52:33	EBSHH01DDc	Still	EBSHH01DDc_05	5	1031.2	483 865.5	880 797.2	483 852.4	880 802.4	14.1	
19/05/2019	02:52:52	EBSHH01DDc	Still	EBSHH01DDc_06	6	1032.0	483 865.5	880 797.2	483 852.8	880 802.4	13.7	
19/05/2019	02:53:26	EBSHH01DDc	Still	EBSHH01DDc_07	7	1032.4	483 865.5	880 797.2	483 853.5	880 803.1	13.4	
19/05/2019	02:53:56	EBSHH01DDc	Still	EBSHH01DDc_08	8	1033.3	483 865.5	880 797.2	483 854.8	880 803.6	12.5	
19/05/2019	02:55:48	EBSHH01DDc	Still	EBSHH01DDc_09	9	1030.6	483 865.5	880 797.2	483 861.1	880 804.2	8.3	
19/05/2019	02:56:31	EBSHH01DDc	Still	EBSHH01DDc_10	10	1032.4	483 865.5	880 797.2	483 864.9	880 803.2	6.0	
19/05/2019	02:57:41	EBSHH01DDc	Still	EBSHH01DDc_11	11	1032.5	483 865.5	880 797.2	483 873.1	880 801.6	8.7	
19/05/2019	02:57:54	EBSHH01DDc	Still	EBSHH01DDc_12	12	1032.5	483 865.5	880 797.2	483 874.6	880 802.1	10.3	
19/05/2019	02:58:32	EBSHH01DDc	Still	EBSHH01DDc_13	13	1032.8	483 865.5	880 797.2	483 877.6	880 802.5	13.1	
19/05/2019	02:58:48	EBSHH01DDc	Still	EBSHH01DDc_14	14	1033.6	483 865.5	880 797.2	483 880.5	880 802.6	15.9	
19/05/2019	02:59:10	EBSHH01DDc	Still	EBSHH01DDc_15	15	1034.5	483 865.5	880 797.2	483 883.4	880 800.3	18.2	
19/05/2019	02:59:43	EBSHH01DDc	Still	EBSHH01DDc_16	16	1032.6	483 865.5	880 797.2	483 886.6	880 801.9	21.6	
19/05/2019	03:00:20	EBSHH01DDc	Still	EBSHH01DDc_17	17	1033.1	483 865.5	880 797.2	483 891.9	880 800.5	26.6	
19/05/2019	03:00:54	EBSHH01DDc	Still	EBSHH01DDc_18	18	1033.1	483 865.5	880 797.2	483 895.2	880 801.1	29.9	
19/05/2019	03:01:58	EBSHH01DDc	Still	EBSHH01DDc_19	19	1033.9	483 865.5	880 797.2	483 904.7	880 799.8	39.2	
19/05/2019	03:02:29	EBSHH01DDc	Still	EBSHH01DDc_20	20	1034.6	483 865.5	880 797.2	483 908.3	880 799.7	42.8	
19/05/2019	03:02:55	EBSHH01DDc	Still	EBSHH01DDc_21	21	1033.3	483 865.5	880 797.2	483 911.4	880 799.5	45.9	
19/05/2019	03:03:26	EBSHH01DDc	Still	EBSHH01DDc_22	22	1034.4	483 865.5	880 797.2	483 913.5	880 799.7	48.0	
19/05/2019	03:04:17	EBSHH01DDc	Still	EBSHH01DDc_23	23	1034.1	483 865.5	880 797.2	483 921.6	880 800.2	56.1	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	03:04:56	EBSHH01DDc	Still	EBSHH01DDc_24	24	1037.1	483 865.5	880 797.2	483 927.7	880 800.1	62.3	
19/05/2019	03:05:35	EBSHH01DDc	Still	EBSHH01DDc_25	25	1038.2	483 865.5	880 797.2	483 928.4	880 799.8	62.9	
19/05/2019	03:05:56	EBSHH01DDc	Still	EBSHH01DDc_26	26	1036.5	483 865.5	880 797.2	483 933.1	880 804.3	67.9	
19/05/2019	03:05:36	EBSHH01DDc	Video	EOL	1	1036.0	483 865.5	880 797.2	483 934.5	880 798.3	69.0	
19/05/2019	07:28:45	EBSHH02DD	Video	SOL	1	1094.6	488 336.0	878 556.0	488 334.8	878 552.1	4.1	
19/05/2019	07:29:24	EBSHH02DD	Video	EOL	1	1094.3	488 336.0	878 556.0	488 336.4	878 552.8	3.2	Winch power loss, camera recovered
19/05/2019	08:12:39	EBSHH02DD	Video	SOL	2	1094.4	488 336.0	878 556.0	488 296.6	878 534.7	44.8	
19/05/2019	08:16:24	EBSHH02DD	Still	EBSHH02DD_01	2	1092.5	488 336.0	878 556.0	488 300.5	878 541.2	38.5	
19/05/2019	08:18:46	EBSHH02DD	Still	EBSHH02DD_02	3	1092.6	488 336.0	878 556.0	488 309.7	878 546.5	28.0	
19/05/2019	08:23:20	EBSHH02DD	Still	EBSHH02DD_03	5	1094.5	488 339.9	878 556.3	488 336.8	878 561.0	5.6	
19/05/2019	08:23:35	EBSHH02DD	Still	EBSHH02DD_04	6	1094.3	488 343.7	878 556.6	488 337.7	878 561.2	7.6	
19/05/2019	08:23:50	EBSHH02DD	Still	EBSHH02DD_05	7	1094.3	488 347.6	878 556.9	488 339.0	878 560.9	9.5	
19/05/2019	08:23:59	EBSHH02DD	Still	EBSHH02DD_06	8	1093.8	488 351.5	878 557.3	488 340.6	878 563.0	12.3	
19/05/2019	08:24:13	EBSHH02DD	Still	EBSHH02DD_07	9	1094.6	488 355.3	878 557.6	488 342.5	878 562.8	13.9	
19/05/2019	08:24:43	EBSHH02DD	Still	EBSHH02DD_08	10	1095.5	488 359.2	878 557.9	488 346.0	878 564.6	14.8	
19/05/2019	08:24:58	EBSHH02DD	Still	EBSHH02DD_09	12	1095.8	488 366.9	878 558.5	488 348.7	878 565.4	19.5	
19/05/2019	08:25:13	EBSHH02DD	Still	EBSHH02DD_10	13	1096.1	488 370.8	878 558.8	488 350.0	878 566.0	22.0	
19/05/2019	08:25:44	EBSHH02DD	Still	EBSHH02DD_11	14	1093.4	488 374.6	878 559.2	488 352.8	878 567.7	23.4	
19/05/2019	08:26:05	EBSHH02DD	Still	EBSHH02DD_12	16	1095.5	488 382.4	878 559.8	488 356.8	878 567.7	26.8	
19/05/2019	08:26:20	EBSHH02DD	Still	EBSHH02DD_13	17	1095.3	488 386.2	878 560.1	488 358.4	878 568.9	29.2	
19/05/2019	08:26:47	EBSHH02DD	Still	EBSHH02DD_14	18	1095.2	488 386.2	878 560.1	488 362.5	878 569.2	25.4	
19/05/2019	08:27:20	EBSHH02DD	Still	EBSHH02DD_15	19	1095.0	488 386.2	878 560.1	488 366.8	878 570.5	22.0	
19/05/2019	08:27:35	EBSHH02DD	Still	EBSHH02DD_16	20	1096.1	488 386.2	878 560.1	488 369.6	878 571.3	20.1	
19/05/2019	08:27:48	EBSHH02DD	Still	EBSHH02DD_17	21	1095.9	488 386.2	878 560.1	488 370.9	878 571.8	19.3	
19/05/2019	08:28:07	EBSHH02DD	Still	EBSHH02DD_18		1097.1	488 386.2	878 560.1	488 373.8	878 571.7	17.0	
19/05/2019	08:28:37	EBSHH02DD	Still	EBSHH02DD_19		1097.0	488 386.2	878 560.1	488 377.6	878 572.7	15.3	
19/05/2019	08:28:51	EBSHH02DD	Still	EBSHH02DD_20		1096.6	488 386.2	878 560.1	488 380.0	878 573.3	14.6	
19/05/2019	08:29:59	EBSHH02DD	Still	EBSHH02DD_21		1097.3	488 386.2	878 560.1	488 388.9	878 575.4	15.5	
19/05/2019	08:30:27	EBSHH02DD	Video	EOL	2	1096.9	488 386.2	878 560.1	488 392.2	878 576.4	17.3	
19/05/2019	19:33:00	EBSHH03DD	Video	SOL	1	1106.5	492 832.3	876 320.2	492 803.4	876 326.1	29.5	
19/05/2019	19:33:31	EBSHH03DD	Still	EBSHH03DD_01	1	1109.6	492 832.3	876 320.2	492 807.0	876 327.1	26.3	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	19:33:53	EBSHH03DD	Still	EBSHH03DD_02	2	1108.1	492 832.3	876 320.2	492 809.4	876 326.5	23.8	
19/05/2019	19:35:05	EBSHH03DD	Still	EBSHH03DD_03	3	1107.1	492 832.3	876 320.2	492 817.8	876 326.3	15.7	
19/05/2019	19:35:32	EBSHH03DD	Still	EBSHH03DD_04	4	1109.4	492 832.3	876 320.2	492 821.4	876 327.7	13.3	
19/05/2019	19:37:06	EBSHH03DD	Still	EBSHH03DD_05	5	1106.9	492 832.3	876 320.2	492 834.0	876 328.4	8.4	
19/05/2019	19:37:53	EBSHH03DD	Still	EBSHH03DD_06	6	1108.8	492 832.3	876 320.2	492 840.4	876 330.1	12.8	
19/05/2019	19:38:15	EBSHH03DD	Still	EBSHH03DD_07	7	1109.9	492 832.3	876 320.2	492 843.7	876 330.6	15.5	
19/05/2019	19:38:49	EBSHH03DD	Still	EBSHH03DD_08	8	1110.4	492 832.3	876 320.2	492 847.8	876 329.7	18.2	
19/05/2019	19:39:02	EBSHH03DD	Still	EBSHH03DD_09	9	1108.7	492 832.3	876 320.2	492 849.1	876 330.1	19.6	
19/05/2019	19:40:11	EBSHH03DD	Still	EBSHH03DD_10	10	1109.2	492 832.3	876 320.2	492 858.2	876 331.8	28.4	
19/05/2019	19:40:44	EBSHH03DD	Video	EOL	1	1107.2	492 832.3	876 320.2	492 863.4	876 332.1	33.4	
19/05/2019	21:17:42	EBSHH03DDa	Video	SOL	1	1106.3	492 832.3	876 320.2	492 781.4	876 327.3	51.3	
19/05/2019	21:17:57	EBSHH03DDa	Still	EBSHH03DDa_01	1	1107.3	492 832.3	876 320.2	492 783.0	876 327.5	49.9	
19/05/2019	21:18:18	EBSHH03DDa	Still	EBSHH03DDa_02	2	1106.5	492 832.3	876 320.2	492 785.0	876 327.3	47.8	
19/05/2019	21:19:01	EBSHH03DDa	Still	EBSHH03DDa_03	3	1108.0	492 832.3	876 320.2	492 788.9	876 327.0	43.9	
19/05/2019	21:19:51	EBSHH03DDa	Still	EBSHH03DDa_04	4	1107.4	492 832.3	876 320.2	492 793.0	876 326.3	39.8	
19/05/2019	21:20:26	EBSHH03DDa	Still	EBSHH03DDa_05	5	1105.7	492 832.3	876 320.2	492 796.8	876 325.9	36.0	
19/05/2019	21:22:02	EBSHH03DDa	Still	EBSHH03DDa_06	6	1107.0	492 832.3	876 320.2	492 807.6	876 323.5	24.9	
19/05/2019	21:22:19	EBSHH03DDa	Still	EBSHH03DDa_07	7	1107.0	492 832.3	876 320.2	492 809.3	876 323.8	23.3	
19/05/2019	21:22:34	EBSHH03DDa	Still	EBSHH03DDa_08	8	1107.8	492 832.3	876 320.2	492 810.4	876 323.7	22.1	
19/05/2019	21:22:48	EBSHH03DDa	Still	EBSHH03DDa_09	9	1107.1	492 832.3	876 320.2	492 811.9	876 323.2	20.6	
19/05/2019	21:23:28	EBSHH03DDa	Still	EBSHH03DDa_10	10	1106.2	492 832.3	876 320.2	492 816.2	876 322.0	16.2	
19/05/2019	21:25:20	EBSHH03DDa	Still	EBSHH03DDa_11	11	1104.2	492 832.3	876 320.2	492 827.3	876 320.0	5.0	
19/05/2019	21:25:34	EBSHH03DDa	Still	EBSHH03DDa_12	12	1104.8	492 832.3	876 320.2	492 828.2	876 320.3	4.1	
19/05/2019	21:25:57	EBSHH03DDa	Still	EBSHH03DDa_13	13	1105.1	492 832.3	876 320.2	492 829.4	876 320.3	2.9	
19/05/2019	21:26:32	EBSHH03DDa	Still	EBSHH03DDa_14	14	1106.7	492 832.3	876 320.2	492 833.3	876 319.6	1.2	
19/05/2019	21:26:58	EBSHH03DDa	Still	EBSHH03DDa_15	15	1105.4	492 832.3	876 320.2	492 835.6	876 319.3	3.4	
19/05/2019	21:27:18	EBSHH03DDa	Still	EBSHH03DDa_16	16	1104.8	492 832.3	876 320.2	492 837.4	876 320.3	5.1	
19/05/2019	21:27:42	EBSHH03DDa	Still	EBSHH03DDa_17	17	1105.2	492 832.3	876 320.2	492 839.1	876 319.3	6.9	
19/05/2019	21:28:06	EBSHH03DDa	Still	EBSHH03DDa_18	18	1104.9	492 832.3	876 320.2	492 840.6	876 319.7	8.3	
19/05/2019	21:28:29	EBSHH03DDa	Still	EBSHH03DDa_19	19	1106.6	492 832.3	876 320.2	492 842.6	876 319.1	10.4	
19/05/2019	21:29:00	EBSHH03DDa	Still	EBSHH03DDa_20	20	1107.2	492 832.3	876 320.2	492 844.5	876 320.5	12.3	
19/05/2019	21:29:21	EBSHH03DDa	Still	EBSHH03DDa_21	21	1106.5	492 832.3	876 320.2	492 845.9	876 319.7	13.6	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
19/05/2019	21:30:12	EBSHH03DDa	Still	EBSHH03DDa_22	22	1106.5	492 832.3	876 320.2	492 849.8	876 319.1	17.5	
19/05/2019	21:30:22	EBSHH03DDa	Still	EBSHH03DDa_23	23	1107.5	492 832.3	876 320.2	492 849.5	876 319.5	17.3	
19/05/2019	21:30:48	EBSHH03DDa	Still	EBSHH03DDa_24	24	1107.0	492 832.3	876 320.2	492 851.5	876 319.6	19.2	
19/05/2019	21:31:10	EBSHH03DDa	Still	EBSHH03DDa_25	25	1107.8	492 832.3	876 320.2	492 853.3	876 318.6	21.1	
19/05/2019	21:31:26	EBSHH03DDa	Still	EBSHH03DDa_26	26	1107.8	492 832.3	876 320.2	492 853.6	876 318.8	21.4	
19/05/2019	21:31:45	EBSHH03DDa	Still	EBSHH03DDa_27	27	1107.7	492 832.3	876 320.2	492 854.9	876 318.4	22.7	
19/05/2019	21:31:56	EBSHH03DDa	Still	EBSHH03DDa_28	28	1107.0	492 832.3	876 320.2	492 855.3	876 317.6	23.2	
19/05/2019	21:31:09	EBSHH03DDa	Still	EBSHH03DDa_29	29	1106.7	492 832.3	876 320.2	492 855.8	876 317.6	23.6	
19/05/2019	21:32:19	EBSHH03DDa	Still	EBSHH03DDa_30	30	1106.6	492 832.3	876 320.2	492 856.6	876 317.6	24.5	
19/05/2019	21:32:34	EBSHH03DDa	Still	EBSHH03DDa_31	31	1108.0	492 832.3	876 320.2	492 857.1	876 317.8	25.0	
19/05/2019	21:32:44	EBSHH03DDa	Video	EOL	1	1107.6	492 832.3	876 320.2	492 857.5	876 317.2	25.4	
19/05/2019	23:37:49	EBSHH06DD	Video	SOL	1	930.0	493 622.3	871 760.8	493 580.4	871 748.3	43.7	
19/05/2019	23:38:39	EBSHH06DD	Still	EBSHH06DD_01	1	932.0	493 622.3	871 760.8	493 580.6	871 750.2	43.0	
19/05/2019	23:39:03	EBSHH06DD	Still	EBSHH06DD_02	2	931.5	493 622.3	871 760.8	493 580.5	871 749.3	43.4	
19/05/2019	23:40:23	EBSHH06DD	Still	EBSHH06DD_03	3	932.0	493 622.3	871 760.8	493 581.3	871 750.2	42.3	
19/05/2019	23:42:33	EBSHH06DD	Still	EOL	1	929.8	493 622.3	871 760.8	493 587.5	871 751.4	36.0	
19/05/2019	23:53:08	EBSHH06DD	Still	SOL	2	932.4	493 622.3	871 760.8	493 594.3	871 751.6	29.5	
19/05/2019	23:53:58	EBSHH06DD	Still	EBSHH06DD_04	4	933.3	493 622.3	871 760.8	493 594.8	871 752.5	28.8	
19/05/2019	23:54:52	EBSHH06DD	Still	EOL	2	931.0	493 622.3	871 760.8	493 595.3	871 752.9	28.2	
20/05/2019	00:05:55	EBSHH06DD	Still	SOL	3	932.5	493 622.3	871 760.8	493 608.0	871 754.2	15.8	
20/05/2019	00:06:07	EBSHH06DD	Still	EBSHH07DD_05	5	931.6	493 622.3	871 760.8	493 608.1	871 754.2	15.7	
20/05/2019	00:06:48	EBSHH06DD	Still	EBSHH07DD_06	6	931.7	493 622.3	871 760.8	493 608.0	871 754.5	15.7	
20/05/2019	00:07:39	EBSHH06DD	Still	EBSHH07DD_07	7	931.6	493 622.3	871 760.8	493 607.9	871 754.5	15.7	
20/05/2019	00:08:25	EBSHH06DD	Still	EBSHH07DD_08	8	932.6	493 622.3	871 760.8	493 607.5	871 754.5	16.1	
20/05/2019	00:08:53	EBSHH06DD	Still	EBSHH07DD_09	9	932.3	493 622.3	871 760.8	493 607.8	871 754.7	15.7	
20/05/2019	00:09:20	EBSHH06DD	Still	EBSHH07DD_10	10	931.8	493 622.3	871 760.8	493 607.4	871 755.3	15.9	
20/05/2019	00:10:07	EBSHH06DD	Still	EBSHH07DD_11	11	932.6	493 622.3	871 760.8	493 607.9	871 754.9	15.6	
20/05/2019	00:10:29	EBSHH06DD	Still	EBSHH07DD_12	12	932.7	493 622.3	871 760.8	493 608.4	871 756.5	14.5	
20/05/2019	00:11:08	EBSHH06DD	Still	EBSHH07DD_13	13	932.8	493 622.3	871 760.8	493 610.2	871 757.0	12.7	
20/05/2019	00:12:00	EBSHH06DD	Still	EBSHH07DD_14	14	931.8	493 622.3	871 760.8	493 611.5	871 757.5	11.3	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	00:12:29	EBSHH06DD	Still	EBSHH07DD_15	15	932.2	493 622.3	871 760.8	493 613.2	871 757.1	9.8	
20/05/2019	00:13:43	EBSHH06DD	Still	EBSHH07DD_16	16	932.9	493 622.3	871 760.8	493 615.5	871 757.2	7.8	
20/05/2019	00:14:11	EBSHH06DD	Still	EBSHH07DD_17	17	932.7	493 622.3	871 760.8	493 616.5	871 757.8	6.5	
20/05/2019	00:14:46	EBSHH06DD	Still	EBSHH07DD_18	18	932.2	493 622.3	871 760.8	493 615.6	871 757.5	7.5	
20/05/2019	00:15:55	EBSHH06DD	Still	EBSHH07DD_19	19	933.0	493 622.3	871 760.8	493 617.6	871 757.3	5.9	
20/05/2019	00:17:20	EBSHH06DD	Still	EBSHH07DD_20	20	932.6	493 622.3	871 760.8	493 620.6	871 757.6	3.6	
20/05/2019	00:17:52	EBSHH06DD	Still	EBSHH07DD_21	21	932.6	493 622.3	871 760.8	493 622.5	871 759.7	1.1	
20/05/2019	00:18:34	EBSHH06DD	Still	EBSHH07DD_22	22	937.0	493 622.3	871 760.8	493 639.9	871 865.6	106.2	
20/05/2019	00:18:52	EBSHH06DD	Still	EBSHH07DD_23	23	932.8	493 622.3	871 760.8	493 625.9	871 759.1	4.0	
20/05/2019	00:19:22	EBSHH06DD	Video	EOL	3	932.8	493 622.3	871 760.8	493 628.0	871 759.5	5.8	
20/05/2019	00:31:36	EBSHH06DD	Video	SOL	4	785.0	493 622.3	871 760.8	493 644.6	871 767.6	23.3	
20/05/2019	00:32:22	EBSHH06DD	Still	EBSHH04DD_24	24	640.3	493 622.3	871 760.8	493 625.9	871 775.2	14.8	
20/05/2019	00:33:35	EBSHH06DD	Video	EOL	4	630.7	493 622.3	871 760.8	493 649.8	871 775.5	31.1	
20/05/2019	04:16:34	EBSHH06DDa	Video	SOL	1	935.3	493 622.3	871 760.8	493 622.7	871 738.0	22.8	
20/05/2019	04:16:48	EBSHH06DDa	Still	EBSHH06DDa_01	1	934.4	493 622.3	871 760.8	493 623.0	871 737.5	23.2	
20/05/2019	04:17:16	EBSHH06DDa	Still	EBSHH06DDa_02	2	933.9	493 622.3	871 760.8	493 621.5	871 739.2	21.6	
20/05/2019	04:17:33	EBSHH06DDa	Still	EBSHH06DDa_03	3	933.9	493 622.3	871 760.8	493 620.9	871 739.2	21.6	
20/05/2019	04:18:32	EBSHH06DDa	Still	EBSHH06DDa_04	4	934.3	493 622.3	871 760.8	493 620.3	871 738.0	22.8	
20/05/2019	04:19:28	EBSHH06DDa	Still	EBSHH06DDa_05	5	882.0	493 622.3	871 760.8	493 620.0	871 742.0	18.9	
20/05/2019	04:19:52	EBSHH06DDa	Still	EBSHH06DDa_06	6	930.0	493 622.3	871 760.8	493 620.7	871 753.4	7.6	
20/05/2019	04:20:36	EBSHH06DDa	Still	EBSHH06DDa_07	7	849.5	493 622.3	871 760.8	493 621.5	871 739.9	20.9	
20/05/2019	04:21:00	EBSHH06DDa	Still	EBSHH06DDa_08	8	933.9	493 622.3	871 760.8	493 620.4	871 741.4	19.5	
20/05/2019	04:21:28	EBSHH06DDa	Still	EBSHH06DDa_09	9	933.4	493 622.3	871 760.8	493 620.8	871 739.6	21.2	
20/05/2019	04:22:01	EBSHH06DDa	Still	EBSHH06DDa_10	10	934.3	493 622.3	871 760.8	493 620.9	871 742.2	18.6	
20/05/2019	04:22:33	EBSHH06DDa	Still	EBSHH06DDa_11	11	933.8	493 622.3	871 760.8	493 620.0	871 742.7	18.3	
20/05/2019	04:23:35	EBSHH06DDa	Still	EBSHH06DDa_12	12	934.4	493 622.3	871 760.8	493 621.1	871 742.4	18.4	
20/05/2019	04:23:57	EBSHH06DDa	Still	EBSHH06DDa_13	13	933.7	493 622.3	871 760.8	493 621.4	871 743.0	17.8	
20/05/2019	04:24:39	EBSHH06DDa	Still	EBSHH06DDa_14	14	934.0	493 622.3	871 760.8	493 591.9	871 787.9	40.7	
20/05/2019	04:25:51	EBSHH06DDa	Still	EBSHH06DDa_15	15	932.8	493 622.3	871 760.8	493 621.3	871 745.0	15.8	
20/05/2019	04:26:22	EBSHH06DDa	Still	EBSHH06DDa_16	16	932.2	493 622.3	871 760.8	493 621.9	871 745.5	15.3	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	04:28:09	EBSHH06DDa	Still	EBSHH06DDa_17	17	932.2	493 622.3	871 760.8	493 615.7	871 808.3	48.0	
20/05/2019	04:28:51	EBSHH06DDa	Still	EBSHH06DDa_18	18	932.0	493 622.3	871 760.8	493 616.6	871 798.0	37.7	
20/05/2019	04:29:39	EBSHH06DDa	Still	EBSHH06DDa_19	19	932.0	493 622.3	871 760.8	493 612.3	871 833.2	73.1	
20/05/2019	04:30:34	EBSHH06DDa	Still	EBSHH06DDa_20	20	932.0	493 622.3	871 760.8	493 611.9	871 823.0	63.1	
20/05/2019	04:33:14	EBSHH06DDa	Still	EBSHH06DDa_21	21	932.0	493 622.3	871 760.8	493 612.8	871 835.4	75.3	
20/05/2019	04:37:30	EBSHH06DDa	Video	EOL	1	932.0	493 622.3	871 760.8	493 611.4	871 843.3	83.2	
20/05/2019	06:49:54	EBSHH05DD	Video	SOL	1	920.5	488 805.9	873 862.8	488 753.3	873 859.9	52.7	
20/05/2019	06:49:56	EBSHH05DD	Still	EBSHH05DD_01	1	920.1	488 805.9	873 862.8	488 753.4	873 860.5	52.6	
20/05/2019	06:50:54	EBSHH05DD	Still	EBSHH05DD_02	2	917.7	488 805.9	873 862.8	488 753.9	873 861.9	52.0	
20/05/2019	06:51:42	EBSHH05DD	Still	EBSHH05DD_03	3	917.5	488 805.9	873 862.8	488 753.3	873 863.7	52.7	
20/05/2019	06:56:16	EBSHH05DD	Still	EBSHH05DD_04	4	918.3	488 805.9	873 862.8	488 761.4	873 871.7	45.4	
20/05/2019	07:00:30	EBSHH05DD	Still	EBSHH05DD_05	5	920.2	488 805.9	873 862.8	488 787.4	873 878.7	24.4	
20/05/2019	07:00:51	EBSHH05DD	Still	EBSHH05DD_06	6	920.7	488 805.9	873 862.8	488 790.1	873 879.9	23.2	
20/05/2019	07:01:16	EBSHH05DD	Still	EBSHH05DD_07	7	921.2	488 805.9	873 862.8	488 793.7	873 879.2	20.5	
20/05/2019	07:01:51	EBSHH05DD	Still	EBSHH05DD_08	8	921.6	488 805.9	873 862.8	488 797.9	873 880.1	19.0	
20/05/2019	07:02:13	EBSHH05DD	Still	EBSHH05DD_09	9	921.9	488 805.9	873 862.8	488 802.2	873 880.9	18.5	
20/05/2019	07:02:31	EBSHH05DD	Still	EBSHH05DD_10	10	921.8	488 805.9	873 862.8	488 805.1	873 881.2	18.4	
20/05/2019	07:02:53	EBSHH05DD	Still	EBSHH05DD_11	11	922.9	488 805.9	873 862.8	488 807.2	873 881.5	18.7	
20/05/2019	07:03:31	EBSHH05DD	Still	EBSHH05DD_12	12	921.7	488 805.9	873 862.8	488 811.6	873 881.2	19.2	
20/05/2019	07:04:07	EBSHH05DD	Still	EBSHH05DD_13	13	923.7	488 805.9	873 862.8	488 817.3	873 882.2	22.5	
20/05/2019	07:04:42	EBSHH05DD	Video	EOL	1	921.8	488 805.9	873 862.8	488 821.0	873 882.7	24.9	Vessel could not hold the position at this heading
20/05/2019	08:06:14	EBSHH05DDa	Video	SOL	1	917.4	488 805.9	873 862.8	488 761.6	873 859.7	44.4	
20/05/2019	08:09:41	EBSHH05DDa	Still	EBSHH05DDa_01	1	917.9	488 805.9	873 862.8	488 781.0	873 857.5	25.5	
20/05/2019	08:10:11	EBSHH05DDa	Still	EBSHH05DDa_02	2	918.3	488 805.9	873 862.8	488 783.6	873 857.3	23.0	
20/05/2019	08:11:50	EBSHH05DDa	Still	EBSHH05DDa_03	3	919.1	488 805.9	873 862.8	488 795.7	873 856.3	12.1	
20/05/2019	08:12:38	EBSHH05DDa	Still	EBSHH05DDa_04	4	919.5	488 805.9	873 862.8	488 799.9	873 857.7	8.0	
20/05/2019	08:13:07	EBSHH05DDa	Still	EBSHH05DDa_05	5	918.1	488 805.9	873 862.8	488 803.5	873 856.1	7.2	
20/05/2019	08:13:25	EBSHH05DDa	Still	EBSHH05DDa_06	6	918.8	488 805.9	873 862.8	488 805.6	873 854.5	8.4	
20/05/2019	08:13:45	EBSHH05DDa	Still	EBSHH05DDa_07	7	919.1	488 805.9	873 862.8	488 807.3	873 856.5	6.5	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	08:14:16	EBSHH05DDa	Still	EBSHH05DDa_08	8	919.7	488 805.9	873 862.8	488 812.0	873 854.7	10.1	
20/05/2019	08:14:29	EBSHH05DDa	Still	EBSHH05DDa_09	9	919.2	488 805.9	873 862.8	488 813.0	873 854.7	10.8	
20/05/2019	08:14:50	EBSHH05DDa	Still	EBSHH05DDa_10	10	919.1	488 805.9	873 862.8	488 815.4	873 854.6	12.5	
20/05/2019	08:15:12	EBSHH05DDa	Still	EBSHH05DDa_11	11	919.5	488 805.9	873 862.8	488 818.7	873 854.8	15.1	
20/05/2019	08:15:38	EBSHH05DDa	Still	EBSHH05DDa_12	12	919.4	488 805.9	873 862.8	488 822.6	873 855.0	18.4	
20/05/2019	08:15:55	EBSHH05DDa	Still	EBSHH05DDa_13	13	921.3	488 805.9	873 862.8	488 824.0	873 855.5	19.5	
20/05/2019	08:16:13	EBSHH05DDa	Still	EBSHH05DDa_14	14	921.2	488 805.9	873 862.8	488 825.5	873 855.6	20.9	
20/05/2019	08:16:26	EBSHH05DDa	Still	EBSHH05DDa_15	15	921.5	488 805.9	873 862.8	488 828.0	873 856.4	23.0	
20/05/2019	08:16:43	EBSHH05DDa	Still	EBSHH05DDa_16	16	920.4	488 805.9	873 862.8	488 829.9	873 856.8	24.7	
20/05/2019	08:17:02	EBSHH05DDa	Still	EBSHH05DDa_17	17	922.3	488 805.9	873 862.8	488 832.5	873 857.9	27.0	
20/05/2019	08:17:09	EBSHH05DDa	Video	EOL	1	922.3	488 805.9	873 862.8	488 832.0	873 857.8	26.5	
20/05/2019	09:55:55	EBSHH04DD	Video	SOL	1	879.8	484 335.1	876 101.5	484 267.2	876 107.1	68.1	
20/05/2019	09:56:35	EBSHH04DD	Still	EBSHH04DD_01	1	880.4	484 335.1	876 101.5	484 269.0	876 106.9	66.3	
20/05/2019	09:56:59	EBSHH04DD	Still	EBSHH04DD_02	2	880.7	484 335.1	876 101.5	484 269.7	876 106.3	65.5	
20/05/2019	09:57:52	EBSHH04DD	Still	EBSHH04DD_03	3	880.6	484 335.1	876 101.5	484 274.2	876 105.7	61.0	
20/05/2019	09:58:43	EBSHH04DD	Still	EBSHH04DD_04	4	880.3	484 335.1	876 101.5	484 278.6	876 105.4	56.6	
20/05/2019	09:59:30	EBSHH04DD	Still	EBSHH04DD_05	5	881.4	484 335.1	876 101.5	484 283.3	876 104.0	51.9	
20/05/2019	09:59:52	EBSHH04DD	Still	EBSHH04DD_06	6	882.2	484 335.1	876 101.5	484 285.3	876 103.6	49.8	
20/05/2019	10:00:53	EBSHH04DD	Still	EBSHH04DD_07	7	881.8	484 335.1	876 101.5	484 292.0	876 101.9	43.1	
20/05/2019	10:03:15	EBSHH04DD	Still	EBSHH04DD_08	8	881.2	484 335.1	876 101.5	484 307.9	876 100.3	27.2	
20/05/2019	10:03:43	EBSHH04DD	Still	EBSHH04DD_09	9	882.4	484 335.1	876 101.5	484 311.8	876 099.7	23.3	
20/05/2019	10:04:04	EBSHH04DD	Still	EBSHH04DD_10	10	882.4	484 335.1	876 101.5	484 314.3	876 099.8	20.8	
20/05/2019	10:04:23	EBSHH04DD	Still	EBSHH04DD_11	11	882.2	484 335.1	876 101.5	484 316.6	876 099.7	18.6	
20/05/2019	10:04:40	EBSHH04DD	Still	EBSHH04DD_12	12	882.1	484 335.1	876 101.5	484 319.1	876 100.1	16.1	
20/05/2019	10:04:58	EBSHH04DD	Still	EBSHH04DD_13	13	883.2	484 335.1	876 101.5	484 321.2	876 099.0	14.1	
20/05/2019	10:05:14	EBSHH04DD	Still	EBSHH04DD_14	14	882.0	484 335.1	876 101.5	484 322.0	876 099.8	13.2	
20/05/2019	10:05:56	EBSHH04DD	Still	EBSHH04DD_15	15	882.7	484 335.1	876 101.5	484 324.5	876 098.6	11.0	
20/05/2019	10:05:56	EBSHH04DD	Still	EBSHH04DD_16	16	882.7	484 335.1	876 101.5	484 324.5	876 098.6	11.0	
20/05/2019	10:06:19	EBSHH04DD	Still	EBSHH04DD_17	17	883.0	484 335.1	876 101.5	484 328.6	876 097.4	7.7	
20/05/2019	10:07:08	EBSHH04DD	Still	EBSHH04DD_18	18	882.6	484 335.1	876 101.5	484 334.3	876 097.8	3.8	
20/05/2019	10:07:49	EBSHH04DD	Still	EBSHH04DD_19	19	883.6	484 335.1	876 101.5	484 339.3	876 099.4	4.7	
20/05/2019	10:08:35	EBSHH04DD	Still	EBSHH04DD_20	20	882.5	484 335.1	876 101.5	484 343.7	876 101.4	8.6	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	10:08:53	EBSHH04DD	Still	EBSHH04DD_21	21	883.9	484 335.1	876 101.5	484 345.1	876 101.1	10.0	
20/05/2019	10:09:19	EBSHH04DD	Still	EBSHH04DD_22	22	883.6	484 335.1	876 101.5	484 348.6	876 102.9	13.6	
20/05/2019	10:09:41	EBSHH04DD	Still	EBSHH04DD_23	23	883.8	484 335.1	876 101.5	484 350.6	876 102.6	15.6	
20/05/2019	10:09:56	EBSHH04DD	Still	EBSHH04DD_24	24	883.7	484 335.1	876 101.5	484 351.3	876 102.0	16.2	
20/05/2019	10:10:44	EBSHH04DD	Still	EBSHH04DD_25	25	882.6	484 335.1	876 101.5	484 357.1	876 103.7	22.1	
20/05/2019	10:11:08	EBSHH04DD	Still	EBSHH04DD_26	26	883.8	484 335.1	876 101.5	484 359.1	876 102.8	24.0	
20/05/2019	10:11:16	EBSHH04DD	Video	EOL	1	883.2	484 335.1	876 101.5	484 360.0	876 103.3	24.9	
20/05/2019	14:50:37	EBSHH07DD	Video	SOL	1	662.8	484 779.6	871 405.5	484 808.0	871 414.8	29.9	
20/05/2019	14:51:22	EBSHH07DD	Still	EBSHH07DD_01	1	662.8	484 779.6	871 405.5	484 724.8	871 373.6	63.4	
20/05/2019	14:51:49	EBSHH07DD	Still	EBSHH07DD_02	2	662.9	484 779.6	871 405.5	484 726.3	871 374.2	61.8	
20/05/2019	14:52:37	EBSHH07DD	Still	EBSHH07DD_03	3	661.2	484 779.6	871 405.5	484 730.3	871 377.7	56.6	
20/05/2019	14:53:10	EBSHH07DD	Still	EBSHH07DD_04	4	662.7	484 779.6	871 405.5	484 732.6	871 379.0	53.9	
20/05/2019	14:53:59	EBSHH07DD	Still	EBSHH07DD_05	5	662.0	484 779.6	871 405.5	484 737.5	871 379.7	49.3	
20/05/2019	14:54:41	EBSHH07DD	Still	EBSHH07DD_06	6	662.5	484 779.6	871 405.5	484 741.6	871 380.5	45.5	
20/05/2019	14:54:54	EBSHH07DD	Still	EBSHH07DD_07	7	663.7	484 779.6	871 405.5	484 742.4	871 380.9	44.6	
20/05/2019	14:56:20	EBSHH07DD	Still	EBSHH07DD_08	8	663.1	484 779.6	871 405.5	484 750.5	871 385.6	35.3	
20/05/2019	14:57:38	EBSHH07DD	Still	EBSHH07DD_09	9	663.5	484 779.6	871 405.5	484 758.6	871 389.1	26.6	
20/05/2019	14:57:53	EBSHH07DD	Still	EBSHH07DD_10	10	665.1	484 779.6	871 405.5	484 761.0	871 389.8	24.4	
20/05/2019	14:58:11	EBSHH07DD	Still	EBSHH07DD_11	11	664.1	484 779.6	871 405.5	484 763.2	871 391.2	21.8	
20/05/2019	14:58:28	EBSHH07DD	Still	EBSHH07DD_12	12	665.7	484 779.6	871 405.5	484 764.6	871 391.6	20.4	
20/05/2019	14:58:45	EBSHH07DD	Still	EBSHH07DD_13	13	664.1	484 779.6	871 405.5	484 767.0	871 392.4	18.2	
20/05/2019	14:59:09	EBSHH07DD	Still	EBSHH07DD_14	14	666.7	484 779.6	871 405.5	484 768.9	871 393.8	15.8	
20/05/2019	14:59:29	EBSHH07DD	Still	EBSHH07DD_15	15	667.1	484 779.6	871 405.5	484 771.5	871 394.5	13.6	
20/05/2019	14:59:44	EBSHH07DD	Still	EBSHH07DD_16	16	667.4	484 779.6	871 405.5	484 772.9	871 395.1	12.3	
20/05/2019	15:00:12	EBSHH07DD	Still	EBSHH07DD_17	17	667.0	484 779.6	871 405.5	484 775.1	871 396.6	10.0	
20/05/2019	15:01:15	EBSHH07DD	Still	EBSHH07DD_18	18	668.6	484 779.6	871 405.5	484 781.9	871 400.1	5.9	
20/05/2019	15:01:50	EBSHH07DD	Still	EBSHH07DD_19	19	667.7	484 779.6	871 405.5	484 785.5	871 402.7	6.6	
20/05/2019	15:03:00	EBSHH07DD	Still	EBSHH07DD_20	20	668.7	484 779.6	871 405.5	484 791.3	871 405.7	11.7	
20/05/2019	15:03:22	EBSHH07DD	Still	EBSHH07DD_21	21	668.5	484 779.6	871 405.5	484 793.6	871 407.2	14.1	
20/05/2019	15:03:39	EBSHH07DD	Still	EBSHH07DD_22	22	665.2	484 779.6	871 405.5	484 795.9	871 408.0	16.5	
20/05/2019	15:04:37	EBSHH07DD	Still	EBSHH07DD_23	23	669.4	484 779.6	871 405.5	484 800.0	871 410.0	20.9	
20/05/2019	15:05:05	EBSHH07DD	Still	EBSHH07DD_24	24	669.8	484 779.6	871 405.5	484 801.9	871 411.6	23.2	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	15:05:23	EBSHH07DD	Still	EBSHH07DD_25	25	669.9	484 779.6	871 405.5	484 803.3	871 412.7	24.8	
20/05/2019	15:06:19	EBSHH07DD	Video	EOL	1	662.8	484 779.6	871 405.5	484 808.6	871 414.7	30.5	
20/05/2019	16:53:00	EBSHH08DD	Video	SOL	1		489 250.4	869 166.8	489 191.7	869 161.8	59.0	
20/05/2019	16:53:07	EBSHH08DD	Still	EBSHH08DD_01	1	715.7	489 250.4	869 166.8	489 192.0	869 161.7	58.6	
20/05/2019	16:59:46	EBSHH08DD	Still	EBSHH08DD_02	2	717.1	489 250.4	869 166.8	489 217.6	869 161.4	33.3	
20/05/2019	17:00:24	EBSHH08DD	Still	EBSHH08DD_03	3	716.1	489 250.4	869 166.8	489 221.3	869 160.0	30.0	
20/05/2019	17:00:45	EBSHH08DD	Still	EBSHH08DD_04	4	717.2	489 250.4	869 166.8	489 223.6	869 160.3	27.6	
20/05/2019	17:00:58	EBSHH08DD	Still	EBSHH08DD_05	5	716.3	489 250.4	869 166.8	489 225.5	869 160.9	25.6	
20/05/2019	17:01:42	EBSHH08DD	Still	EBSHH08DD_06	6	717.5	489 250.4	869 166.8	489 230.0	869 160.5	21.4	
20/05/2019	17:01:58	EBSHH08DD	Still	EBSHH08DD_07	7	716.7	489 250.4	869 166.8	489 230.8	869 160.2	20.7	
20/05/2019	17:02:15	EBSHH08DD	Still	EBSHH08DD_08	8	717.2	489 250.4	869 166.8	489 232.0	869 159.8	19.7	
20/05/2019	17:03:35	EBSHH08DD	Still	EBSHH08DD_09	9	717.5	489 250.4	869 166.8	489 238.1	869 159.9	14.2	
20/05/2019	17:04:10	EBSHH08DD	Still	EBSHH08DD_10	10	719.3	489 250.4	869 166.8	489 241.4	869 161.8	10.3	
20/05/2019	17:04:18	EBSHH08DD	Still	EBSHH08DD_11	11	719.6	489 250.4	869 166.8	489 241.5	869 162.4	10.0	
20/05/2019	17:05:40	EBSHH08DD	Still	EBSHH08DD_12	12	716.5	489 250.4	869 166.8	489 250.6	869 164.0	2.9	
20/05/2019	17:06:40	EBSHH08DD	Still	EBSHH08DD_13	13	718.3	489 250.4	869 166.8	489 256.4	869 166.4	6.0	
20/05/2019	17:06:55	EBSHH08DD	Still	EBSHH08DD_14	14	719.3	489 250.4	869 166.8	489 259.0	869 167.6	8.6	
20/05/2019	17:07:20	EBSHH08DD	Still	EBSHH08DD_15	15	719.5	489 250.4	869 166.8	489 260.1	869 168.3	9.8	
20/05/2019	17:08:01	EBSHH08DD	Still	EBSHH08DD_16	16	717.7	489 250.4	869 166.8	489 263.1	869 168.8	12.9	
20/05/2019	17:08:18	EBSHH08DD	Still	EBSHH08DD_17	17	719.0	489 250.4	869 166.8	489 263.5	869 169.5	13.4	
20/05/2019	17:08:31	EBSHH08DD	Still	EBSHH08DD_18	18	719.7	489 250.4	869 166.8	489 264.1	869 170.1	14.1	
20/05/2019	17:09:59	EBSHH08DD	Still	EBSHH08DD_19	19	719.3	489 250.4	869 166.8	489 268.1	869 169.3	17.8	
20/05/2019	17:10:11	EBSHH08DD	Still	EBSHH08DD_20	20	720.3	489 250.4	869 166.8	489 270.5	869 172.2	20.8	
20/05/2019	17:10:22	EBSHH08DD	Still	EBSHH08DD_21	21	719.7	489 250.4	869 166.8	489 272.3	869 171.9	22.4	
20/05/2019	17:10:37	EBSHH08DD	Still	EBSHH08DD_22	22	719.9	489 250.4	869 166.8	489 272.8	869 171.6	22.9	
20/05/2019	17:11:27	EBSHH08DD	Still	EBSHH08DD_23	23	719.2	489 250.4	869 166.8	489 275.0	869 173.0	25.3	
20/05/2019	17:11:58	EBSHH08DD	Still	EBSHH08DD_24	24	720.1	489 250.4	869 166.8	489 275.7	869 173.5	26.1	
20/05/2019	17:12:11	EBSHH08DD	Still	EBSHH08DD_25	25	722.3	489 250.4	869 166.8	489 277.3	869 174.8	28.1	
20/05/2019	17:14:08	EBSHH08DD	Still	EBSHH08DD_26	26	714.3	489 250.4	869 166.8	489 282.9	869 174.0	33.2	
20/05/2019	17:14:31	EBSHH08DD	Still	EBSHH08DD_27	27	720.7	489 250.4	869 166.8	489 283.3	869 175.2	33.9	
20/05/2019	17:15:03	EBSHH08DD	Still	EBSHH08DD_28	28	720.4	489 250.4	869 166.8	489 283.4	869 175.3	34.1	
20/05/2019	17:15:45	EBSHH08DD	Still	EBSHH08DD_29	29	722.5	489 250.4	869 166.8	489 285.8	869 175.9	36.5	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
20/05/2019	17:16:41	EBSHH08DD	Still	EBSHH08DD_30	30	721.9	489 250.4	869 166.8	489 288.1	869 176.8	39.0	
20/05/2019	17:16:52	EBSHH08DD	Still	EBSHH08DD_31	31	722.6	489 250.4	869 166.8	489 291.4	869 178.5	42.6	
20/05/2019	17:17:00	EBSHH08DD	Still	EBSHH08DD_32	32	722.4	489 250.4	869 166.8	489 291.4	869 178.1	42.5	
20/05/2019	17:17:41	EBSHH08DD	Still	EBSHH08DD_33	33	720.7	489 250.4	869 166.8	489 295.0	869 178.7	46.1	
20/05/2019	17:18:08	EBSHH08DD	Still	EBSHH08DD_34	34	721.6	489 250.4	869 166.8	489 296.9	869 179.6	48.2	
20/05/2019	17:18:19	EBSHH08DD	Still	EBSHH08DD_35	35	721.4	489 250.4	869 166.8	489 297.7	869 180.0	49.1	
20/05/2019	17:18:35	EBSHH08DD	Still	EBSHH08DD_36	36	722.8	489 250.4	869 166.8	489 297.3	869 180.3	48.8	
20/05/2019	17:19:09	EBSHH08DD	Still	EBSHH08DD_37	37	721.6	489 250.4	869 166.8	489 298.6	869 181.4	50.3	
20/05/2019	17:19:26	EBSHH08DD	Still	EBSHH08DD_38	38	722.2	489 250.4	869 166.8	489 301.3	869 181.9	53.1	
20/05/2019	17:19:46	EBSHH08DD	Still	EBSHH08DD_39	39	723.6	489 250.4	869 166.8	489 301.6	869 181.0	53.1	
20/05/2019	17:20:10	EBSHH08DD	Video	EOL	1	723.6	489 250.4	869 166.8	489 301.6	869 181.5	53.2	
20/05/2019	19:34:00	EBSWS08Top	WS	BIOA1, BIOA2, WS	1	5.0	489 250.4	869 166.8	489 251.3	869 172.1	5.4	
20/05/2019	19:58:00	EBSWS08Top	WS	BIOB1, BIOB2	2	5.0	489 250.4	869 166.8	489 252.2	869 171.6	5.1	
20/05/2019	20:17:00	EBSWS08Top	WS	BIOC1, BIOC2	3	5.0	489 250.4	869 166.8	489 252.1	869 170.3	3.8	
20/05/2019	20:42:00	EBSWS08Top	WS	Spare	4	5.0	489 250.4	869 166.8	489 252.1	869 175.0	8.3	
20/05/2019	23:12:00	EBSWS08Bot	WS/ WP	BIOA1, BIOA2, WS, WP	1	711.4	489 250.4	869 166.8	489 264.4	869 157.1	17.1	
20/05/2019	00:35:00	EBSWS08Bot	WS	BIOB1, BIOB2	2	715.8	489 250.4	869 166.8	489 257.7	869 163.3	8.1	
20/05/2019	01:31:00	EBSWS08Bot	WS/ WP	BIOC1, BIOC2, WP	3	716.8	489 250.4	869 166.8	489 262.3	869 162.4	12.7	
20/05/2019	01:46:00	EBSWS08Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	202.8	489 250.4	869 166.8	489 255.1	869 174.8	9.3	
20/05/2019	02:38:00	EBSWS08Mid	WS	BIOC1, BIOC2	2	201.3	489 250.4	869 166.8	489 261.6	869 164.2	11.5	
21/05/2019	04:23:00	EBSWS07Bot	WS/ WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	662.4	484 779.6	871 405.5	484 797.9	871 391.3	23.2	
21/05/2019	05:28:00	EBSWS07Bot	WS	BIOC1, BIOC2,	2	662.5	484 779.6	871 405.5	484 794.3	871 392.2	19.9	
21/05/2019	06:24:00	EBSWS07Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	198.0	484 779.6	871 405.5	484 780.5	871 401.0	4.6	
21/05/2019	07:05:00	EBSWS07Mid	WS	BIOC1, BIOC2	2	199.8	484 779.6	871 405.5	484 778.1	871 401.9	3.9	
21/05/2019	07:35:00	EBSWS07Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	484 779.6	871 405.5	484 779.9	871 406.7	1.2	
21/05/2019	07:57:00	EBSWS07Top	WS	BIOC1, BIOC2	2	5.0	484 779.6	871 405.5	484 779.1	871 394.9	10.6	

Geodetic Parameters: WGS84 UTM Zone 21 N												
Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
21/05/2019	09:44:00	EBSWS04Bot	WS/ WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	880.3	484 335.1	876 101.5	484 336.8	876 100.8	1.8	
21/05/2019	11:45:00	EBSWS04Bot	WS/ WP	BIOC1, BIOC2, WP	2	895.3	484 335.1	876 101.5	484 332.0	876 108.9	8.0	
21/05/2019	12:56:00	EBSWS04Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	237.4	484 335.1	876 101.5	484 334.2	876 106.9	5.5	
21/05/2019	13:37:00	EBSWS04Mid	WS	BIOC1, BIOC2	2	239.2	484 335.1	876 101.5	484 340.9	876 104.6	6.6	
21/05/2019	13:57:00	EBSWS04Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	484 335.1	876 101.5	484 336.4	876 108.0	6.7	
21/05/2019	14:23:00	EBSWS04Top	WS	BIOC1, BIOC2	2	5.0	484 335.1	876 101.5	484 335.0	876 107.3	5.8	
21/05/2019	16:01:00	EBSWS05Bot	WP	WP	1	918.2	488 805.9	873 862.8	488 820.3	873 846.7	21.6	Niskins not triggered
21/05/2019	18:32:00	EBSWS05Bot	WP	WP	2	915.7	488 805.9	873 862.8	488 814.9	873 854.3	12.4	Niskins not triggered
21/05/2019	19:53:00	EBSWS05Bot	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	3	918.4	488 805.9	873 862.8	488 806.8	873 865.4	2.7	
21/05/2019	20:37:00	EBSWS05Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	488 805.9	873 862.8	488 797.4	873 860.8	8.8	
21/05/2019	20:59:00	EBSWS05Top	WS	BIOC1, BIOC2	2	5.0	488 805.9	873 862.8	488 797.5	873 862.0	8.5	
21/05/2019	21:34:00	EBSWS05Bot	WS	BIOC1, BIOC2	4	918.4	488 805.9	873 862.8	488 815.9	873 852.7	14.2	
21/05/2019	22:17:00	EBSWS05Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	204.2	488 805.9	873 862.8	488 799.8	873 869.1	8.8	
21/05/2019	22:46:00	EBSWS05Mid	WS	BIOC1, BIOC2	2	203.0	488 805.9	873 862.8	488 802.4	873 862.1	3.7	
21/05/2019	00:21:00	EBSWS06Bot	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	931.0	493 622.3	871 760.8	493 645.0	871 752.0	24.3	
21/05/2019	01:24:00	EBSWS06Bot	WS	BIOC1, BIOC2, WP	2	932.8	493 622.3	871 760.8	493 629.8	871 745.7	16.8	
21/05/2019	02:03:00	EBSWS06Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	199.1	493 622.3	871 760.8	493 626.6	871 769.1	9.4	
21/05/2019	02:32:00	EBSWS06Mid	WS	BIOC1, BIOC2	2	201.0	493 622.3	871 760.8	493 626.7	871 762.8	4.8	
21/05/2019	02:50:00	EBSWS06Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	493 622.3	871 760.8	493 623.3	871 765.8	5.1	
21/05/2019	03:10:00	EBSWS06Top	WS	BIOC1, BIOC2	2	5.0	493 622.3	871 760.8	493 623.6	871 767.1	6.4	
22/05/2019	04:33:00	EBSWS03Bot	WS/ WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	1100.0	492 832.3	876 320.2	492 838.1	876 298.4	22.5	
22/05/2019	05:50:00	EBSWS03Bot	WS/	BIOC1, BIOC2, WP	2	1101.0	492 832.3	876 320.2	492 829.9	876 310.3	10.2	

Geodetic Parameters: WGS84 UTM Zone 21 N

Date	Time [UTC]	Transect / Station	Type	Sample Rep / Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
			WP									
22/05/2019	06:35:00	EBSWS03Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	200.4	492 832.3	876 320.2	492 833.5	876 319.9	1.3	
22/05/2019	07:05:00	EBSWS03Mid	WS	BIOC1, BIOC2	2	203.1	492 832.3	876 320.2	492 834.1	876 319.4	2.0	
22/05/2019	07:21:00	EBSWS03Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	492 832.3	876 320.2	492 832.5	876 320.2	0.2	
22/05/2019	07:39:00	EBSWS03Top	WS	BIOC1, BIOC2	2	5.0	492 832.3	876 320.2	492 831.7	876 321.6	1.6	
22/05/2019	08:58:00	EBSWS02Bot	WS/ WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	1089.6	488 361.4	878 558.8	488 357.6	878 569.3	11.1	
22/05/2019	10:11:00	EBSWS02Bot	WS/ WP	BIOC1, BIOC2, WP	2	1089.6	488 361.4	878 558.8	488 359.9	878 565.3	6.6	
22/05/2019	11:03:00	EBSWS02Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	204.9	488 361.4	878 558.8	488 359.3	878 562.1	3.9	
22/05/2019	11:29:00	EBSWS02Mid	WS	DNA C1, C1	2	198.2	488 361.4	878 558.8	488 358.7	878 561.2	3.6	
22/05/2019	11:53:00	EBSWS02Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	488 361.4	878 558.8	488 356.8	878 557.8	4.8	
22/05/2019	12:06:00	EBSWS02Top	WS	BIOC1, BIOC2	2	5.0	488 361.4	878 558.8	488 356.4	878 560.4	5.2	
22/05/2019	13:24:00	EBSWS01Bot	WS/ WP	BIOA1, BIOA2, BIOB1, BIOB2, WS, WP	1	1027.2	483 890.6	880 797.5	483 877.2	880 811.0	19.0	
22/05/2019	14:37:00	EBSWS01Bot	WS/ WP	BIOC1, BIOC2, WP	2	1029.5	483 890.6	880 797.5	483 888.0	880 797.3	2.6	
22/05/2019	15:18:00	EBSWS01Mid	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	201.8	483 890.6	880 797.5	483 895.6	880 798.9	5.2	
22/05/2019	15:49:00	EBSWS01Mid	WS	BIOC1, BIOC2	2	201.7	483 890.6	880 797.5	483 895.9	880 799.0	5.5	
22/05/2019	16:04:00	EBSWS01Top	WS	BIOA1, BIOA2, BIOB1, BIOB2, WS	1	5.0	483 890.6	880 797.5	483 889.8	880 797.8	0.8	
22/05/2019	16:27:00	EBSWS01Top	WS	BIOC1, BIOC2	2	5.0	483 890.6	880 797.5	483 890.6	880 799.7	2.2	

Notes:

UTC = Coordinated Universal Time
BSL = Below sea level
SOL = Start of line
EOL = End of line
FA/FB = Faunal sample FA/FB
BC = Box corer
BIO = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample
WS = Physico-chemical water sample
WP = Water profile

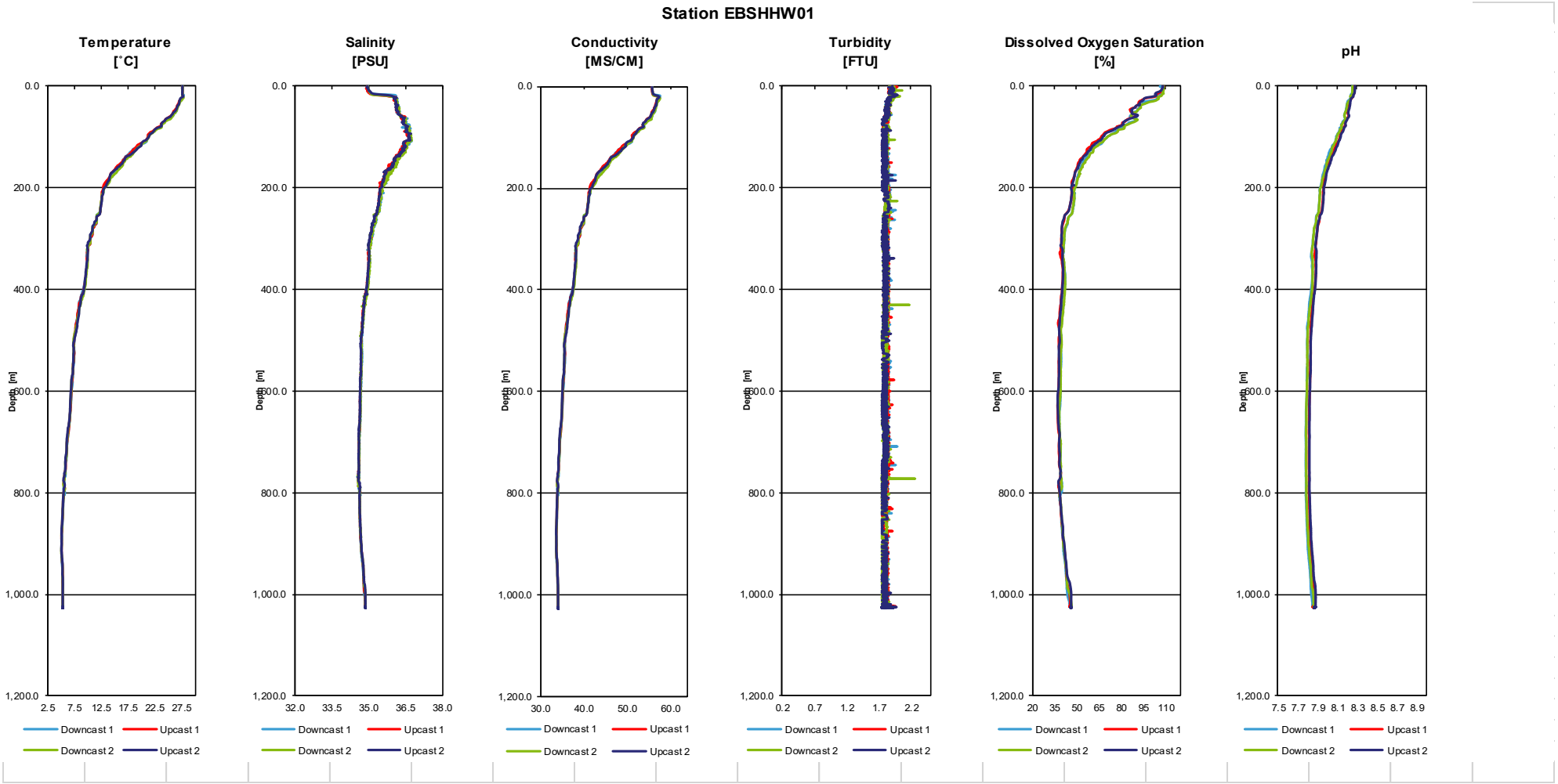
C.2 SEDIMENT LOG

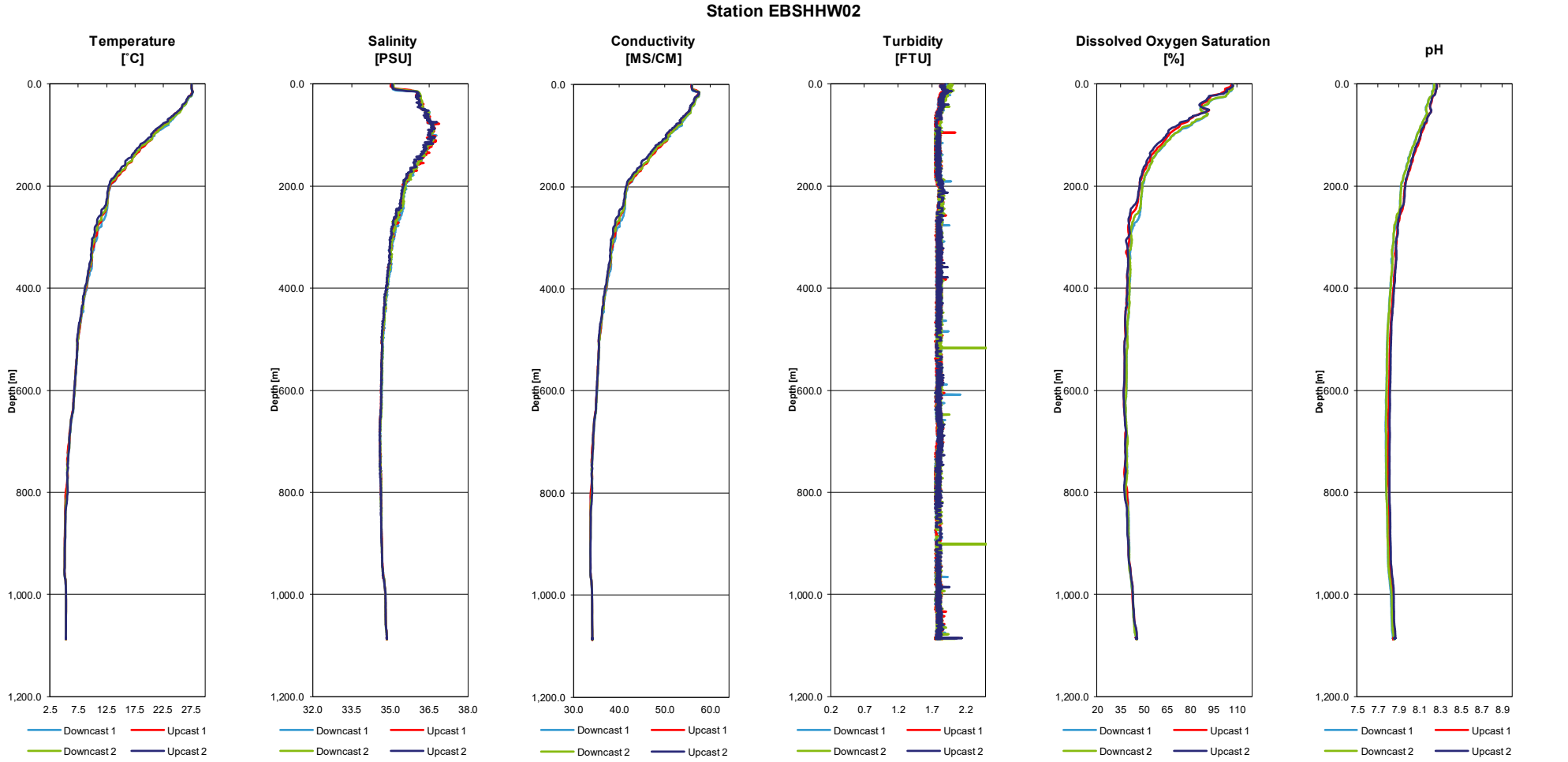
Date	Time [UTC]	Station	Sample Rep	Fix No.	Sample Depth	Temp [˚C]	Redox [mV]	pH	Sediment Description (including stratigraphy)				Comments (fauna, smell, bioturbation, debris)
									Depth [cm]	Sediment Type	Sediment Description	Munsell Colour	
17/05/2019	18:14:00	EBSHH01	FA, FB		32	17	246	7.30	2	M	Mud	2.5 Y 4/4	
17/05/2019	18:14:00	EBSHH01				16	241	7.31	5	M			
17/05/2019	18:14:00	EBSHH01				14	251	7.37	10	M			
17/05/2019	21:56:41	EBSHH01	PC, BIO		41	23	346	7.30	2	M	Mud	2.5 Y 4/4	
17/05/2019	21:56:41	EBSHH01				21	341	7.30	5	M			
17/05/2019	21:56:41	EBSHH01				16	341	7.30	10	M			
18/05/2019	00:20:31	EBSHH02	PC, FA, FB, BIO		40	21	384	7.36	2	M	Mud	2.5 Y 4/4	
18/05/2019	00:20:31	EBSHH02				17	377	7.36	5	M			
18/05/2019	00:20:31	EBSHH02				12	377	7.36	10	M			
18/05/2019	02:23:14	EBSHH03	PC, FA, FB, BIO		42	20	353	7.40	2	M	Mud	2.5 Y 4/4	Bioturbation- Gas smell
18/05/2019	02:23:14	EBSHH03				17	352	7.40	5	M			
18/05/2019	02:23:14	EBSHH03				11	353	7.40	10	M			
18/05/2019	04:02:17	EBSHH06	PC, FA, FB, BIO		38	18	365	7.27	2	M	Mud	2.5 Y 4/4	
18/05/2019	04:02:17	EBSHH06				13	365	7.27	5	M			
18/05/2019	04:02:17	EBSHH06				17.6	365	7.27	10	M			
18/05/2019	05:49:50	EBSHH05	PC, FA, FB, BIO		45	14	324	7.35	2	M	Mud	2.5 Y 5/4	3 cm - 4 cm of brown mud, below clay
18/05/2019	05:49:50	EBSHH05				12	324	7.35	5	M			
18/05/2019	05:49:50	EBSHH05				12	324	7.35	10	M			
18/05/2019	07:36:31	EBSHH04	PC, FA, FB, BIO		45	16.6	306	7.33	2	M	Mud	2.5 Y 5/4	3 cm - 4 cm of brown mud, below clay
18/05/2019	07:36:31	EBSHH04				16	306	7.32	5	M			
18/05/2019	07:36:31	EBSHH04				16	206	7.33	10	M			
18/05/2019	09:25:36	EBSHH07	PC, FA, FB, BIO		33	15	334	7.44	2	M	Mud	2.5 Y 5/4	3 cm- 4 cm brown mud
18/05/2019	09:25:36	EBSHH07				18.9	334	7.44	5	M			Followed by grey clay
18/05/2019	09:25:36	EBSHH07				19	334	7.44	10	M			
18/05/2019	10:03:02	EBSHH08	PC, FA, FB, BIO		49	16	344	7.45	2	M	Mud	5 Y 5/3	3 cm - 4 cm mud followed by clay
18/05/2019	10:03:02	EBSHH08				12	344	7.42	5	M			

Date	Time [UTC]	Station	Sample Rep	Fix No.	Sample Depth	Temp [˚C]	Redox [mV]	pH	Sediment Description (including stratigraphy)				Comments (fauna, smell, bioturbation, debris)
									Depth [cm]	Sediment Type	Sediment Description	Munsell Colour	
18/05/2019	10:03:02	EBSHH08				12	344	7.42	10	M			

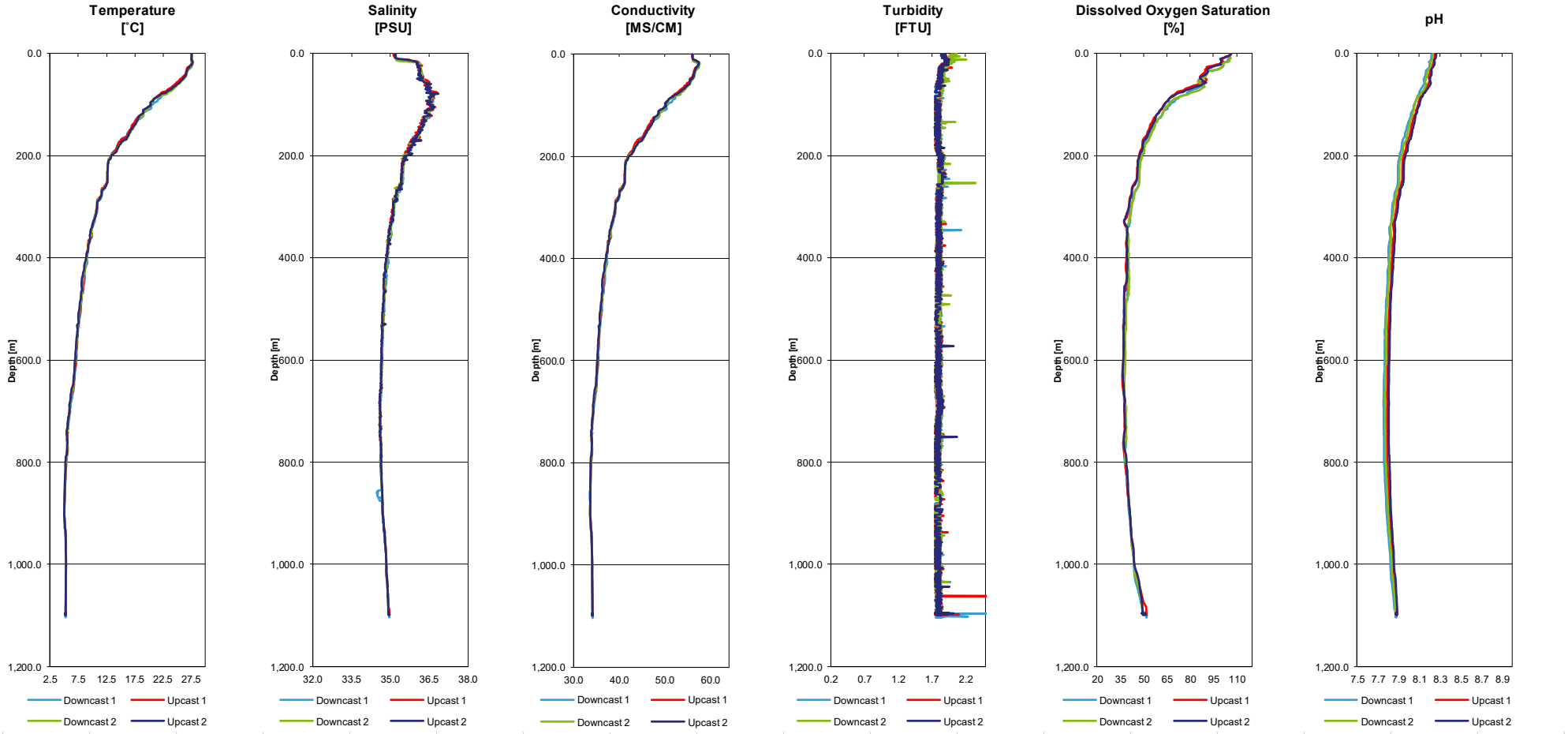
Notes:
UTC = Coordinated Universal Time
FA/FB = Faunal sample A/B
BIO = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample

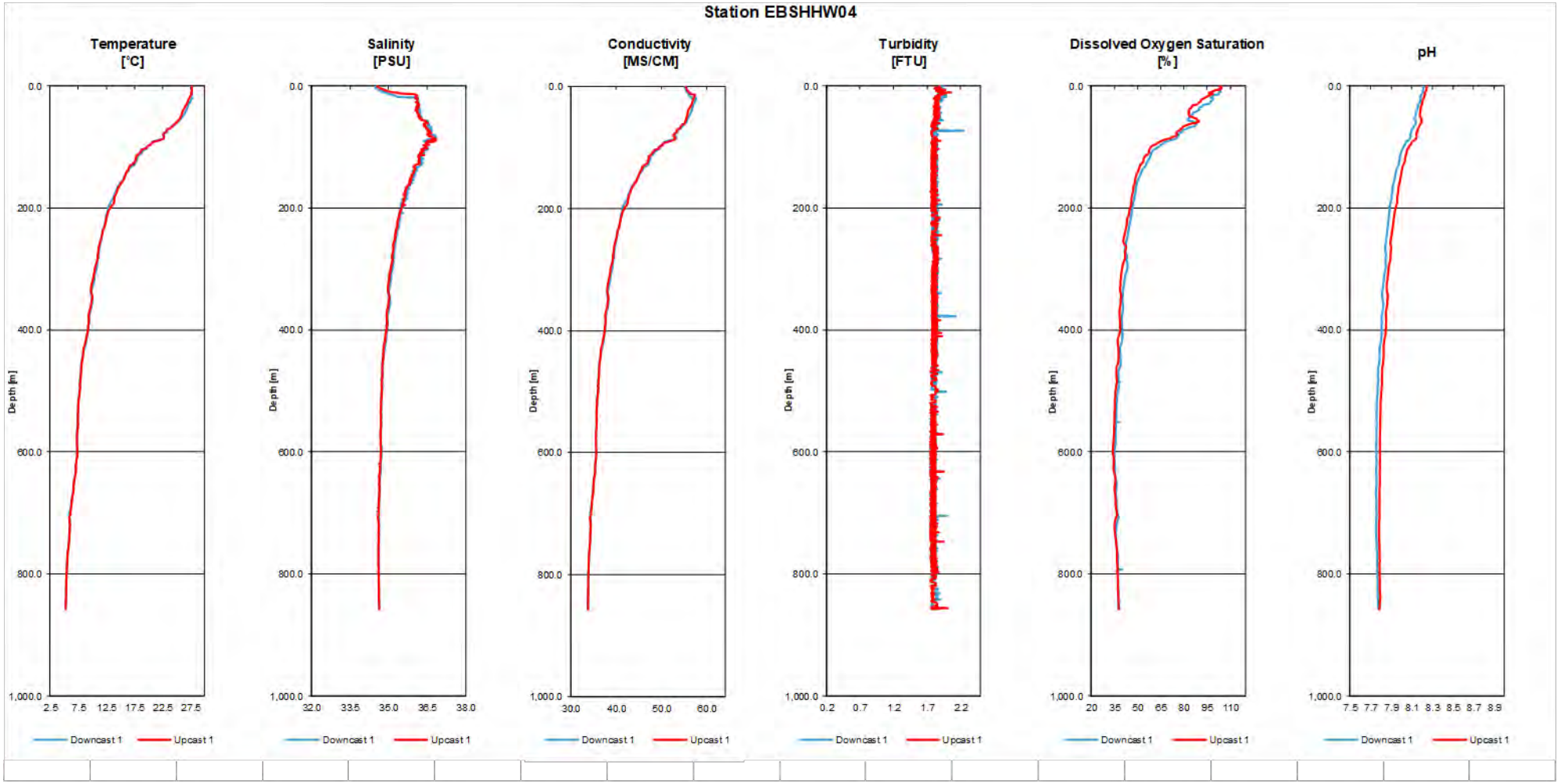
D. WATER PROFILES

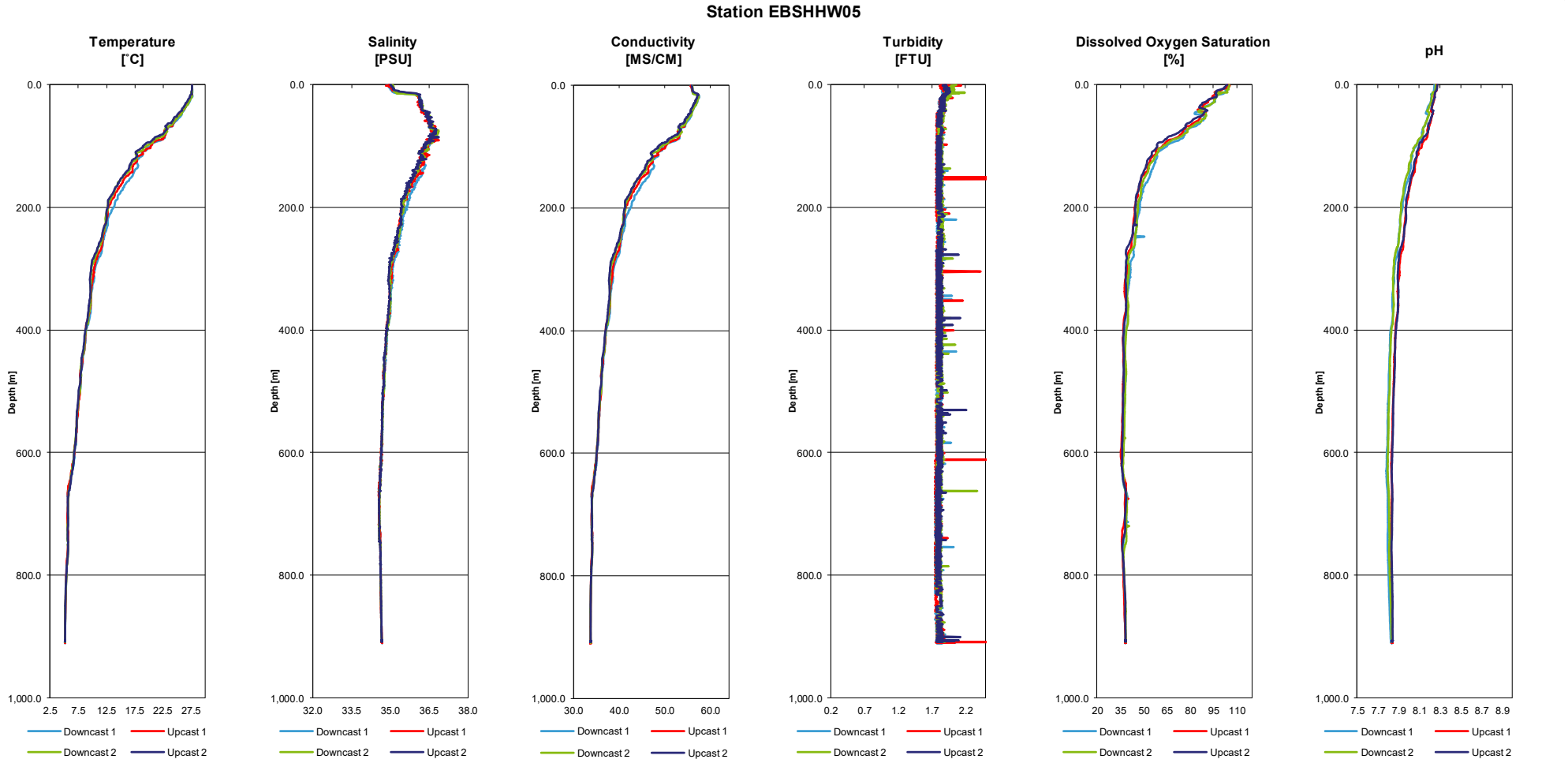



Station EBSHHW02
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2

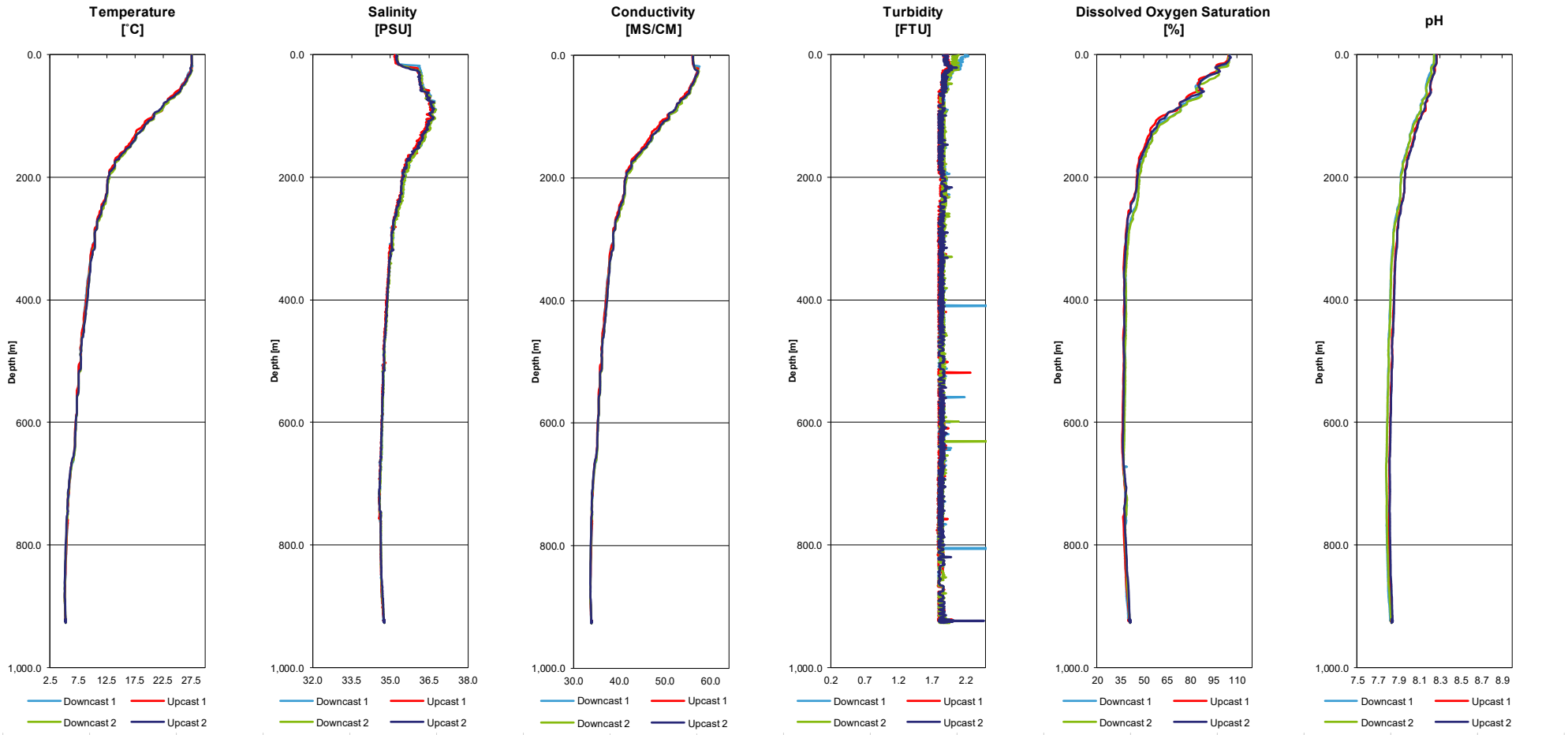
Station EBSHHW03



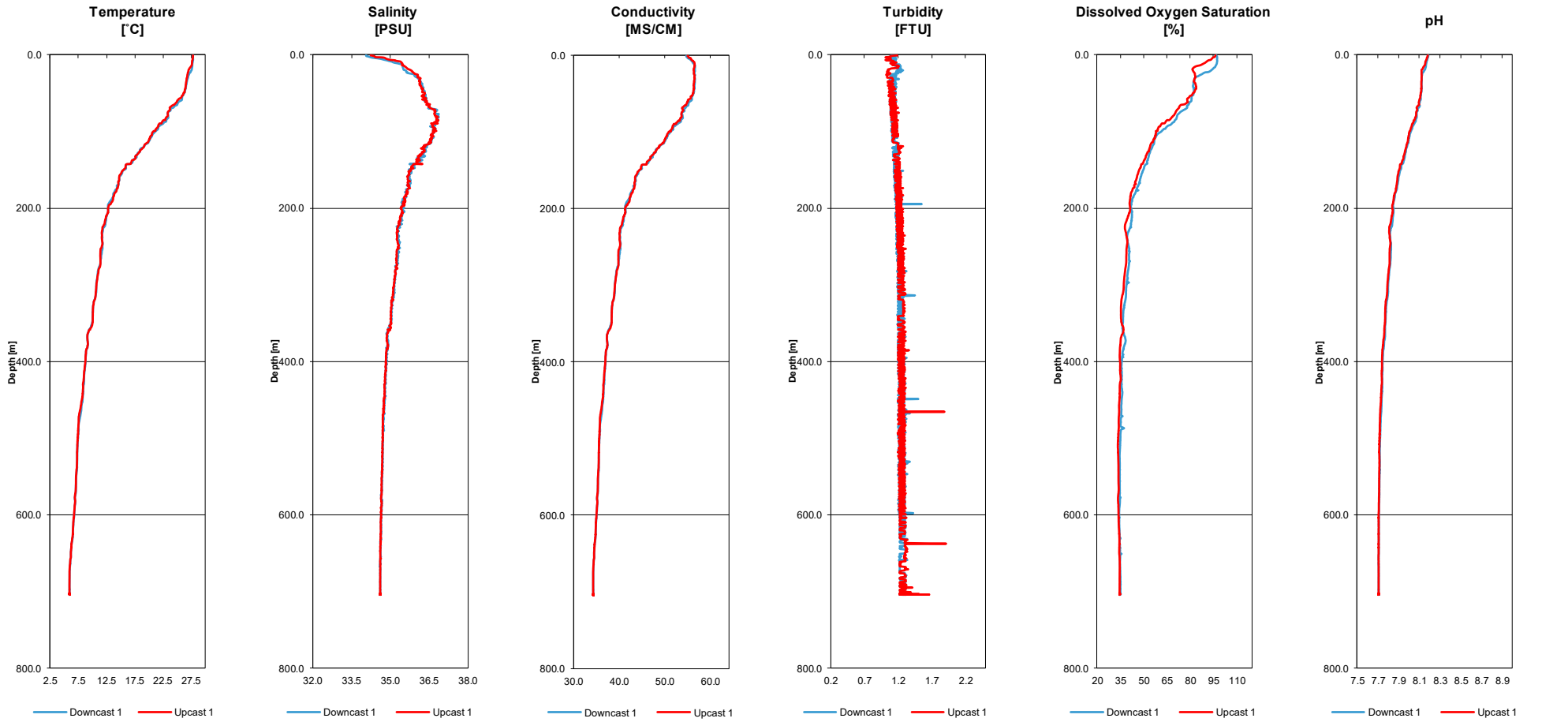

Station EBSHHW04
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1


Station EBSHHW05
Temperature [˚C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2

Station EBSHHW06



Station EBSHHW08



Environmental Baseline Survey, ExxonMobil Hammerhead Development Offshore Guyana

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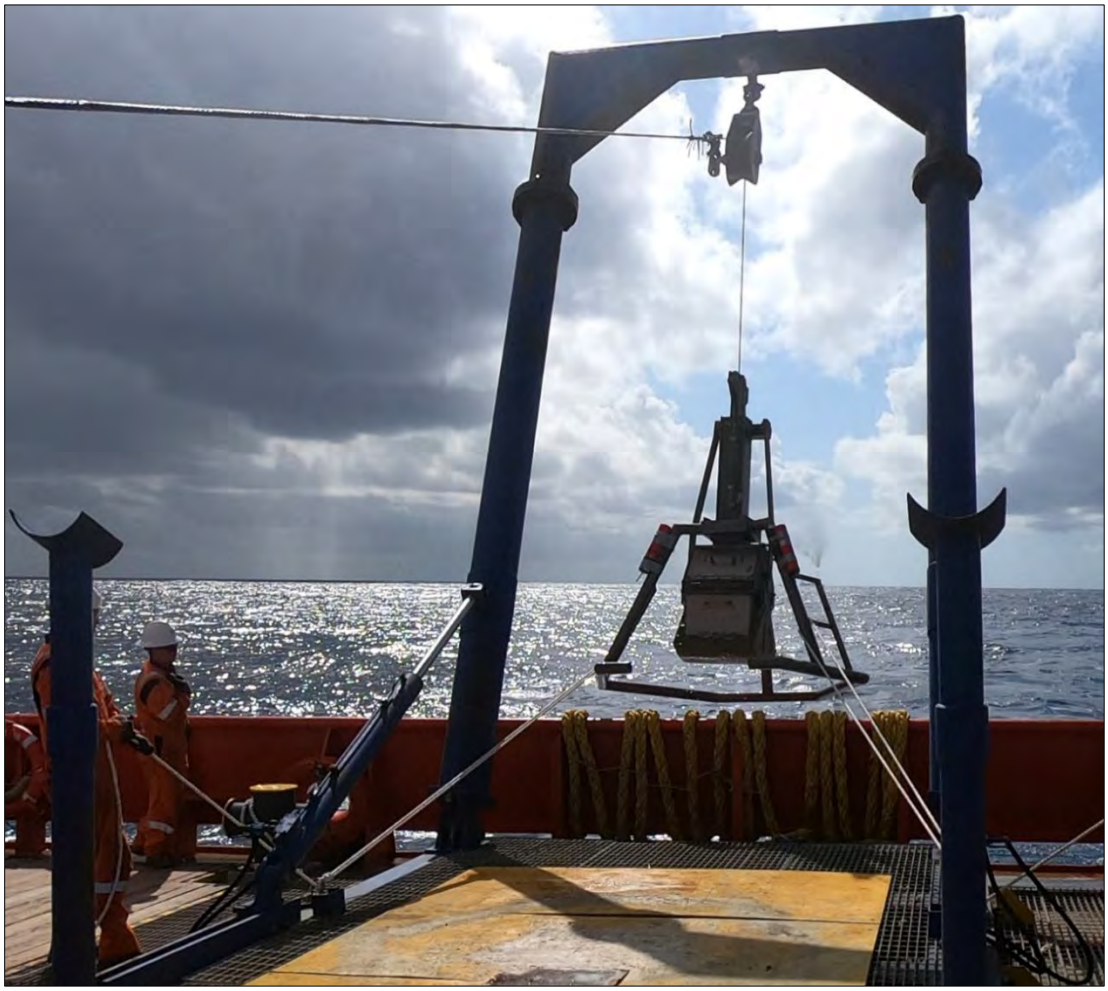
Environmental Baseline Survey
ExxonMobil Hammerhead Development Offshore Guyana

June 2020



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Environmental Baseline Survey

ExxonMobil Hammerhead Development

Offshore Guyana

DOCUMENT NO. CSA-BENTHIC-FL-20-81299-3532-05-REP-02-FIN

Version	Date	Description	Prepared by:	Reviewed by:	Approved by:
01	05/15/2020	Initial draft for review	B. Graham	K. Gifford	B. Graham
02	05/22/2020	Revised draft	B. Graham	B. Douglas	B. Graham
FIN	06/11/2020	Final	B. Graham	K. Gifford C. Kelly	B. Graham

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Executive Summary

CSA Ocean Sciences Inc. (CSA) was contracted by BENTHIC Geotec Pty Ltd (BENTHIC) to provide Environmental Baseline Survey (EBS) services associated with the Hammerhead Development offshore Guyana. The Hammerhead Development is operated by Esso Exploration and Production Guyana Limited (Esso) an affiliate of ExxonMobil. During the EBS, physicochemical and biological data were collected within the study area to meet the following objectives:

- Determine and document environmental baseline conditions (i.e. physicochemical and biological) against which effects from proposed future oil and gas operations can be compared; and
- Identify parameters within the local ecosystem that may be sensitive to change and provide a reference point to evaluate future claims of impacts.

This EBS report includes content in support of data results and discussion, as briefly described below.

- **Survey Design**: describes the attributes (e.g. number, location) of sampling stations.
- **Field Methods**: describes survey equipment, personnel, sampling methods specific to collection and on-board processing, and quality assurance measures.
- **Laboratory Methods and Data Processing**: summarizes aspects of sampling parameters, identifies analytical laboratories, and describes aspects of data analysis and laboratory techniques specific to sampling parameters.
- **Literature Cited**: provides bibliographic information for referenced journal articles, books, or grey literature.
- **Appendices**: provides information in support of the EBS findings including analytical laboratory datasheets, infauna data, hydrographic profiles, and sediment metals regression plots.

This EBS describes characteristics of the seabed sediments, with specific reference to redox potential depth gradient, particle size distribution/grain size, total organic carbon (TOC), hydrocarbon content, metals, and infauna analysis.

- Redox potential (Eh) values were all positive ranging from a low of 100 to 233 mV that are indicative of aerobic conditions. As expected, there was a general trend of indirect correlation between Eh values and sediment depth with decreasing values with increasing depth.
- Overall, sediment grain size was mainly silty clay, based on Shepard's classification. Stations were characterized by sediment with less than 30% sand and high proportions of silt and clay fractions with the exception of Station HH-8 that had relatively even proportions of sand, silt, and clay.
- The sediment TOC concentrations in the study area are relatively low ranging from 0.17% to 0.65%.
- TPH concentrations in sediment ranged from 3 to 1,233 $\mu g\ g^{-1}$ and were generally similar among all stations except Station HH-2. TPH concentrations exceeding 1,100 $\mu g\ g^{-1}$ were considerably elevated at Station HH-2 with levels hundredfold over the other EBS stations. The presence of synthetic based fluids in the sediment could be a possible reason for the observed elevated TPH at Station HH-2.
- PAH concentrations in sediment ranged from 37.2 to 319 ng g^{-1} and like TPH were generally similar among all stations except Station HH-2. Station HH-2 total PAH concentration (319 ng g^{-1}) was considerably elevated but well below the effects range low (ERL) (4,022 ng g^{-1}) value for total PAHs in marine sediment. Fossil Fuel Pollution Index ratio for sediments from the Hammerhead Development EBS study area range from 0.14 to 0.23 indicating that PAHs in sediments are predominantly from pyrogenic sources.

- There were some notable elevated levels of sediment metals. In particular, the levels of barium were extremely elevated at Station HH-2 and elevated to lesser extents at Stations HH-3 and HH-1. Barium in sediment samples from stations HH-1, HH-2, and HH-3 with concentrations greater than 1,000 ppm (mg kg^{-1}) may be indicative of drilling activities with discharge of drilling muds. Arsenic and nickel concentrations exceeded the ERL at 6 of 8 stations but did not the effects range median (ERM). All other metals concentrations for the survey were below their respective ERL benchmarks, where applicable.
- There was an approximate sevenfold increase in the mean aluminum concentration between this EBS (7.24%) and the 2018 Liza 2 Field Development EBS (1.15%). There is variability in the observed sediment aluminum concentrations ranging from 3.85% to 8.46% during this EBS that well exceeds the aluminum concentration range of 1.04% to 1.27% observed during the 2018 Liza 2 Field Development EBS. The observed aluminum concentration during this Hammerhead Development EBS are typically expected for deep water clay sediments. The sources for the stark differences between this EBS and the 2018 EBS sediment aluminum concentrations are uncertain but could be influenced by analytical laboratories and associated methods between surveys, natural influx of aluminosilicate terrigenous sediments, and/or anthropogenic activities.
- The 8 box core samples collected from the survey area yielded 204 individuals and 37 total taxa from eight phyla. Most of the individuals (60.3%) were contributed by the annelids followed by arthropods (19.6%), and nematodes (17.2%). Annelids were also represented by the most infaunal taxa (24) followed by arthropods (6), and echinoderms (2). The overall infauna density ranged from 98.0 to 359.2 individuals per m^2 with a mean of 208.2 ± 79.3 individuals per m^2 across all stations.
- The diversity indices indicated that the assemblage has generally low species richness and diversity but high evenness across all stations indicating similar relative abundances among taxa and correspondingly low numerical dominance.
- Cluster analysis and the multidimensional scaling ordination do not reveal any discrete groups of infauna samples that would indicate spatial aggregation or other assemblage patterns.

This EBS describes water column characteristics through the collection of hydrographic profiling data and water samples for analyses of total suspended solids (TSS), TOC, hydrocarbon content, and metals at depth within the study area.

- Overall, hydrographic data at all EBS stations appeared typical of the offshore open ocean environment for the region. Seawater temperature ranged from 4.07°C to 28.19°C. Temperature changed very little in the upper 60 to 70 m of the water column which marked the top of the thermocline observed below the well-mixed surface portion of the water column. Salinity ranged from 34.54 to 37.20 practical salinity units (PSU). There was a distinctive surface lens of low salinity water above the high salinity layer with maximum of about 37 PSU that delineated the halocline depth at about 170 m. The pH was generally stable throughout the water column ranging from 8.07 to 9.62. Turbidity was low at all stations with an overall mean of 0.25 nephelometric turbidity units (NTU). DO concentration ranged from 3.90 to 8.47 mg L^{-1} during the survey and DO saturation ranged from 40.78% to 105.49%.
- TOC concentrations were very low at all EBS stations and was detectable in the surface water at Station HH-1 with a level of 0.3 mg L^{-1}; all other sampling locations were below the detection limit of 0.2 mg L^{-1}.
- TSS levels were low in the EBS study area with most samples below the analytical laboratory reporting limits of 5 mg L^{-1}.

- Concentrations of hydrocarbons in the water column of the EBS study were very low with TPH levels at all sampling stations and depths being below the analytical detection limit of 13 µg L^{-1}. PAH concentrations in seawater ranged from 0 to 24.1 ng L^{-1} with highest total PAH concentration observed in the surface waters at Station HH-2 that has sediments characterized by highly elevated TPH and PAHs levels. All PAH levels were well below Criterion Continuous Concentration (CCC) values, when applicable, indicating PAHs present in the water column do not represent a hazard to marine organisms and the general offshore marine ecosystem.
- Total metal concentrations within the water column were low except for strontium and molybdenum. All metal concentrations are reported as lower than the CCC toxicity reference values with a few exceptions of molybdenum. The source of the elevated levels of molybdenum are uncertain but could be influenced by regional mining activities.

This EBS documents the existing state of the seafloor marine environment with high definition videographic data. All visually documented habitat was soft bottom substrate that supported a relatively depauperate biological assemblage as based on the sampling area viewed from the imagery Representative seafloor image at Station HH-02 likely indicated that the content of the surficial sediments were strongly influenced by discharges of drilling muds and cuttings.

The report includes a Conclusion and Recommendations section that presents primary data analytical results relevant to understanding potential impacts to the various aspects of the environment from ongoing and future offshore oil and gas activities. These findings provide the basis for recommendations to address informational data gaps and parameters most informative to understanding and detecting impacts. For example, there were high sediment hydrocarbon and metal locations within the Hammerhead Development EBS study area that could facilitate appropriate monitoring initially to understand the hydrocarbon source by using “fingerprint” sampling for operator-utilized non-aqueous drilling fluids and secondarily to evaluate chemical persistence in the environment and recovery to ambient conditions. Another example specific to infauna, the level of EBS infauna sampling appears to be adequate for generally characterizing the regional assemblage. However, a more comprehensive characterization of the assemblage may be required for infauna data to detect potential effects of offshore activities within the study area. More infauna samples within the EBS study area with a random positioning for stations stratified based on water depth would greatly enhance the ability to characterize the assemblage relative to local variability (e.g. depth gradient), species diversity, and spatial patterns (i.e., distinct assemblage groupings). The provided recommendations are intended to provide data for resources at risk to better facilitate assessing effects from oil and gas activities.

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List of Acronyms and Abbreviations

ALS	ALS Environmental
BENTHIC	BENTHIC Geotec Pty Ltd
CCC	Criterion Continuous Concentration
CoC	chain of custody
CSA	CSA Ocean Sciences (Trinidad) Ltd.
CTD	conductivity-temperature-depth
DO	dissolved oxygen
DP-2	dynamic positioning-2
EBS	environmental baseline survey
Eh	redox potential
ERL	effects range low
ERM	effects range median
ESIA	Environmental and Social Impact Assessment
Esso	Esso Exploration and Production Guyana Limited
FFPI	Fossil Fuel Pollution Index
FTL	Fauna Trinidad Limited
HiPAP	high precision acoustic positioning system
IES	Initial Environmental Survey
ISO	International Organization for Standardization
LED	light emitting diode
LIPL	lowest practical identification level
MDS	multidimensional scaling
mV	millivolts
NELAP	National Environmental Laboratory Accreditation Program
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbons
PM	particulate matter
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSU	practical salinity unit
QA	quality assurance
QC	quality control
SBE	Sea-Bird Electronics
SIMPROF	similarity profile analysis
TDI	TDI-Brooks International, Inc.
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
UNSEL	United States Naval Electronic Laboratory
USBL	ultra-short baseline
USEPA	United States Environmental Protection Agency

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1.0 Introduction

CSA Ocean Sciences Inc. (CSA) was contracted by BENTHIC Geotec Pty Ltd (BENTHIC) to provide Environmental Baseline Survey (EBS) services associated with the Hammerhead Development offshore Guyana. The Hammerhead Development is operated by Esso Exploration and Production Guyana Limited (Esso) an affiliate of ExxonMobil. The Hammerhead Field is located, approximately 170 km offshore Georgetown, Guyana, in the Stabroek Block (**Figure 1**). Water depths within the EBS study area, located within and extended outside the boundaries of the Hammerhead Field, ranged from approximately 800 to 1,900 m.

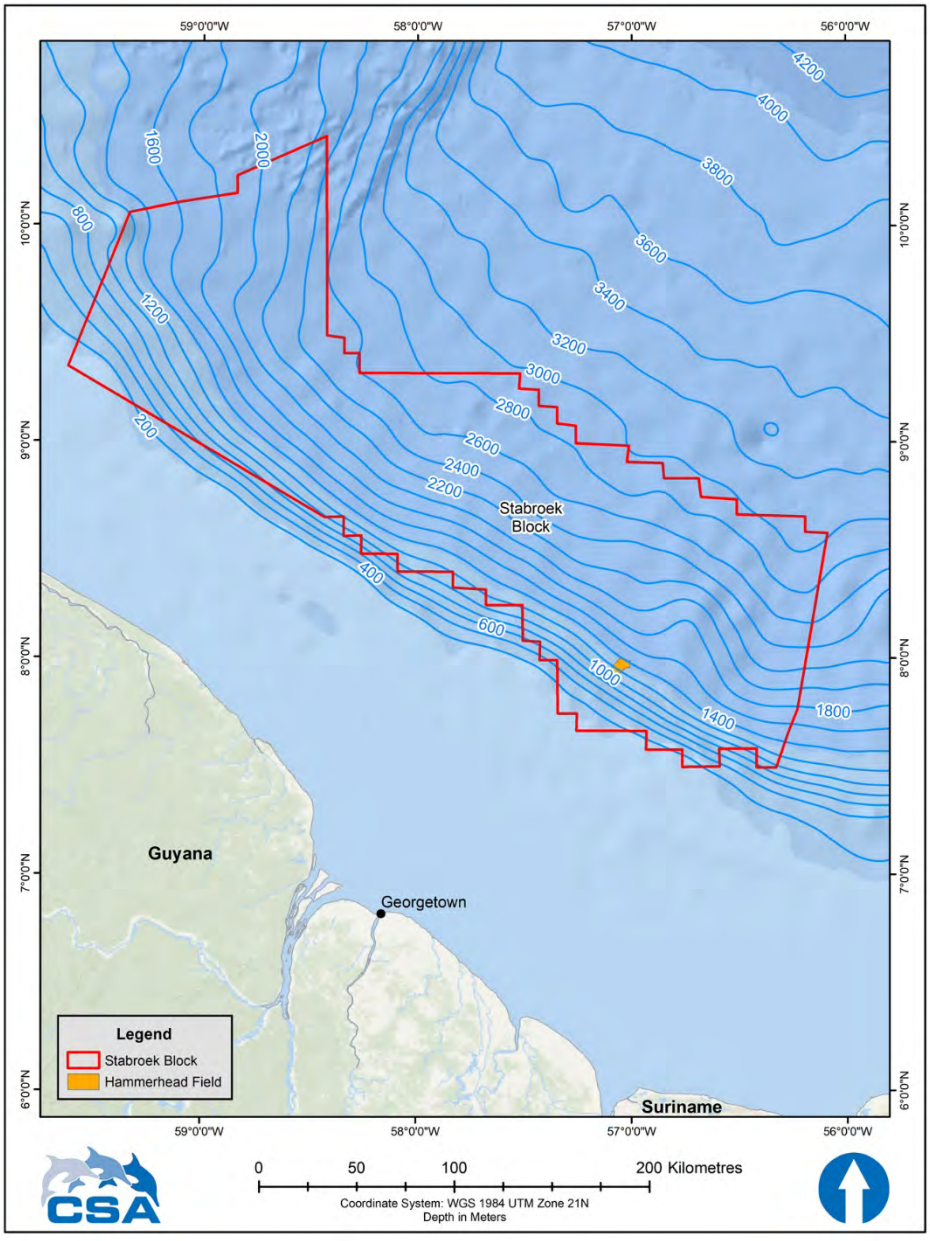

Figure 1. The Environmental Baseline Survey study area is located within and extends outside the boundaries of the Hammerhead Field within the Stabroek Block offshore Guyana.

1.1 OBJECTIVES

Based on the ExxonMobil general specifications, an offshore Initial Environmental Survey (IES) considered synonymous with an EBS, should be conducted to provide information on existing environmental conditions as a precursor to project or operational activities having potential influences on the environmental. The findings of the EBS are typically used in the support of the programmatic Environment, Socioeconomic, and Health Impact Assessment (ESHIA) process specific to understanding potential impacts to the various aspects of the environment. Other applications of the EBS findings are relevant to understanding potential engineering constraints based on sediment physical and chemical properties and oil spill response (i.e., presence of environmentally sensitive biomes).

During the EBS, physicochemical and biological data were collected within the study area to meet the following objectives:

- Determine and document environmental baseline conditions (i.e. physicochemical and biological) against which effects from proposed future oil and gas operations can be compared; and
- Identify parameters within the local ecosystem that may be sensitive to change and provide a reference point to evaluate future claims of impacts.

The specific EBS tasks to meet with the programmatic objectives were as follows:

- Determine characteristics of the seabed sediments, with specific reference to redox potential depth gradient, particle size distribution/grain size, total organic carbon (TOC), hydrocarbon content (total petroleum hydrocarbons [TPH] and polycyclic aromatic hydrocarbons [PAHs]), metals (aluminum [Al]; arsenic [As]; barium [Ba]; beryllium [Be]; cadmium [Cd]; cobalt [Co]; chromium [Cr]; copper [Cu]; iron [Fe]; lead [Pb]; mercury [Hg]; manganese [Mn]; molybdenum [Mo]; nickel [Ni]; selenium [Se]; silver [Ag]; strontium [Sr]; tin [Sn]; thallium [Tl]; vanadium [V]; and zinc [Zn]), and infauna analysis;
- Determine water column characteristics through the collection of hydrographic profiling data and water samples for analyses of total suspended solids (TSS), TOC, hydrocarbon content (TPH and PAHs), and metals (same as for seabed sediments) at depth within the study area; and
- Document the existing state of the marine environment at selected areas with full color, high definition videographic data.

EBS data, in establishing baseline conditions, would provide the comparative basis for any future environmental monitoring. The EBS, as designed and approved by ExxonMobil, is considered fit-for-purpose to meet programmatic objectives as based on providing data of measurable, and with level of quality, to be scientifically defensible.

1.2 REPORT ORGANIZATION

This EBS report is organized as follows:

- **Section 1 – Introduction**: outlines general survey background, location and objectives.
- **Section 2 – Survey Design**: describes the attributes (e.g. number, location) of sampling stations.
- **Section 3 – Field Methods**: describes survey equipment, personnel, sampling methods specific to collection and on-board processing, and quality assurance measures.
- **Section 4 – Laboratory Methods and Data Processing**: summarizes aspects of sampling parameters, identifies analytical laboratories, and describes aspects of data analysis and laboratory techniques specific to sampling parameters.

- **Section 5 – Results and Discussion**: summarizes and presents survey data, including general interpretation of the findings, with comparisons to environmental standards and relevant regional programs, as appropriate.
- **Section 6 – Conclusions and Recommendations**: generally summarizes the analytical results relevant to understanding potential impacts to the environment and provides recommendations to address potential data gaps for assessing effects from oil and gas activities.
- **Section 7 – Literature Cited**: provides bibliographic information for referenced journal articles, books, or grey literature.
- **Appendices:** provides information in support of the EBS findings including analytical laboratory datasheets, infauna data, hydrographic profiles, and sediment metals regression plots.

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2.0 Survey Design

The survey design, developed by ExxonMobil, consists of eight sampling stations at fixed locations within and around the Hammerhead Development Field. **Table 1** provides the EBS station designations based on Esso naming convention and sampling locations, proposed and actual navigational coordinates, and water depths. **Figure 2** shows the actual locations of sample stations surveyed during the EBS.

Table 1. Environmental baseline survey station designations, based on Esso naming convention and sampling location alpha-numeric codes, proposed and actual navigational coordinates, and water depths. Navigational coordinates are presented in the World Geodetic System 1984 (WGS84) and projected using the Universal Transverse Mercator (UTM), Zone 21 North.

Naming Convention Station	Sample Location	Navigational Coordinates				Water Depth (m)
		Proposed		Actual		
		X - Easting (m)	Y - Northing (m)	X - Easting (m)	Y - Northing (m)	
NC21G20EBC101	HH-01	487,396.6	877,361.6	487,378.6	877,355.1	1,033
NC21G20EWS101				487,363.9	877,336.1	
NC21G20EBC102	HH-02	488,856.5	879,755.9	488,860.2	879,762.5	1,149
NC21G20EWS102				488,826.9	879,771.9	
NC21G20EBC103	HH-03	490,309.9	878,595.6	490,318.9	878,609.2	1,168
NC21G20EWS103				490,268.1	878,634.5	
NC21G20EBC104	HH-04	484,301.5	875,632.8	484,294.7	875,635.5	873
NC21G20EWS104				484,280.8	875,622.9	
NC21G20EBC105	HH-05	513,374.4	880,015.1	513,372.5	880,036.1	1,545
NC21G20EWS105				513,254.9	880,089.8	
NC21G20EBC106	HH-06	505,791.0	881,310.5	505,793.8	881,319.6	1,481
NC21G20EWS106				505,686.2	881,319.8	
NC21G20EBC107	HH-07	495,413.3	879,347.0	495,414.9	879,359.8	1,261
NC21G20EWS107				495,341.9	879,401.4	
NC21G20EBC108	HH-08	512,694.4	884,738.1	512,688.1	884,754.6	1,633
NC21G20EWS108				512,601.5	884,771.1	

Note that sample naming convention follow the format as described:
AreaCode_Country_Year_SampleType_Station sequential#.
Area Code for this program is “NC21”; Country for this program is “G”; Year for this program is “20”; sample type is EBC = environmental box core or EWS = environmental water sample.

Sediment and water column sampling and seafloor imagery collection was conducted at each of the eight sampling stations. Sediment sampling was conducted for analyses of biotic (i.e. infauna) and abiotic parameters. Water column sampling included water sample collection and hydrographic profiling. At each station, water samples were collected at three depths within the water column: 1) near-surface; 2) mid-water (at the thermocline beneath the mixed surficial layer); and 3) near-bottom (approximately 20 m above the seafloor). Hydrographic profiling was conducted within the entire water column. To visually document the seafloor in the study area, videographic data was acquired at all sampling stations with a box core-mounted, remote pressure-activated high-definition camera system. Quality assurance (QA)/quality control (QC) samples (e.g. QA/QC blanks) were collected for selected sediment and seawater chemistry parameters.

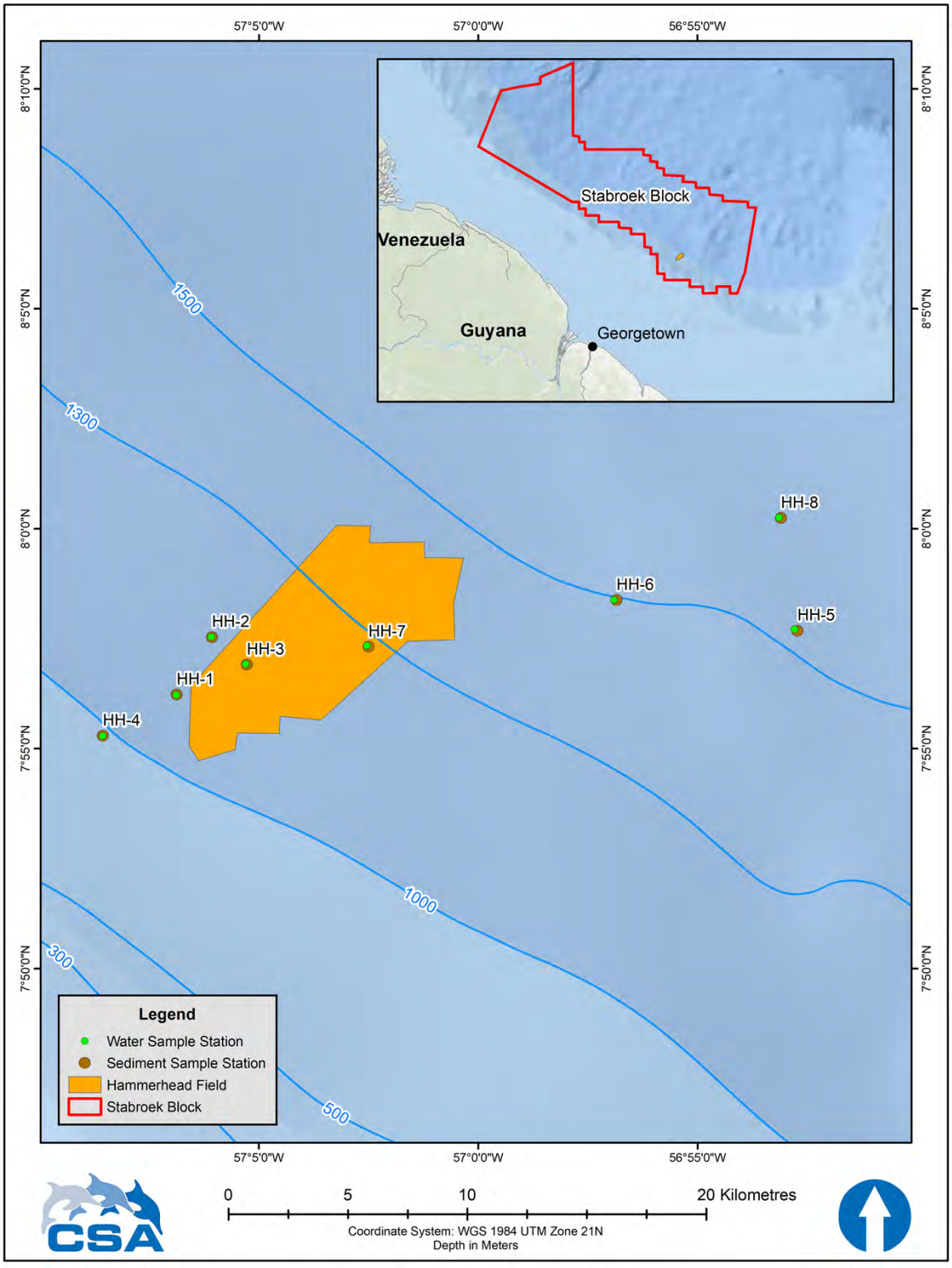

Figure 2. Locations of sampling stations for the Environmental Baseline Survey located within and around the Hammerhead Field in the Stabroek Block, offshore Guyana.

3.0 Field Methods

3.1 VESSEL, NAVIGATION AND EQUIPMENT

The Hammerhead Development EBS was conducted using the MMA *Valour*, a BENTHIC-contracted 84-m dynamic positioning-2 (DP-2) supply vessel. The MMA *Valour* was built in 2013 and capable of providing accommodation and provisioning for 60 persons. The vessel was outfitted with a winch system and articulating A-frame capable of launching and recovering all survey equipment.

Survey navigation services and associated equipment was provided by the BENTHIC contractor, UTEC, that configured, calibrated, tested, and operated survey positional equipment onboard the vessel. All positioning equipment and procedures were directed by BENTHIC in accordance with Esso specifications to meet with survey objectives. The high precision acoustic positioning system (HiPAP) was interfaced with the vessel ultra-short baseline (USBL) system for tracking the survey equipment during deployment. The HiPAP system during survey operations provides vessel guidance, digital navigation data logging, and a real-time display of the ship's position relative to deployed equipment during sample collection.

The primary sampling equipment used during the EBS to collect all survey data are listed and briefly described below.

- Sea-Bird Electronics (SBE) 19*plus* V2 Conductivity-Temperature-Depth (CTD) profiler is used to measure hydrographic profiles from the sea surface to near the seafloor; data was logged internally and then downloaded and processed by CSA personnel following retrieval.
- SBE 32 Water Carousel water sampling rosette is rated to 6,000 m depth and has a 12-position configuration that hold 5-L Go-Flo bottles. The Rosette was coupled with the CTD, allowing the bottles to be individually fired based on time and/or pressure.
- OSIL seabed camera system includes high definition camera (1080p at 30fps), dimmable 5,000 lumens light emitting diode (LED) light, and battery pack (rechargeable 13AH LiPo) that is rated to 6,000 m.
- United States Naval Electronic Laboratory (USNEL) box corer with removeable stainless steel sampling box that provides a 0.25 m^2 sediment sample surface area.
- Electrical high-power winch used to deploy and retrieve sampling equipment.
- A-frame with hydraulic power unit used to deploy and retrieve sampling equipment.
- Sediment infauna sieve station for processing infauna samples.

3.2 PERSONNEL

The survey team comprised of four CSA persons including two Marine Scientists and two Operations Specialists. The CSA survey team was assisted with all aspects of deck operations by BENTHIC personnel. The team conducted 24-hour operations and during the EBS, each 12-hr shift was be staffed by one Marine Scientist and one Operations Specialists.

Responsibilities of CSA marine scientists during the EBS were to:

- Implement the sampling plan in coordination with Operations Specialists;
- Review, interpret, and manage field data;
- Support science-based decision-making according to objectives and schedule;

- Provide additional QA/QC;
- Direct the compilation and distribution of scientific information; and
- Produce daily status reports.

Responsibilities of CSA operations specialists during the EBS were to:

- Implement the sampling plan in coordination with scientists;
- Support mobilization, demobilization, equipment integration and deck operations;
- Program and operate oceanographic instrumentation;
- Oversee sample collection and handling; and
- Implement CSA Health, Safety, Security and Environment policies and procedures.

3.3 SEDIMENT SAMPLING

Sediment sample parameters, associated guidelines for containers (type and size), preservation methods, and holding times are provided in **Table 2**. These guidelines are based on United States Environmental Protection Agency (USEPA) standards and laboratory recommendations.

Table 2. Summary of sediment parameters, guidelines for containers, preservation method and holding times for samples collected during the Hammerhead Development Environmental Baseline Survey.

Parameter/Analyte(s)	Minimum Sample Weight	Container Type and Size	Storage Conditions and/or Preservation Method	Holding Time
Redox Potential (Eh)	*In situ* measurement using oxidation-reduction potential meter			
Grain size	200 g (wet)	125-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
TOC	50 g	125-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	28 days
TPH and PAH	200 g	125-mL wide-mouth glass jar	Freeze, ship on ice, and store frozen	28 days
Metals[1]	150 g	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Delimited to 28 days for Hg
Infauna	--	1-L wide-mouth plastic	8% buffered formalin with rose bengal stain; ship and store at room temperature	90 days

PAH = polycyclic aromatic hydrocarbons, TOC = total organic carbon; TPH = total petroleum hydrocarbons; "-- " = not applicable.

[1] Metals include: aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), manganese (Mn), molybdenum (Mo), selenium (Se), silver (Ag), strontium (Sr), tin (Sn), thallium (Tl); vanadium (V), and zinc (Zn).

A single sediment grab was collected at each sampling station with a standard deep-water USNEL box corer with removeable stainless steel sampling box. The USNEL box core opening is 0.25 m^2 and provides adequate sediment for concurrent collection of physicochemical and biological (i.e. infauna) sampling parameters. The sediment sampling gear was deployed and retrieved using an articulating A-frame and winch system. As each grab/box core sample was retrieved, it was visually examined to determine acceptability. Photographs and general description (e.g., color, texture, presence/absence of biota, odor) of surficial sediments were collected for acceptable box cores. The criterion for acceptance of each box core sample was a minimum depth of approximately 20 cm of undisturbed sediment. Acceptable cores were processed with the overlying water siphoned off using flexible tubing (e.g., Tygon). Overlying water was siphoned through a 0.5-mm sieve; organisms trapped on the sieve were included with the benthic infaunal sample. Processing for the box core included inserting a 0.35-m × 0.35-m stainless steel

partition into the sediment to separate the infauna sample inside the partition from the physicochemical sample outside the partition (**Image 1**).

Image 1. Sampling box of United States Naval Electronic Laboratory (USNEL) corer was partitioned with a 0.35-m × 0.35-m stainless steel partition to separate physicochemical and macroinfaunal samples during the Hammerhead Development Environmental Baseline Survey.

3.3.1 Redox Potential

Sediment redox potential (Eh value) as measured in millivolts was recorded from three subsurface locations: 0 to 2 cm; approximately 5 cm; and approximately 10 cm. Measurements were taken with an ExStik waterproof oxidation-reduction potential (ORP) meter to generally characterize the oxidative state of the surficial sediments with a positive Eh value indicating aerobic sediments probably with relatively low levels of organic matter.

A 3-inch diameter butyrate core tube was inserted into the sediment inside the 0.35-m × 0.35-m box core stainless steel partition to a depth of approximately 15 cm (**Image 2**). The butyrate core had holes along the side at the 2-cm, 5-cm, and 10-cm subsurface sediment locations for insertion of the ORP meter sensor probe. The holes in the core tube were taped closed at time of insertion with the tape being removed just prior to sensor probe insertion to minimize exposure of the sediment to air. The sensor probe remained in place until the meter reading was stable for obtaining the Eh value. Once all subsurface depth readings were taken, the sediment from the core was processed through the 0.5-mm sieve with the station's macroinfauna sample.

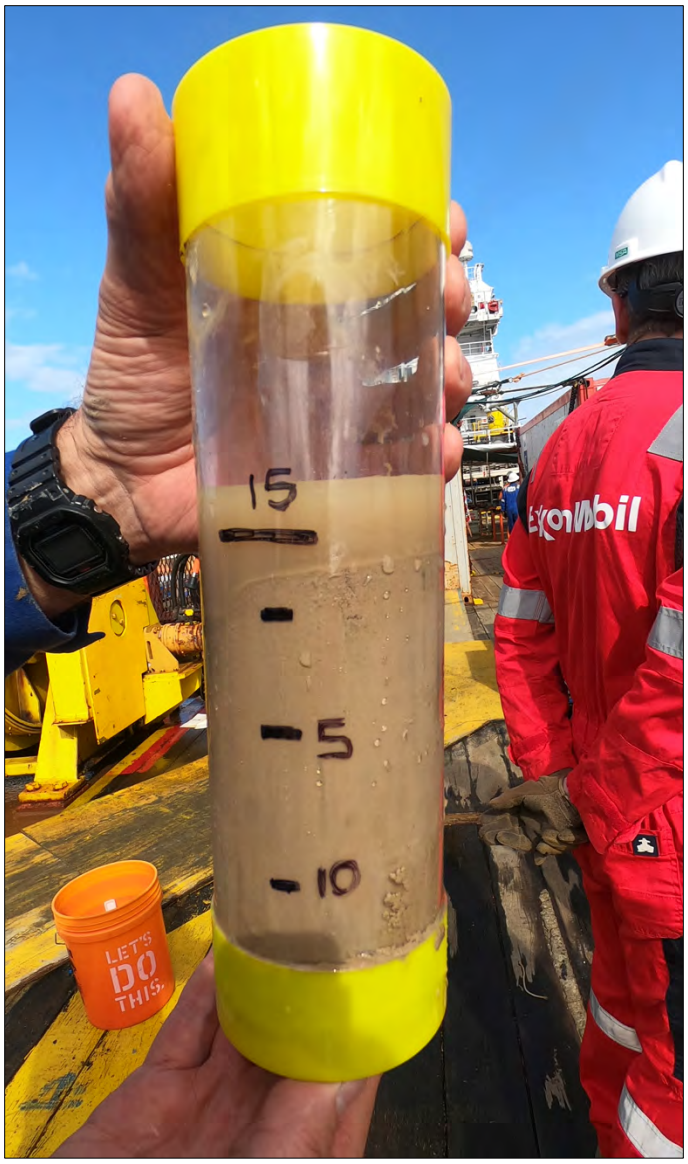

Image 2. A 3-inch diameter butyrate core tube was used to sample 2-cm, 5-cm, and 10-cm subsurface sediment locations for redox potential during the Hammerhead Development Environmental Baseline Survey.

3.3.2 Physiochemistry

Physicochemical samples were collected from outside the 0.35-m × 0.35-m partition. All chemical and geological samples were collected from the top 2 to 3 cm of sediment using a pre-cleaned stainless-steel spoon. Samples were placed directly in pre-cleaned and labeled sample containers (as appropriate for specified parameters). **Table 2** summarizes sample handling and storage requirements for sediment samples. Sediment samples were analyzed for grain size, TOC, total metals (Al, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Hg, Ni, Mn, Mo, Se, Ag, Sr, Sn, Tl, V, and Zn) and hydrocarbons (TPH and PAH).

3.3.3 Macroinfauna

The portion of sediment within the 0.35-m x 0.35-m partition was sampled for macroinfauna analyses. Macroinfaunal samples were collected directly from top 12 to 15 cm of sediment. Samples were elutriated and wet-sieved on board over a 0.5-mm mesh sieve with gentle streams of seawater of high volume and low pressure using a floatation (overflow barrel) technique (**Image 3**) that minimizes trauma to the infaunal organisms and facilitates separation from the sediment. The 0.5-mm mesh sieve was selected for sampling to be consistent with previous Esso-contracted environmental survey work conducted in the Stabroek Block.

Image 3. Sieving station for processing infauna using the floatation (overflow barrel) technique.

The infaunal sieving station consists of a seawater supply manifold and hoses, mixing-overflow barrel, sieve screen and holder, and collection sink with drain hoses. The following three steps are required to process macroinfaunal samples:

1. Supply seawater in the barrel with a controllable flow rate to facilitate overflow of seawater from the barrel to the sieve screen.

2. The collected sediment is placed within the barrel in stages and is gently worked by hand and the flow of the supply seawater to break down and suspend the sediment.

3. After the sediment is emptied from the barrel, the processed sample (consisting of macroinfauna, some residual sediment and debris remaining on the sieve screen) is transferred to a sample container (or containers) and preserved with a 10% borax-buffered formalin-in-seawater solution (1:10 dilution of 37% formalin).

Processed samples were placed in 1-L plastic jars and labeled, taped, and properly stored aboard the vessel. Once preserved in formalin, infauna samples were stored at ambient temperature with a holding time of approximately 90 days.

3.4 WATER COLUMN SAMPLING

Water sample parameters, associated guidelines for containers (type and size), preservation method for samples, and holding times are provided in **Table 3**. These guidelines are based on USEPA standards and laboratory recommendations.

Table 3. Summary of seawater parameters, guidelines for containers, preservation method, and holding times for samples collected during the Hammerhead Development Environmental Baseline Survey.

Parameter	Minimum Sample Volume	Container Type and Size	Storage and Preservation Method	Holding Time
Temperature, conductivity/salinity, DO, pH, and turbidity	*In situ* measurement using SBE 19*plus* V2 SeaCAT profiler			
TOC	250-mL	250-mL amber glass bottle	H_2SO_4 to pH <2; cool to 4°C; ship on ice	28 days
TSS	1 L	1-L plastic bottle	In-field filtration with 1.5 µm particle retention glass-fiber filter; store pre-weighed filter frozen; ship on ice	Indefinite when filtered (within 7 days of collection) and frozen
TPH and PAH	1 L	1-L amber glass bottle	Methylene chloride; cool to 4°C; ship on ice	40 days
Metals[1]	1 L	1-L HDPE plastic	HNO_3 to pH <2; cool to 4°C; ship on ice	Delimited to 28 days for Hg

DO = dissolved oxygen; HDPE = high-density polyethylene; H_2SO_4 = sulfuric acid; HNO_3 = nitric acid; PAHs = polycyclic aromatic hydrocarbons; SBE = Sea-bird Electronics; TOC = total organic carbon; TPH = total petroleum hydrocarbons; TSS = total suspended solids.

[1] Metals include: aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), manganese (Mn), molybdenum (Mo), selenium (Se), silver (Ag), strontium (Sr), tin (Sn), thallium (Tl); vanadium (V), and zinc (Zn).

3.4.1 Hydrographic Profiling

Hydrographic measurements were collected with a factory calibrated SBE 19*plus* V2 SeaCAT profiler mounted on the rosette sampler (**Image 4**). Hydrographic profiles were conducted for conductivity/salinity, temperature, dissolved oxygen (DO), pH, and turbidity. Two profiles were conducted at each sampling station; the initial profile was specific to determining the depth of the thermocline below the surficial mixed layer. The second profile was of the entire water column from near-surface to near-bottom and recorded at 0.5-second intervals as the profiler was lowered through the water column at a relatively constant speed.

Image 4. Hydrographic profiler and water sample bottles mounted on a rosette carousel sampler.

3.4.2 Seawater Collection

Discrete seawater samples were collected from three water depths (near-surface, mid-water, and near-bottom). Samples were collected using pre-cleaned, 5-L water bottles mounted on the water sampling rosette for analyses of TOC, TSS, metals, and hydrocarbons. Field and QA/QC samples were transferred into pre-cleaned sample containers, processed and stored; appropriate sample preservative volumes were put in containers prior to survey sampling.

3.5 PHOTOGRAPHIC DATA

Seafloor photographs and video were acquired at all sediment stations with a remote pressure-activated high-definition OSIL seabed camera system mounted onto the frame of the USNEL box core (**Image 5**). The high definition camera (1080p at 30fps), dimmable 5,000 lumens LED light, and battery pack (rechargeable 13AH LiPo) is rated to 6,000 m and can be programed prior to deployment to turn on and begin recording at a specific depth. Due to the water depths within the study area, the camera system

recorded continuous visual data during the within-station deployment. The box core was momentarily left stationary following penetration of the seafloor sediments to ensure adequate temporal photographic coverage for collection of a least 15 still images of the seafloor. The camera system's visual detection begins at approximately 1 m above the seafloor due to light penetration within the water column.

Image 5. Seafloor photographs and video were acquired at all sediment stations with a remote pressure-activated high-definition OSIL seabed camera system mounted onto the frame of the United States Naval Electronic Laboratory (USNEL) box core. The system consisted of a high definition camera (top mounted unit) and light emitting diode (LED) light (lower mounted unit).

3.6 QUALITY ASSURANCE/QUALITY CONTROL

Field QA/QC measures were implemented during the EBS in order to collect representative samples, allow assessment of potential sources of contamination, minimize data and sample loss, and ensure collection of requisite samples.

3.6.1 Quality Assurance

A QA program was undertaken to ensure that the project generated scientifically defensible data of known quality that meet the project objectives. CSA's QA program included the selection of qualified analytical laboratories, deployment of an experienced field team, and detailed preparation during mobilization.

Analytical Laboratories

Selected analytical laboratories had established QA programs and extensive experience in the analysis of marine samples. Sediment, seawater, and infauna analytical laboratories and accreditations, as appropriate, are presented in **Section 4.1.2**.

Field Personnel

The field survey team was composed of well-qualified and highly experienced CSA personnel and augmented with experienced subcontracted technicians. The use of experienced staff who follow appropriate precautions and are attentive to detail when conducting field operations minimizes error, enhances quality, and maximizes efficiency in conducting the survey. The EBS was conducted on a 24-hour basis and field team members worked in 12-hour shifts with between-shift briefings to ensure program continuity.

Mobilization

Prior to the survey, the scope of work was reviewed by the project team to ensure that all field survey operations and individual responsibilities were familiar to team members. The requirements for the survey included provision for, and access to, the following: appropriate numbers and types of containers, chemicals and other field supplies; field methods and procedures; sample identification labels; checklists; chain-of-custody (CoC) forms; sample disposition and shipping arrangements; and QC measures. Responsibilities for documenting these survey activities as an integral part of mobilization were assigned to field team members, as appropriate.

3.6.2 Quality Control Measures

QC measures included the following:

- Preparation of equipment blanks to determine the potential of sample contamination by the sampling equipment;
- Preparation of field blanks to determine the potential of sample contamination from containers and general sample handling;
- Use of field duplicates (i.e., homogenized splits) to check reproducibility of laboratory and field procedures;
- Preparation and completion of sample/data checklists;
- Equipment performance and data checks;
- Use of CoC processes for sample handling; and
- Post-survey shipment and sample tracking.

QC samples (e.g. blanks and laboratory duplicates) were prepared for sediment and seawater metals and hydrocarbon parameters. An approximate 10% level of QC was attained for appropriate sample parameters.

Sea-Bird Electronics Profiler Data Check

During or soon after a water column profile cast was completed, hydrographic data were examined by a CSA scientist to check the collected data were within expected ranges (for the conditions at the EBS study area), the equipment was functioning normally, and the configuration of data files was correct.

Data and Sample Collection Checklists

Prior to the survey, data and sample checklists were prepared by the Chief Scientist and completed in the field as appropriate for QC. Prior to departing each sampling station, the Chief Scientist reviewed the checklist and ensured collection and proper storage of the required station data and samples.

Sample Preservation and Holding Times

Samples were preserved as specified by the appropriate analytical laboratory or industry best practices. Post-survey planning for the shipment of samples to designated laboratories ensured delivery to within the recommended holding times and conditions.

3.6.3 Sample Handling and Transport

Samples were transported following a CoC process and a CoC record accompanied all samples. Persons involved in the custody of the samples signed the appropriate CoC forms and ensured the samples were properly handled, stored and transported to the analytical laboratory. Each sample had a unique identifier that was directly tracked to the data sheets. Labels were waterproof and securely fastened to the container. Bubble-wrap padding was used to separate and pad/insulate all glass containers to avoid breakage. Sample shipping containers were secured to be leak proof, avoid cross-contamination, and prevent sample loss during transport.

3.6.4 Document and Data Security

Station and date were indicated on all data sheets used for the hydrographic profile (CTD) logs, sample logs, and CoC sheets. Upon completion of the survey, the field logbook and other documents completed or acquired in the field were copied and the copies were archived with the project files. Copies of completed CoC forms were requested from the respective laboratories and stored with the project files.

Navigation and positioning data and field data files from the Sea-Bird CTD profiler were regularly saved to a computer file and backed up on a separate removable medium (e.g. flash memory/data stick or CD-R/RW). Backup media were stored and transported separately from the field computer. Upon return to Stuart (Florida), the Chief Scientist ensured that all data were properly backed up or archived on CSA's local area network file server.

4.0 Laboratory Methods and Data Processing

4.1 SEDIMENT AND WATER

4.1.1 Sampling Parameters

Table 4 summarizes the analytical methods and laboratory-specified method detection limits for sediment and seawater parameters, and the accredited laboratory used for sample analysis. Analytical data summaries for sediment and water samples are provided as **Appendix A**.

Table 4. Parameters, analytical methods, quantification limits and analytical laboratories for sediment and seawater samples collected during the Hammerhead Development Environmental Baseline Survey.

Parameter/Analyte	Analytical Method	Quantification Limits	Units	Analytical Laboratory
Sediment				
Grain Size Distribution	Particle Size Distribution; modified from Carter and Gregorich, 2006	0.1	µm	KaizenLab
Total Organic Carbon	USEPA 9060	0.1	%	ALS
Aluminum	USEPA 6010C	22 to 25	ppm	
Arsenic	USEPA 6020A	3.6 to 4	ppm	
Barium	USEPA 6010C	8.7 to 10	ppm	
Beryllium	USEPA 6020A	0.14 to 0.16	ppm	
Cadmium	USEPA 6020A	0.14 to 0.16	ppm	
Chromium	USEPA 6020A	1.4 to 1.6	ppm	
Cobalt	USEPA 6020A	0.14 to 0.16	ppm	
Copper	USEPA 6020A	0.71 to 0.8	ppm	
Iron	USEPA 6010C	87 to 100	ppm	
Lead	USEPA 6020A	0.36 to 0.4	ppm	
Manganese	USEPA 6020A	0.36 to 0.4	ppm	
Mercury	USEPA 1631E	1.8 to 3.2	ppb	
Molybdenum	USEPA 6020A	0.36 to 0.4	ppm	
Nickel	USEPA 6020A	1.4 to 1.6	ppm	
Selenium	USEPA 6020A	7.1 to 8	ppm	
Silver	USEPA 6020A	0.14 to 0.16	ppm	
Strontium	USEPA 6010C	4.6 to 5	ppm	
Thallium	USEPA 6020A	0.14 to 0.16	ppm	
Tin	USEPA 6020A	0.71 to 0.8	ppm	
Vanadium	USEPA 6020A	1.4 to 1.6	ppm	
Zinc	USEPA 6020A	3.6 to 4	ppm	
TPH	USEPA 8015C Modified	0.05*	ppm	TDI Brooks
PAH	USEPA 8270D Modified	0.5*	ppb	
Infauna	Taxonomy and abundance	LPIL	N/A	Fauna Trinidad Ltd.

Table 4. (Continued).

Parameter/Analyte	Analytical Method	Quantification Limits	Units	Analytical Laboratory
Seawater				
Total Organic Carbon	USEPA 9060A	1	ppm	ALS
Total Suspended Solids	SMEWW 2540D	5	ppm	
Aluminum	USEPA 6010C	21	ppm	
Arsenic	USEPA 6020A	0.5	ppm	
Barium	USEPA 6020A	1	ppm	
Beryllium	USEPA 6020A	0.02	ppm	
Cadmium	USEPA 6020A	0.02	ppm	
Chromium	USEPA 6020A	0.2	ppm	
Cobalt	USEPA 6020A	0.02	ppm	
Copper	USEPA 6020A	0.1	ppm	
Iron	USEPA 6010C	21	ppm	
Lead	USEPA 6020A	0.05	ppm	
Manganese	USEPA 6020A	4	ppm	
Mercury	USEPA 1631E	0.5	ppb	
Molybdenum	USEPA 6010C	8.4	ppm	
Nickel	USEPA 6020A	0.2	ppm	
Selenium	USEPA 6020A	1	ppm	
Silver	USEPA 6020A	0.02	ppm	
Strontium	USEPA 6010C	1.1	ppm	
Thallium	USEPA 6020A	0.02	ppm	
Tin	USEPA 6010C	21	ppm	
Vanadium	USEPA 6010C	4.2	ppm	
Zinc	USEPA 6020A	0.5	ppm	
TPH	USEPA 8015C Modified	0.25*	ppb	TDI Brooks
PAH	USEPA 8270D Modified	5*	ppt	

ALS = ALS Environmental; LPIL = lowest practical identification level; PAH = polycyclic aromatic hydrocarbons; N/A = not applicable; SMEWW = Standard Methods for the Examination of Water and Wastewater; TDI Brooks = TDI-Brooks International, Inc.; TPH = total petroleum hydrocarbons; USEPA = U.S. Environmental Protection Agency;
Carter MR, Gregorich EG (Editors). 2006. Soil sampling and methods of analysis. In: Canadian Society of Soil Science, 2nd ed. CRC Press/Taylor & Francis Group, LLC.
* Quantification limits of vary by analyte; presented is highest limit of detection.

4.1.2 Analytical Laboratories

ALS Environmental (ALS) laboratories in Kelso, Washington, is a National Environmental Laboratory Accreditation Program (NELAP) accredited contract laboratory with extensive experience in seawater and marine sediments analyses. ALS provides sophisticated, modern analytical services specific to the minerals (i.e., geochemistry), life sciences (i.e., environmental), and energy (i.e., oil and gas) industries. More than 20 million samples per year are analyzed by ALS's staff of 13,000 in 350 locations in 55 countries around the world. ALS's major hub facilities are located in Australia, Asia, North America, South America, Europe, the Middle East, and Africa. ALS's certifications and accreditations include ISO/International Electrotechnical Commission (IEC) 17025:2005, NELAP (National Environmental Laboratory Accreditation Conference Institute 2009), and conformance with Good Laboratory Practice. ALS conducted the analyses of seawater TSS, TOC, and metals, and sediment TOC and metals.

TDI-Brooks International, Inc. (TDI Brooks), located in College Station, Texas, owns and operates B&B Laboratories. With state-of-the-art equipment and an accomplished staff, they specialize in the analysis of organics, including petroleum hydrocarbons, with extensive experience in analysis of seawater and marine sediments. B&B Laboratories operates a Quality Management System that complies with the requirements of ISO 9001:2015 for the analysis of geochemical, geotechnical, and environmental samples. They are also accredited for ISO\IEC 17025:2017 and have certification validating that all analytical processes are fully established, functional, and meet international standards. B&B Laboratories has participated in the highly rigorous U.S. National Institute of Standards and Technology intercalibration exercise for trace organics since 1997 and has always ranked in the top group for this exercise. B&B Laboratory methods are based on highly modified USEPA methods that are performance-based and meet the requirements of ISO 17025:2017 with specialization in the extraction and analysis of organic compounds. TDI Brooks conducted the analyses for seawater and sediment hydrocarbons (TPH and PAHs).

KaizenLab is an established environmental laboratory with expertise in environmental organic, inorganic and microbiology analysis. KaizenLab, Analytical Division of Kaizen Environmental Services (Trinidad) Limited, is a well-established environmental laboratory with over 20 years of analytical experience. It specializes in analytical techniques applied to environmental chemistry for water and wastewater analysis, oil analysis, soil and solid waste characterization, food chemistry and microbiology. As an ISO/IEC 17025:2005 internationally accredited laboratory, KaizenLab operates a rigorous QA/QC program. KaizenLab conducted the analyses of sediment grain size.

Fauna Trinidad Ltd. (FTL) provides services to address biological sample analyses for macroinfauna. Based in Trinidad and Tobago, they offer services in ecological and biological analyses specifically for environmental impact assessments and environmental monitoring. FTL has a combination of over 12 years of collected experience in the environmental field with dynamic and innovative approaches to science and ecology. Their primary expertise is in the identification of faunal species, particularly marine benthic macroinfauna. FTL offers expertise in ecological analyses complemented with reporting that integrates standard scientific techniques and indices with appropriate statistical analyses. CSA has previously worked with FTL to provide services to address infauna, phytoplankton, and zooplankton analysis. Certifications or accreditations are not applicable for taxonomic analytical laboratories. FTL analyzed the EBS macroinfauna samples.

4.1.3 Benchmark Values

Sediment chemistry analytical results were interpreted in the context of the actual values relative to benchmark values to evaluate their biological relevance. Metals and hydrocarbon concentrations were compared to the USEPA sediment quality benchmarks. A benchmark is a chemical concentration in sediment above which there is the possibility of harm to organisms in the environment. The USEPA recommends benchmark values such as the effects range low (ERL) and effects range median (ERM) to assess the potential risk to fish and other marine life (Long and Morgan, 1990). These sediment quality guidelines are based on marine sediment chemistry paired with sediment toxicity bioassay data. The benchmarks represent points on a continuum of chemical concentrations ranked from lowest (least toxic) to highest (more toxic) concentrations defined as follows:

- ERL is indicative of concentrations below which adverse effects rarely occur; and
- ERM is indicative of concentrations above which adverse effects frequently occur.

Analytical results of seawater metals were compared to USEPA Criterion Continuous Concentration (CCC) toxicity reference values (Buchman, 2008). The USEPA CCC for seawater analytes is the chronic criteria that are based on average chemical concentration estimates in water that does not adversely affect aquatic organisms during an extended exposure period (i.e., 96 hours). Survey results for seawater metals

analyses are presented in context with international environmental quality standards to evaluate potential toxicity risks within the Hammerhead Development EBS study area. There are no internationally accepted toxicity reference benchmark values for total nitrogen or TPH concentrations in seawater.

4.1.4 Normalization of Metals Data

To determine the relationship between individual pairs of parameters, sediment metal concentrations were normalized with aluminum. Concentrations of aluminum and other metals vary naturally in ambient seafloor sediments, primarily due to differences in sediment grain size. Clay sediments are composed primarily of aluminosilicates and typically have higher concentrations of metals. Sediments classified as silt or sand are primarily composed of quartz and fragments of carbonate shell, which dilute ambient metals concentrations (Herut and Sandler, 2006). Aluminum concentration is assumed to correlate linearly with other metals concentrations when there is no anthropogenic input (Trefry et al., 2003, 2013). It is reasonable to assume that a metal concentration is enhanced by anthropogenic activity if the metal concentration deviates greatly from the linear regression of that metal versus sediment percent concentration of aluminum.

4.2 INFAUNA

Multi-species assemblages such as marine infauna exhibit patterns in composition and abundance within a defined habitat that can be difficult to characterize in a single metric or analysis. Taking a hierarchical view can help reduce this complexity by examining different scales of assemblage structure ranging from assemblage-wide to individual species (e.g., Maurer, 1999). Assemblage-wide assessments summarize structure in a single unit such as total density, total abundance, or total biomass. These are variables that will correlate with broad scale environmental factors that affect all species in the assemblage collectively. At the opposite scale are species that respond individually to environmental influences. The individual species level is analyzed with multivariate methods capable of visualizing patterns of taxonomic composition among samples and, inversely, species or taxa responsible for potential patterns in the samples. Intermediate between these two scales are species richness, diversity, and evenness. These measurable assemblage properties do not account for the unique biology of individual species but view them as equivalent units. Intermediate assemblage structure is analyzed with indices calculated from raw sample data. The goal of pre-impact analyses is to establish patterns at these different levels prior to any potential disturbance to permit analysis of future effects.

Specimens were sorted, counted and identified to the lowest practical identification level (LPIL). Identifications were performed using relevant keys and literature. Specimens were sent to taxonomic experts for identification, if required. Infauna samples were transferred from the formalin preservative to 70% denatured alcohol for archival.

Species and their abundances were entered into a spreadsheet for each station. A tabulated list of taxa abundance observed for infauna samples at all stations is provided in **Appendix B**. The data were then used to determine the following:

- Species list;
- Relative proportions of each phylum by number of species and number of individuals to evaluate the dominance of the most common phyla;
- Mean and total number of individuals for each station; and
- Density of organisms per station. All macroinfauna samples were normalized by sediment surface area to estimate density.

Infauna assemblage structure in the EBS study area was assessed with univariate diversity indices and multivariate analysis of species composition. Three diversity indices that capture different aspects of

species-abundance relationships were used to analyze the samples. The Margalef's richness index (d) is a measure of biodiversity indicating the relative number of different species in a sample and/or stratum. Margalef index has no limit value and it varies depending upon the number of species. It is used for comparison of the stations considering only one component of diversity (species richness). The higher the d value the higher the species richness; it can be inferred that sites with more taxa are considered richer. The Shannon-Weiner index (H') emphasizes species in the middle (not common or rare) of the species rank abundance sequence and accounts for both abundance and evenness of the species present. The greater H' value, the greater the diversity and evenness of the sample; the values are generally between 1.5 and 3.5 with the index rarely greater than 4. Pielou's evenness index (J') measures how evenly the number of individuals is distributed among the species. J' ranges between 0 and 1; a lower J' value indicates less evenness in community structure, and possible presence of a dominant species, while a higher J' value indicates more evenness. Diversity indices were calculated using Plymouth Routines in Multivariate Ecological Research (PRIMER) version 7 software (Clarke and Gorely, 2006).

Multivariate analyses were used to identify groups of samples with similar taxonomic composition and proportional abundances. Groups or clusters may reflect physical environmental influences such as sediment grain size or organic carbon content but could also be caused by biotic patterns of competition and predation. Understanding the existence and cause of such groups is an important step in pre-impact analysis that will support interpretation of post-impact results.

Two multivariate analytical techniques (cluster analysis and ordination) that employ different numerical routines to identify patterns of compositional similarity were used to provide independent outcomes from the same data. Because multivariate methods can recognize structure from randomly generated data, corroborating outcomes from these different methods would suggest observed patterns to be real.

PRIMER software was used to perform a multivariate cluster analysis using the Bray-Curtis similarity index (Bray and Curtis, 1957) which compares pairwise, the similarities between each pair of variables (e.g. stations are the variables and criterion for comparison is species composition). Data was subject to a square root transformation prior to calculating pairwise similarity among all samples using the Bray-Curtis similarity index. The similarity matrix was analyzed with group-average cluster analysis and non-metric multi-dimensional scaling (MDS) ordination.

Clustering was carried out by group average sorting and results were displayed as a dendrogram. A similarity profiles (SIMPROF) test was used to test statistical significance of any groups formed by the cluster analysis (Clarke and Gorley, 2015). The SIMPROF test compares observed similarity profiles (similarities ordered from smallest to largest plotted against their rank) with a similarity profile representing a null hypothesis of no structure within that group. Repeated application of this test divides samples into increasingly smaller subgroups. SIMPROF tests performed here used 999 random permutations and a 5% significance level.

The same sample similarity matrix analyzed by cluster analysis was also analyzed with MDS. The MDS ordination technique provides a 2D projection of inter-sample relationships in abstract (ordination) space. Like the dendrogram, stations most similar in terms of faunal composition and proportional abundance clustered near one another in the 2D ordination diagram (Clarke and Gorley, 2015).

4.3 HYDROGRAPHIC PROFILES

Digital data files from hydrographic casts taken with the CTD profiler were processed by a CSA scientist using SBE data processing software, a proprietary modular family of data processing software specific to SBE oceanographic instruments. The SBE data, loop edit and bin mean modules were used to convert the data from the raw hexadecimal format to engineering units in a text file, extract the appropriate cast

section, remove any loops in the record, smooth the data and import the file into a spreadsheet. Hydrographic profile graphics were generated from the spreadsheet using Sigma Plot software.

4.4 SEAFLOOR IMAGERY

Video photograph data were reviewed to generally characterize the seafloor substrate and associated biota, if distinguishable, at each photographic location. The presence of epifauna, indications of infauna activity and sediment type were documented from the imagery. Photographic data were reviewed to provide representative images of the benthic habitat as documented within the EBS study area; representative images from each of the photographic locations is presented in **Section 5.3**. A complete set of seafloor imagery has been provided to Esso as an immediate post-survey deliverable; Esso required at least 15 seafloor still images from each of the sampling stations.

5.0 Results and Discussion

The EBS field sampling was conducted from 11 to 13 March 2020; this does not include the vessel transit to and from Chaguaramas, Trinidad and Tobago. The locations of the EBS sampling stations are shown in **Figure 2** and listed in **Table 1**. Weather conditions were relatively calm during the EBS sampling, with winds from the east and northeast direction at 10 to 15 knots and <1.5 m seas. No weather standby days were incurred during EBS sampling.

5.1 SEDIMENT

5.1.1 Redox Potential

Redox potential (Eh) is a measure of the oxidation or reduction state of a medium as measured in millivolts (mV). Oxidation is defined as removal of electrons from a compound and conversely reduction is defined as the addition of electrons to a compound. Eh values of less than −100 mV indicate anaerobic environments, while values greater than 100 mV indicate aerobic environments (Suthersan, 2001). **Table 5** provides the Eh values for the subsurface depths of 2-cm, 5-cm, and 10-cm at each of the EBS sediment sampling stations. Eh values were all positive ranging from a low of 100 to 233 mV that are indicative of aerobic conditions. As expected, there was a general trend of indirect correlation between Eh values and sediment depth with decreasing values with increasing depth.

Table 5. The redox potential values for the subsurface depths of 2-cm, 5-cm, and 10-cm at each of the Hammerhead Development Environmental Baseline Survey sediment sampling stations.

Station	Redox Potential (millivolts)		
	2-cm	5-cm	10-cm
HH-01	171	166	164
HH-02	164	139	127
HH-03	187	107	100
HH-04	167	151	139
HH-05	191	178	181
HH-06	233	212	201
HH-07	213	201	168
HH-08	230	210	215

5.1.2 Grain Size

Grain size and classification based on Shepard (1954) for all stations are presented in **Table 6**. Grain size fractions consist of sand, silt, and clay as defined by the Wentworth scale with sand-sized particles having diameters from <2 mm to >62.5 µm; silt-sized particles having diameters from <62.5 µm to >4 µm; and clay at < 4 µm. Overall, sediment grain size was mainly silty clay, based on Shepard's classification (Shepard, 1954). Except for Station HH-8, stations were characterized by sediment with less than 30% sand and high proportions of silt and clay fractions (**Table 6**). The grain size distribution observed within the study area is similar to sediments from the Liza 2 Field Development EBS (Benthic USA LLC., 2019) with mean value for the clay fractions exceeding 50%. **Figure 3** is a ternary diagram to graphically depict the relative proportions of the primary sediment components (sand, silt, and clay) for all stations.

Table 6. Grain size distribution and classification based on Shepard (1954) for sediment samples collected during the Hammerhead Development Environmental Baseline Survey.

Station	Sand (%)	Silt (%)	Clay (%)	Classification
HH-1	15.0	28.8	56.2	Silty Clay
HH-2	6.3	42.5	51.2	Silty Clay
HH-3	2.5	41.3	56.2	Silty Clay
HH-4	6.3	50.0	43.7	Clayey Silt
HH-5	21.3	25.0	53.7	Sand/Silt/Clay
HH-6	23.8	30.0	46.2	Sand/Silt/Clay
HH-7	2.5	38.8	58.7	Silty Clay
HH-8	31.3	28.7	40.0	Sand/Silt/Clay
Mean	13.62	35.64	50.74	Silty Clay

Shepard FP. 1954. Nomenclature based on sand-silt-clay ratios. Journal of Sedimentary Petrology 24:151-158.

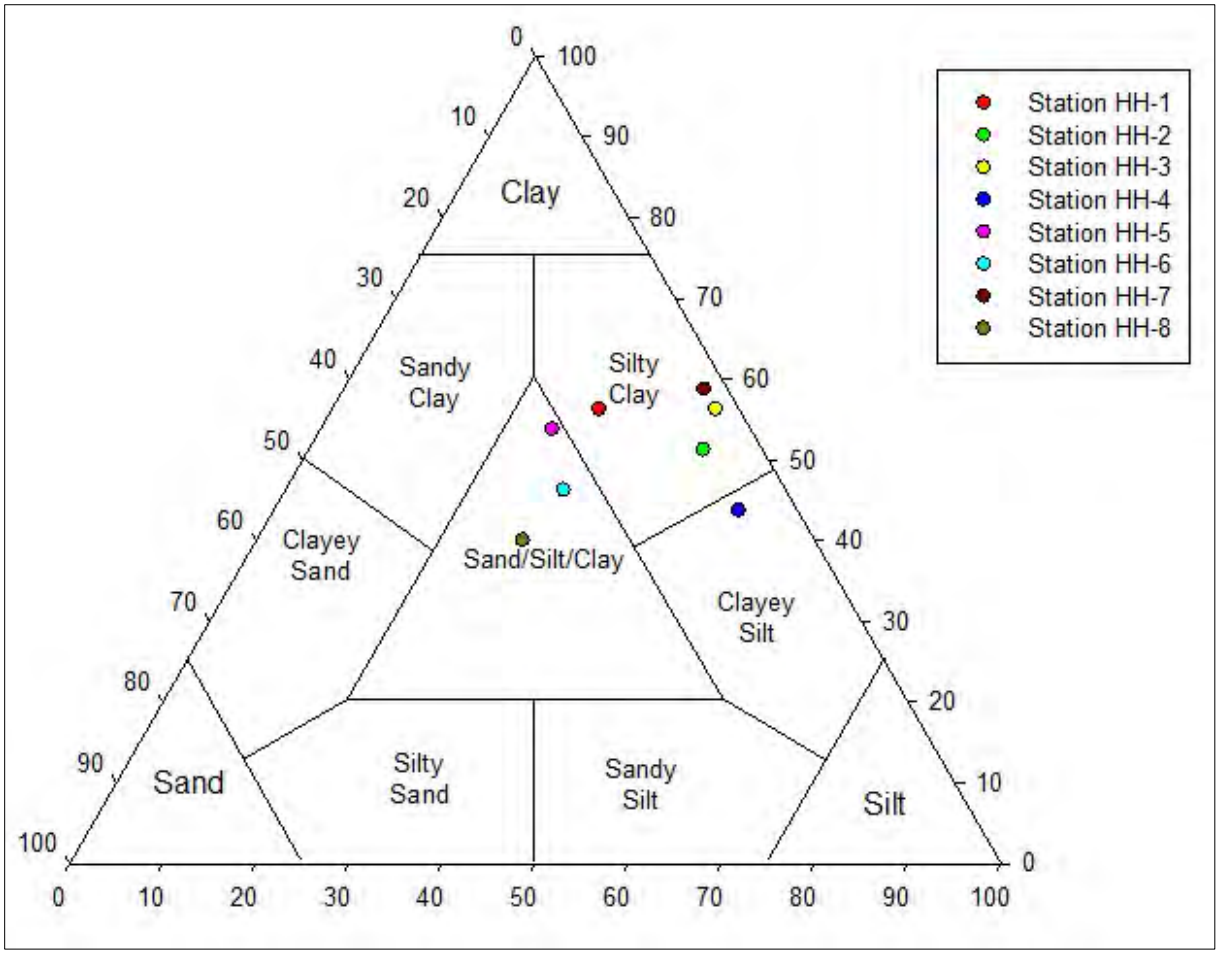

Figure 3. Ternary diagram depicting grain size characteristics for sediment samples collected during the Hammerhead Development Environmental Baseline Survey.

5.1.3 Total Organic Carbon

TOC concentrations (%) for all EBS stations are presented in **Table 7**. The sediment TOC concentrations in the study area are relatively low ranging from 0.17% to 0.65%. These low TOC concentrations are similar to the concentration range of 0.33% to 0.57% reported from a previous regional study for the Liza 2 Field Development (Benthic USA LLC., 2019) and are in the expected range for deep water offshore sediments (Escobar-Briones and García-Villalobos, 2009). There are currently no USEPA benchmark values for TOC concentration in marine sediments.

Table 7. Total organic carbon concentrations for sediment samples collected during the Hammerhead Development Environmental Baseline Survey.

Station	Total Organic Carbon (%)
HH-01	0.55
HH-02	0.17
HH-03	0.25
HH-04	0.49
HH-05	0.58
HH-06	0.55
HH-07	0.20
HH-08	0.65

5.1.4 Hydrocarbons

Sediment hydrocarbon concentrations within the Hammerhead Development EBS study area are presented in **Table 8**. Hydrocarbons analyzed in sediments included TPH and PAHs. TPH is a group of several hundred organic compounds that come from crude oil. The TPH value as presented is the collective total of extractable petroleum hydrocarbons from carbon range C9 through C40 and is the sum of unresolved and resolved analytes. The TPH value includes both the aliphatic and aromatic fractions with predominance of the aliphatics.

PAHs are constituents of crude oil and the PAHs found in the marine environment are divided into two groups, petrogenic and pyrogenic. Petrogenic PAHs are present in oil and oil products. Typically, the presence of petrogenic PAHs in offshore environments are associated with oil seeps, oil spills, and produced water discharges from offshore oil installations (Pampanin and Sydnes, 2013). Pyrogenic PAHs arise from the incomplete combustion of organic matter commonly produced by fires, internal combustion engines, and furnaces. Following dispersal via long-distance mechanisms, these pyrogenic PAHs can reach waters and sediments of relatively remote areas. PAHs analyzed from EBS sediment samples include 16 USEPA priority pollutants. PAHs are a component of the TPH value.

Hydrocarbons were analyzed further to determine predominant source for PAHs using the Fossil Fuel Pollution Index (FFPI) to estimate the ratio of petrogenic sourced PAHs relative to total PAHs (Boehm and Farrington, 1984). The FFPI is based on the knowledge that combustion-derived (pyrogenic) PAH assemblages are enriched in three- to five-ringed PAH compounds while fossil fuels (petrogenic) are enriched in polynuclear organosulfur compounds (e.g., dibenzothiophene) and two- to three-ringed PAH assemblages (Steinhauer and Boehm, 1992). The FFPI is calculated by the following equation (Boehm and Farrington, 1984):

$$\frac{\left[\Sigma\ naphthalenes(C_o - C_4) + \Sigma\ dibenzothiophenes(C_o - C_3) + \frac{1}{2}\Sigma\ phenanthrenes(C_o - C_1) + + \Sigma\ phenanthrenes(C_2 - C_4)\right]}{\Sigma\ PAH}$$

An FFPI ratio of 0 to 0.25 indicates PAH assemblages dominated by pyrogenic sources, a ratio of approximately 0.25 to 0.49 is indicative of intermediate PAH assemblages containing a mix of pyrogenic and petrogenic sources, and a ratio of 0.5 to 1.0 is indicative of PAH assemblages dominated by petrogenic sources (Boehm and Farrington, 1984). The FFPI ratio for sediments from the Hammerhead Development EBS study area as provided in **Table 8** range from 0.14 to 0.23 indicating that PAHs in sediments are predominantly from pyrogenic sources. This is contrary to the findings of the Liza 2 Field Development EBS (Benthic USA LLC., 2019) that indicated sediment PAHs were predominantly from biogenic sources, rather than pyrogenic.

Table 8. Hydrocarbon concentrations and Fossil Fuel Pollution Index (FFPI) ratio for sediment from the Hammerhead Development Environmental Baseline Survey.

Station	TPH ($\mu g\ g^{-1}$)	PAHs ($ng\ g^{-1}$)	FFPI
HH-1	10	70.0	0.15
HH-2	1,110	319	0.23
HH-2 Duplicate	1,233	319	0.23
HH-3	10	81.2	0.21
HH-4	14	87.4	0.17
HH-5	3	37.2	0.14
HH-6	11	64.9	0.21
HH-7	9	76.4	0.19
HH-8	4	37.9	0.23

PAHs = polycyclic aromatic hydrocarbons; TPH = total petroleum hydrocarbons.

TPH concentrations ranged from 3 to 1,233 $\mu g\ g^{-1}$ and were generally similar among all stations except Station HH-2. TPH concentrations exceeding 1,100 $\mu g\ g^{-1}$ were considerably elevated at Station HH-2 with levels hundredfold over the other EBS stations. A previous study concerning offshore oil and gas drilling impacts revealed near-field sediment with elevated TPH levels consisting of synthetic based fluids and biogenic hydrocarbons, with no indication of the presence of petroleum hydrocarbons (Neff et. al, 2005). The presence of synthetic based fluids in the sediment could be a possible reason for the observed elevated TPH at Station HH-2. The sediment TPH levels were generally elevated as compared to sediments from the Liza 2 Field Development EBS (Benthic USA LLC., 2019) that had extremely low levels, ranging from <1.4 to 2.21 $\mu g\ g^{-1}$. The TPH values, that included both aliphatic and aromatic fractions, had a different basis for this EBS than the Liza 2 Field Development EBS with TPH values that only included the aliphatic fractions (Benthic USA LLC., 2019) and is uncertain to what extent this influences observed differences in TPH values between the EBSs. There are no internationally accepted toxicity reference values for TPH concentrations in marine sediments.

Sixty-four PAHs, including the 16 USEPA priority PAHs, were analyzed in sediment samples that constituted total PAH (**Table 8**). PAH concentrations in sediment ranged from 37.2 to 319 $ng\ g^{-1}$ and like TPH were generally similar among all stations except Station HH-2. Station HH-2 total PAH concentration (319 $ng\ g^{-1}$) was considerably elevated but well below the ERL (4,022 $ng\ g^{-1}$) and ERM (44,702 $ng\ g^{-1}$) values for total PAHs in marine sediment. The sediment total PAH values within the Hammerhead Development EBS study area were elevated relative to the sediments from the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019) that had low total PAH levels, ranging from 17.83 to 22.59 $ng\ g^{-1}$. Concentration of the 16 USEPA priority pollutant PAHs in sediments is presented in **Table 9**. All detectable concentrations of priority pollutant PAHs were below respective ERLs during the EBS. Acenaphthene, fluorene, and naphthalene were considerably elevated at Station HH-2 possibly a result of discharged drilling muds in the sediments (Sanzone et. al., 2016).

Table 9. Concentrations of the sixteen USEPA priority pollutant polycyclic aromatic hydrocarbons (PAH) in sediment during the Hammerhead Development Environmental Baseline Survey. PAH concentrations are compared to respective effects range low (ERL) values (Buchman, 2008).

PAH (ng g^{-1})	Station								ERL (ng g^{-1})
	HH-1	HH-2	HH-3	HH-4	HH-5	HH-6	HH-7	HH-8	
Acenaphthene	0.059	5.36	0.080	0.081	0.021	0.085	0.073	0.031	16.0
Acenaphthylene	<0.01	<0.2	0.051	<0.01	0.042	0.060	<0.01	0.041	44.0
Anthracene	0.169	<0.6	0.162	0.210	0.077	0.119	0.154	0.075	85.3
Benz(a)anthracene	0.398	0.437	0.305	0.508	0.123	0.221	0.326	0.134	261.0
Benzo(a)pyrene	0.321	0.744	0.226	0.433	0.118	0.217	0.291	0.134	430.0
Benzo(b)fluoranthene	1.25	1.20	1.27	1.33	0.575	1.01	1.24	0.611	--
Benzo(g,h,i)perylene	0.649	0.144	0.548	0.740	0.255	0.427	0.544	0.269	--
Benzo(k,j)fluoranthene	0.432	0.724	0.376	0.465	0.234	0.376	0.417	0.229	--
Chrysene/Triphenylene	1.27	1.68	1.28	1.31	0.613	1.04	1.37	0.663	384.0
Dibenzo(a,h)anthracene	0.426	0.285	0.468	0.360	0.091	0.195	0.298	0.105	63.4
Fluoranthene	0.982	1.28	0.905	1.03	0.512	0.861	0.975	0.552	600.0
Fluorene	0.230	10.9	0.821	0.186	0.309	0.557	0.584	0.284	19.0
Indeno(1,2,3-c,d)pyrene	0.380	0.293	0.062	0.442	0.164	0.277	0.329	0.182	--
Naphthalene	0.756	4.81	0.164	0.475	0.378	0.375	0.409	0.439	160.0
Phenanthrene	1.82	3.27	2.27	1.91	1.01	1.84	1.82	1.01	240.0
Pyrene	0.861	1.56	0.740	1.03	0.335	0.581	0.743	0.379	665.0

-- = not applicable.

5.1.5 Metals

Metal analytes include potential contaminants associated with offshore oil and gas activities, priority pollutants, and primary mineralogical indicators. Barite [barium sulfate ($BaSO_4$)] is a common weighting agent for all types of drilling fluids used in the oil and gas industry. Subsequently, Ba is an important tracer of drilling fluids that may be discharged during offshore drilling activities. Compared with marine sediments, commercial drilling mud barites may contain elevated concentrations of several metals, including As, Cd, Cu, Hg, and Pb. These metals, in addition to Cr, Ni, and Zn, are all priority pollutants (USEPA, 2014). V is found in relatively low concentrations in drill muds and certain crude oils. Al and Fe are useful in interpreting metals concentrations because they are good indicators of the sediment mineral type.

Total metal concentrations for sediment samples at each station during the Hammerhead Development EBS are presented in **Table10**. The respective USEPA ERL and ERM guideline values are also provided for metals, where available. Total Se and Ag concentrations were below the analytical laboratory's reporting limit of 8 mg kg^{-1} and 0.16 mg kg^{-1}, respectively; therefore, the analytical results for these sediment analytes will not be discussed further.

There were some notable elevated levels of metals at some stations. In particular, the levels of barium were extremely elevated at Station HH-2 and elevated to lesser extents at Stations HH-3 and HH-1. Barium in sediment samples from Stations HH-1, HH-2, and HH-3 (**Table 10**) with concentrations greater than 1,000 ppm (mg kg^{-1}) may be indicative of drilling activities with discharge of drilling muds (Neff, 2002; Neff et al., 2005). When compared to benchmarks, arsenic and nickel concentrations exceeded the ERL at 6 of 8 stations. Neither arsenic nor nickel concentrations, exceeded the ERM. All other metals concentrations for the survey were below their respective ERL benchmarks, where applicable.

Observed variability of metals concentrations within the EBS study area are likely a function of sediment grain size, organic carbon content, and mineralogy. Additionally, regional drilling activities may have influenced some potential barite-associated metal analytes. Highest concentrations of As, Cd, Cu, Pb, and V were observed at Station HH-2 that had the highest levels of Ba and appears to be the result of drill mud deposition. The sediment metal concentrations within the Hammerhead Development EBS study area were generally comparable to the sediments from the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019) with the exceptions of Al, Ba, Se, and V. Selenium had much lower concentrations (less than half) while Al, Ba, and V had much higher concentrations than observed in the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019).

Of particular concern was the approximate sevenfold increase in the mean Al concentration between this EBS (7.24%) and the 2018 Liza 2 Field Development EBS (1.15%) (Benthic USA LLC., 2019). An interlaboratory analytical calibration was conducted to validate the calculated Al concentrations for the Hammerhead Development EBS sediment samples with results confirming there is regional elevation in sediment Al concentrations as based on the findings of this EBS. There is variability in the observed sediment Al concentrations ranging from 3.85% to 8.46% (**Table 10**) during this EBS that well exceeds the Al concentration range of 1.04% to 1.27% observed during the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019). The observed Al concentration during this Hammerhead Development EBS are most expected for deep water clay sediments (Turekian and Wedepohl, 1961, Salomons and Förstner, 1984, Wedepohl, 1995). The sources for the stark differences between this EBS and the 2018 EBS sediment Al concentrations are uncertain but could be influenced by analytical laboratories and associated methods between surveys, natural influx of aluminosilicate terrigenous sediments, and/or anthropogenic activities.

Al, useful in interpreting sediment metals concentrations, should have a concentration that correlates linearly with other metals concentrations when there is no anthropogenic influence (Trefry et al., 2003, 2013). To determine whether observed metal concentrations are regionally anomalous, regression analysis was conducted correlating sediment percent Al with other metals concentrations to assess the potential for influence by anthropogenic inputs. The positions of regression plots were based on a probability distribution relative to the 99% prediction interval; there is less than 1% probability that plots inside the prediction interval are due to chance. Subsequently, metal concentrations plotted outside the prediction interval could be considered anomalous in comparison with expected natural variation for specific metals. The prediction interval range is a function of the number of samples.

The Hammerhead Development EBS sediment sampling size (i.e. number of stations) is considered sufficient for this type of regression analysis to provide a relatively high degree of certainty; any outliers, beyond the 99% prediction interval would be considered anomalous. Due to the apparent contamination from regional drilling activities, the exceedingly high Ba concentrations from HH-1, HH-2, and HH-3 were removed before calculating the linear regression and 99% prediction intervals. This removal left only five data points for the Ba regression, a very low sample size for the analysis, but the resulting prediction limits will be sensitive to abnormally high barium concentrations in any future regional sampling efforts (**Figure 4**). The regression plots show that all metal concentrations when plotted in correlation with sediment percent Al were within the 99% prediction interval; therefore, the regression analyses indicate EBS metal concentrations are considered regionally ambient and establish baseline conditions specific to these sediment metal analytes. Two representative plots are provided in **Figures 4** and **5**; all regression plots are included in **Appendix C**.

Table 10. Metals concentrations (mg kg^{-1} unless otherwise noted) in sediment collected during the Hammerhead Development Environmental Baseline Survey. Concentrations are compared to effects range low (ERL) and effects range median (ERM) (Long and Morgan, 1990). Total selenium (Se) and silver (Ag) concentrations were below the analytical laboratory's reporting limit of 8 mg kg^{-1} and 0.16 mg kg^{-1}, respectively; results are not presented for these metals. Concentrations in red are in exceedance of the ERL.

Station	Metal Analytes																		
	Al %	As	Ba	Be	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Sr	Tl	Sn	V	Zn
HH-1	8.37	9.5	1,260	1.97	<0.16	48.9	10.7	17.8	37,600	19.8	708	0.0502	1.16	34.1	396	0.72	2.73	94.2	84.1
HH-1 Dup	8.31	9.2	1,350	1.93	<0.16	49.9	10.3	16.9	37,900	20.1	699	0.0286	1.27	33.4	400	0.73	2.70	96.4	89.3
HH-2	8.14	11.5	16,200	1.91	0.18	51.5	10.3	22.0	38,100	29.5	455	0.0498	1.58	30.5	659	0.74	2.82	100.0	114.0
HH-3	8.17	10.7	3,100	1.95	<0.16	49.2	11.6	18.2	37,900	20.7	906	0.0457	1.62	35.8	429	0.75	2.67	95.1	88.9
HH-4	8.46	9.2	451	2.03	0.16	52.1	10.5	16.9	39,000	21.2	766	0.0375	1.64	34.3	348	0.78	2.85	95.9	89.1
HH-5	3.85	7.5	250	0.24	<0.16	18.4	5.8	10.6	19,200	9.6	313	0.0315	0.5	15.5	583	0.39	1.35	51.6	43.2
HH-6	6.86	8.5	374	1.11	0.15	34.4	9.2	17.5	31,400	16.9	484	0.0543	0.76	27.2	565	0.63	2.29	82.8	71.0
HH-7	8.13	11.1	486	1.92	0.15	46.4	10.8	19.0	37,300	21.8	782	0.0622	1.25	35.8	422	0.80	2.94	100.0	95.5
HH-8	4.86	7.6	322	0.47	<0.16	19.1	6.5	13.2	23,700	11.3	357	0.0375	0.55	17.9	603	0.45	1.67	62.7	50.7
ERL	--	8.2	--	--	1.2	81	--	34	--	46.7	--	0.15	--	20.9	--	--	--	--	150
ERM	--	70	--	--	9.6	370	--	270	--	218	--	0.71	--	51.6	--	--	--	--	410

-- = not applicable; Al = aluminum; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; Mn = manganese; Mo = molybdenum; Ni = nickel; Pb = lead; Sn = tin; Sr = strontium; Tl = thallium; V = vanadium; Zn = zinc.

Buchman MF. 2008. Screening quick reference tables. NOAA OR&R Report 08-1. NOAA, Office of Response and Restoration, Seattle, WA. 34 pp.

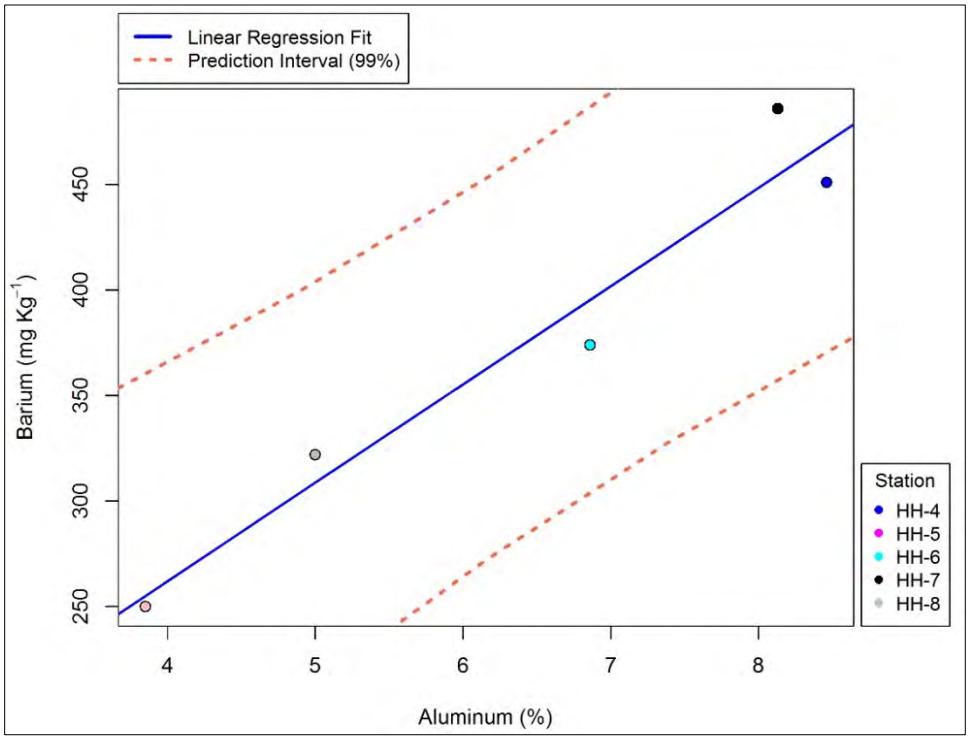

Figure 4. Representative linear regression for relationship between sediment percent aluminum and concentrations of barium.

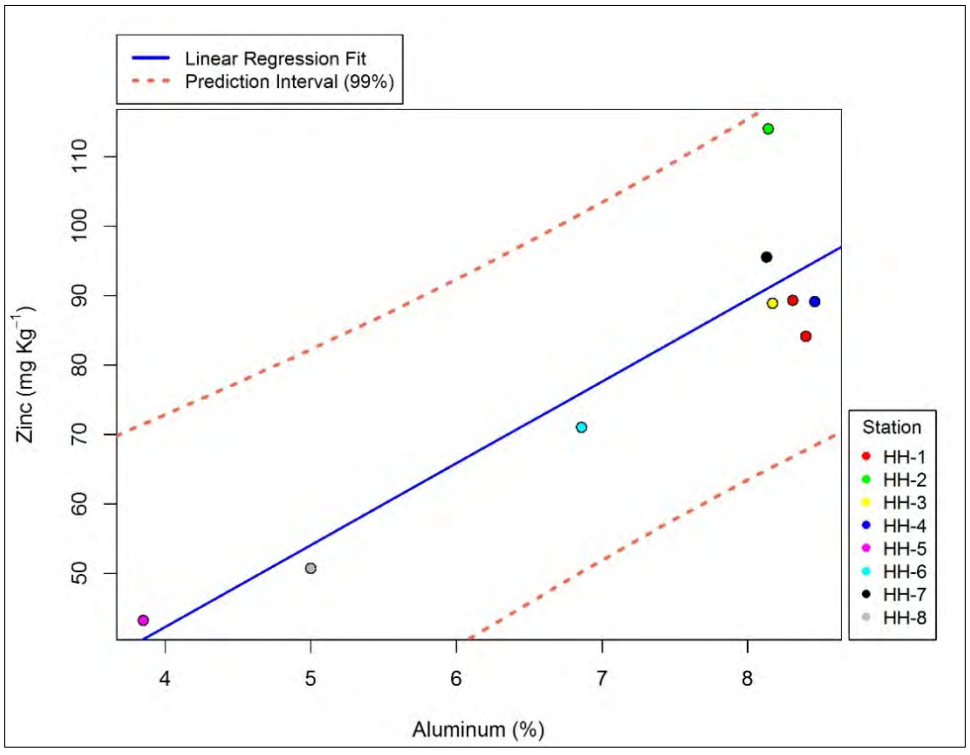

Figure 5. Representative linear regression for relationship between sediment percent aluminum and concentrations of zinc.

5.1.6 Macroinfauna

The 8 box core samples collected from the survey area yielded 204 individuals and 37 total taxa from eight phyla; the arthropod *Lucifer* sp., was removed prior to analyses as this taxon is a water column dweller not infauna. The distribution of abundance and taxa among these phyla are shown in **Figures 6** and **8**, respectively. Most of the individuals (60.3%) were contributed by the annelids followed by arthropods (19.6%), and nematodes (17.2%). Annelids were also represented by the most infaunal taxa (24) followed by arthropods (6), and echinoderms (2). The phyla Sipunculida, Nematoda, Nemertea, Mollusca, and Chordata, were each represented by a single taxon (**Figure 7**).

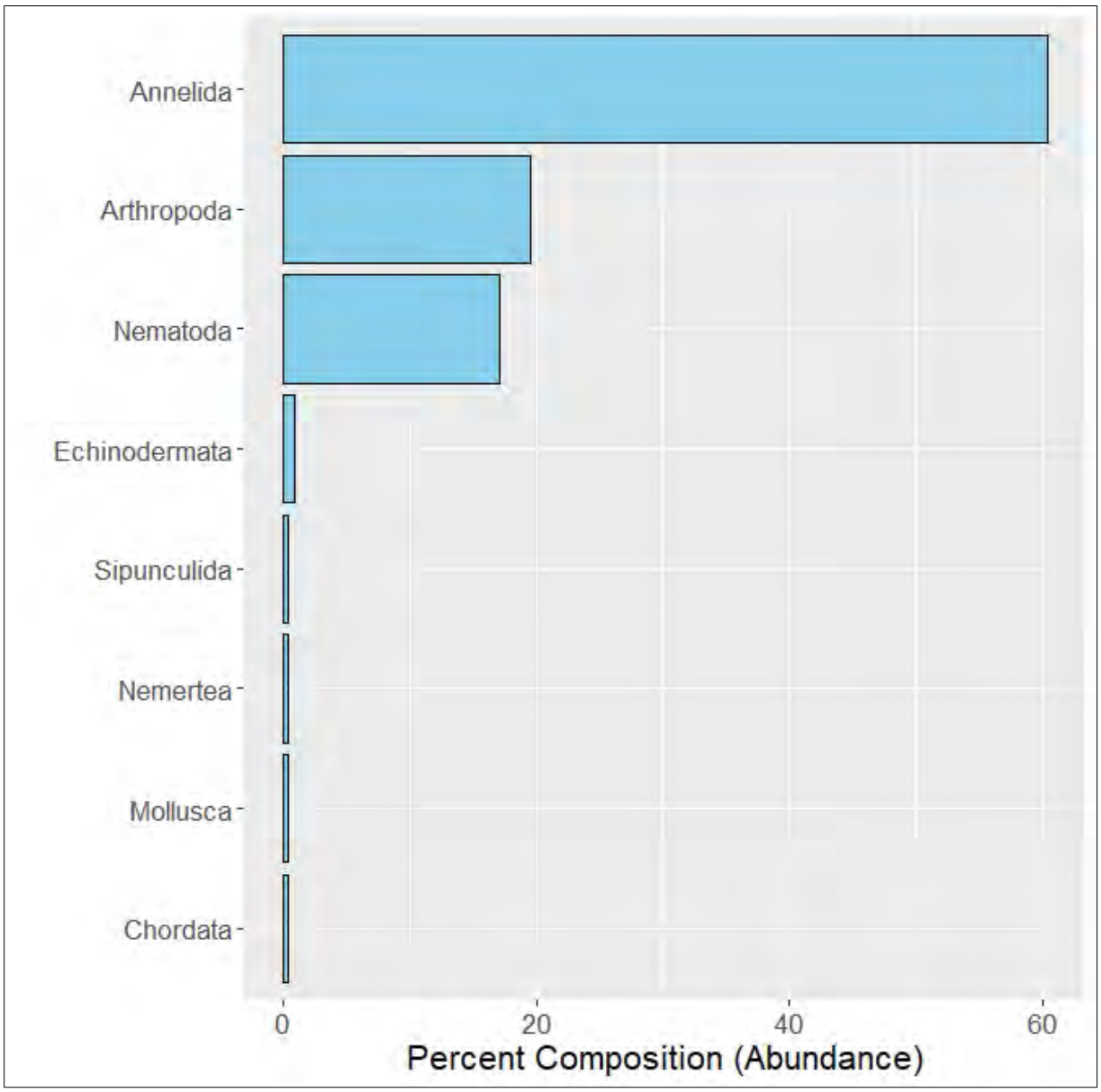

Figure 6. Percent composition of infauna individual organisms for each phylum collected during the Hammerhead Development Environmental Baseline Survey.

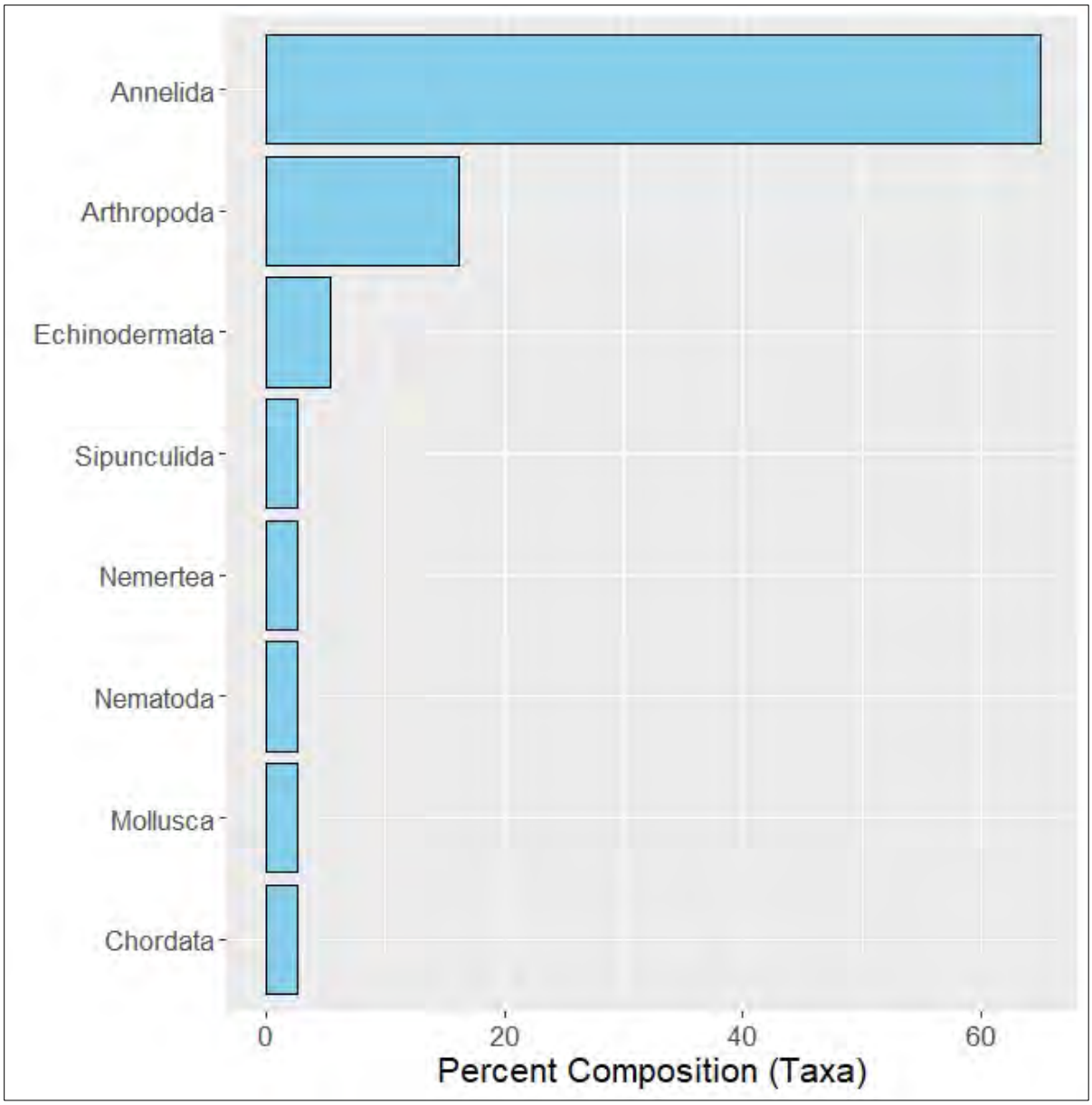

Figure 7. Percent composition of infauna taxa for each phylum collected during the Hammerhead Development Environmental Baseline Survey.

The overall infauna density ranged from 98.0 to 359.2 individuals per m^2 with a mean of 208.2 ± 79.3 individuals per m^2 across all stations (**Table 11**). Total numbers of taxa and individuals from each station are shown in **Figure 8** and presented in **Table 11**. Number of taxa, abundance, and density recorded from station HH-5 were higher than values observed at other stations.

The diversity indices indicated that the assemblage has generally low species richness (d) and diversity (H') but high evenness (J) **Table 11**. The species richness values ranged from 2.8 to 4.5 and diversity ranged from 1.98 to 2.49. Evenness measured with Pielou's J was high across all stations ranging from 0.86 to 0.95 indicating similar relative abundances among taxa and correspondingly low numerical dominance.

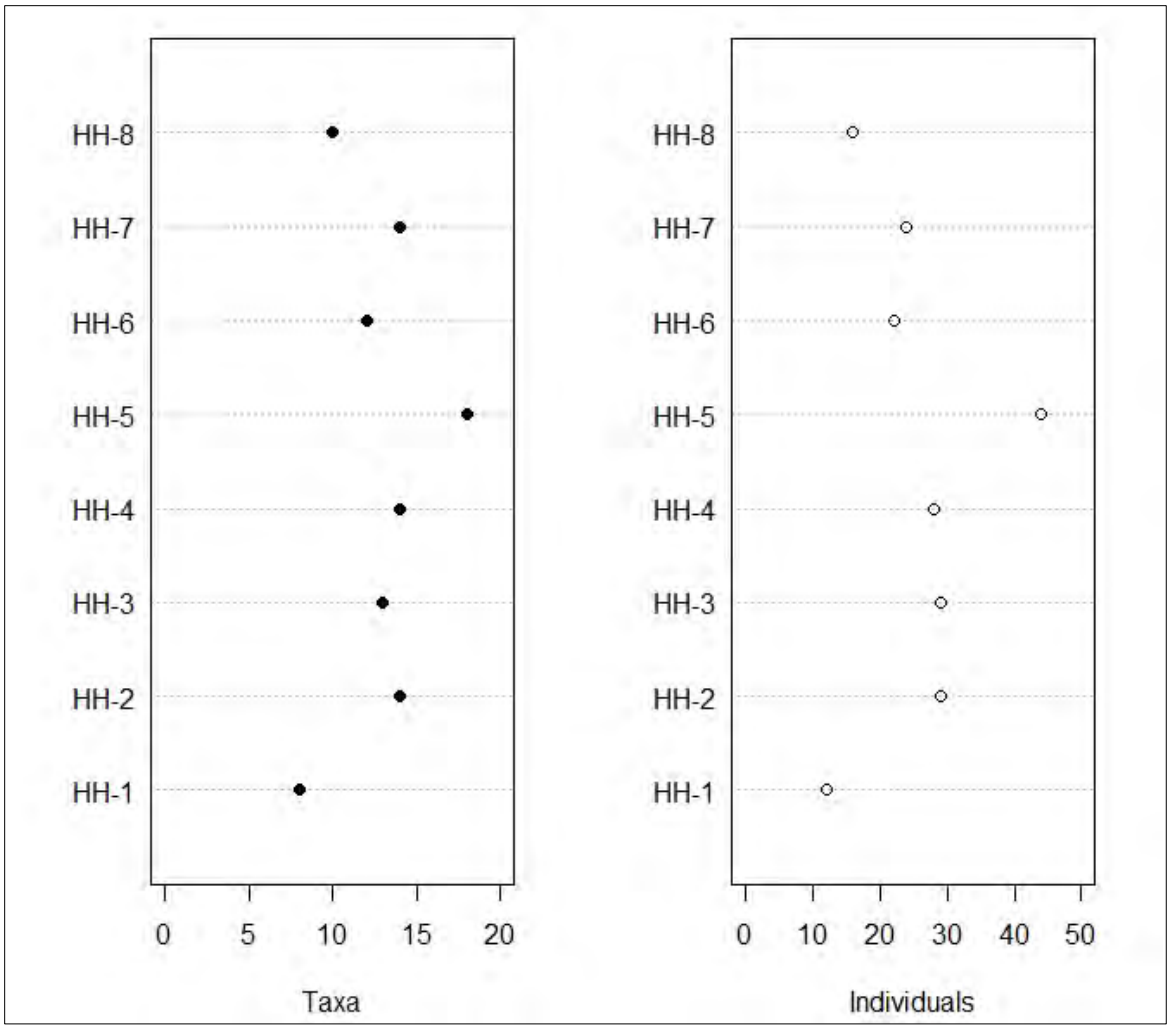

Figure 8. Number of taxa and total number of individuals collected during the Hammerhead Development Environmental Baseline Survey.

Table 11. Total taxa (S), number of individuals (N), density (N m^{-2}), species richness (d), evenness (J'), and diversity (H') calculated for infauna samples of the Hammerhead Development Environmental Baseline Survey.

Station	S	N	N m^{-2}	d	J'	H'
HH-1	8	12	98.0	2.817	0.952	1.979
HH-2	14	29	236.7	3.861	0.915	2.414
HH-3	13	29	236.7	3.564	0.931	2.387
HH-4	14	28	228.6	3.901	0.926	2.444
HH-5	18	44	359.2	4.492	0.862	2.492
HH-6	12	22	179.6	3.559	0.946	2.350
HH-7	14	24	195.9	4.091	0.893	2.358
HH-8	10	16	130.6	3.246	0.910	2.096
Mean	12.9	25.5	208.2	3.691	0.917	2.315

The ten most abundant taxa identified are shown in **Table 12**. These taxa collectively account for 68% of the abundance recorded during the EBS. Numerically dominant taxa include six polychaete annelids, three arthropods, and one nematode. The most abundant taxa, Nematode sp. a., *Glycera* sp. a, and *Capitella* sp. a., accounted for 17.2%, 9.3%, and 8.3% of the 204 individuals collected, respectively.

Table 12. The ten most abundant infaunal taxa collected during the Hammerhead Development Environmental Baseline Survey.

Phylum	Taxon	Occurrence (Number of Stations)	Numbers of Individuals	Density (m^2)	Percent Abundance
Nematoda	Nematode sp. a	7	35	35.7	17.2
Annelida	*Glycera* sp. a	6	19	19.4	9.3
Annelida	*Capitella* sp. a	5	17	17.3	8.3
Arthropoda	*Ampelisica* sp. a	8	15	15.3	7.4
Annelida	Spionid sp.a	5	11	11.2	5.4
Arthropoda	*Idotea* sp. a	5	10	10.2	4.9
Annelida	*Notomastus* sp. a	5	10	10.2	4.9
Annelida	*Magelona* sp.a	4	8	8.2	3.9
Annelida	*Cirratulus* sp. a	6	7	7.1	3.4
Arthropoda	*Gnathia* sp. a	3	7	7.1	3.4

The infauna assemblage was investigated using multivariate analyses to assess any patterns in taxonomic similarity among samples. To help objectively identify any discrete groups of stations or taxa, the stations-by-taxa data table was ordered based on cluster analyses of stations and taxa respectively (**Figure 9**); taxa include all 37 individual identified taxa. The cluster analysis of stations, with all stations having a similarity of around 40% or more, did not show any patterns of aggregation of taxa across the samples. However, the analysis did indicate some subtle compositional differences at stations HH-5 and HH-2. Station HH-5 was the only station with *Capitella capitata*, *Corbula aequivalvus*, *Diastylis* sp. a, and *Eunice* sp. a. while *Diplocirrus* sp. a., *Grubeulepis* sp. a, and *Gyptis* sp. a, were only collected at station HH-2. The SIMPROF test (p=0.32) supported the observation of no discrete groupings by showing that all samples formed a statistically similar group based on taxonomic composition at the level of the EBS study area. Like the cluster analysis, the MDS ordination plot does not reveal any discrete groups of samples that would indicate spatial aggregation or other assemblage patterns (**Figure 10**).

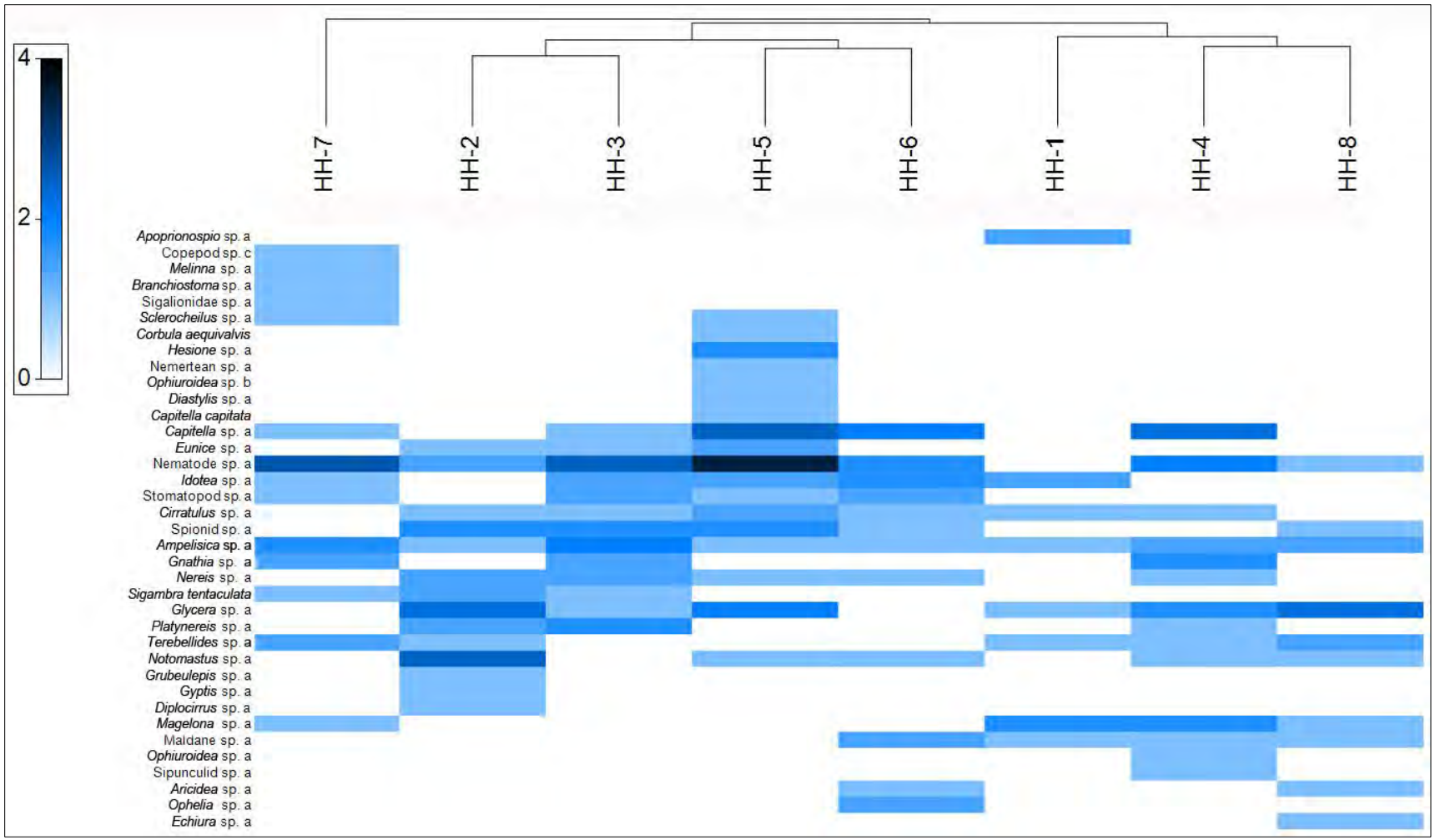

Figure 9. Two-way cluster analysis based on sample similarity (top) and the 37 individual identified taxa (side) from the study area infauna assemblage. The gray lines in the sample dendrogram indicate samples within a statistically defined group according to a SIMPROF test. The blue scale shows square root transformed abundance values for the listed taxa.

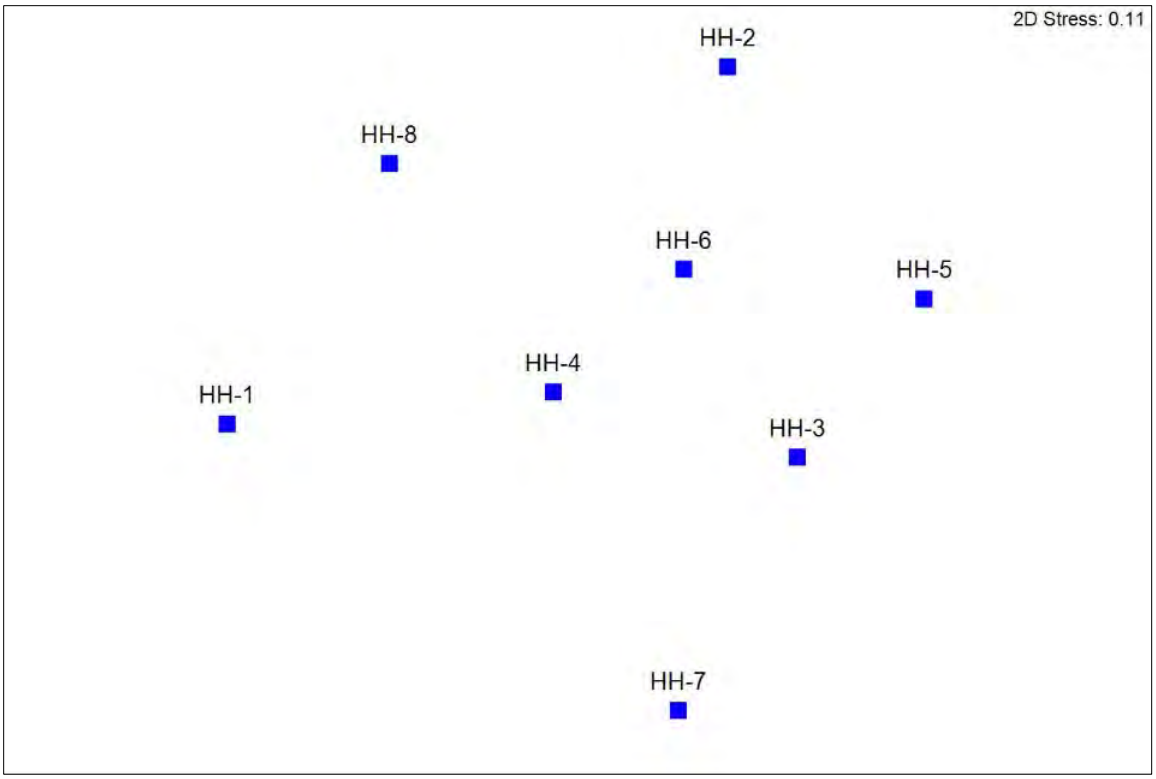

Figure 10. Multidimensional scaling (MDS) ordination of samples by similarity in taxonomic composition for infauna collected during the Hammerhead Development Environmental Baseline Survey. The MDS ordination does not reveal any discrete groups of samples that would indicate spatial aggregation or other assemblage patterns.

The infauna assemblage characterized by the samples collected in the EBS study area consisted mostly of polychaete annelids, arthropods, and nematodes which was similar to the assemblage described from the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019). Community-wide measures of density (average 208 m^{-2}) and abundance were generally low when compared with other deep-sea areas in similar water depths (e.g., Grassle and Maciolek, 1992; Oliver et al., 2011) and lower than the average infauna density of 359 individuals m^{-2} from the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019). Measures of diversity including total taxa, species richness, and species diversity were also low relative to other areas. Evenness (J) was high across stations largely due to the low abundances of individuals at each of the stations, the divisor in the J calculation. High evenness is a characteristic of deep-sea infauna assemblages in many areas (Grassle and Maciolek, 1992). High evenness corresponds with low numerical dominance which was observed with the present data set; the most abundant taxon, a nematode, accounted for 17.2% of the individuals collected during the EBS. It appears that the assemblage sampled within the EBS study area is a small part of a larger, relatively homogenous sedimentary environment with broad-scale influences such as low input of organic matter and similar sediment grain size distribution. The low diversity and abundance may be due to the very small seafloor sampling area (e.g., Oliver et al, 2011). Obvious species-level patterns were not evident from multivariate analyses, and no outlying groups of samples with similar taxonomic composition and proportional abundances were found in either cluster analysis or MDS. The assemblage properties of the infauna described from the eight stations will provide an adequate baseline from which to evaluate potential impacts of activities within the study area.

5.2 SEAWATER

5.2.1 Hydrographic Profiles

Hydrographic profiles were collected for conductivity/salinity, temperature, DO, turbidity, and pH. **Table 12** provides the minimum and maximum recorded values for hydrographic parameters at all stations. **Figures 11** and **12** provide representative hydrographic profiles of the study area (Station HH-7 based on being an intermediary between the shallowest and deepest stations). **Appendix D** contains all hydrographic profile plots for the Hammerhead Development EBS. Overall, hydrographic data at all EBS stations appeared typical of the offshore open ocean environment for the region.

Table 12. Minimum, maximum, and mean values for all hydrographic profile parameters at seawater sampling stations during the Hammerhead Development Environmental Baseline Survey.

Station	Data	Temperature (°C)	Salinity (PSU)	Dissolved Oxygen		pH	Turbidity (NTU)
				(mg L^{-1})	(%)		
HH-1	Min	5.15	34.58	3.94	41.68	8.15	0.20
	Max	27.73	37.08	6.80	104.91	8.66	0.58
	Mean	10.28	35.13	4.75	53.67	8.27	0.26
HH-2	Min	5.00	34.59	3.92	41.46	8.07	0.21
	Max	27.74	37.20	6.79	104.83	8.68	0.37
	Mean	9.47	35.08	4.86	53.73	8.29	0.25
HH-3	Min	4.99	34.58	3.90	41.37	8.33	0.20
	Max	27.85	37.07	6.80	105.05	8.73	0.57
	Mean	9.57	35.06	4.84	53.69	8.42	0.24
HH-4	Min	5.31	34.54	3.94	42.00	8.19	0.21
	Max	27.72	37.18	6.81	105.10	8.70	1.26
	Mean	11.22	35.17	4.61	53.59	8.34	0.26
HH-5	Min	4.23	34.60	3.91	40.78	8.31	0.19
	Max	28.03	37.00	8.37	105.25	8.74	0.36
	Mean	8.29	35.03	5.55	58.97	8.41	0.25
HH-6	Min	4.43	34.58	3.94	41.41	8.31	0.19
	Max	28.19	36.97	8.15	105.49	8.76	0.99
	Mean	8.60	35.01	5.40	58.05	8.42	0.24
HH-7	Min	4.92	34.60	3.90	41.27	8.27	0.08
	Max	27.95	36.97	7.40	105.48	8.74	0.41
	Mean	9.28	35.07	4.94	54.25	8.36	0.25
HH-8	Min	4.07	34.59	3.94	41.73	8.15	0.19
	Max	28.07	36.81	8.47	105.43	9.62	2.46
	Mean	8.13	35.04	5.77	61.02	8.51	0.24
Overall	Min	4.07	34.54	3.90	40.78	8.07	0.08
	Max	28.19	37.20	8.47	105.49	9.62	2.46
	Mean	9.16	35.06	5.17	56.41	8.40	0.25

NTU = nephelometric turbidity unit; PSU = practical salinity unit.

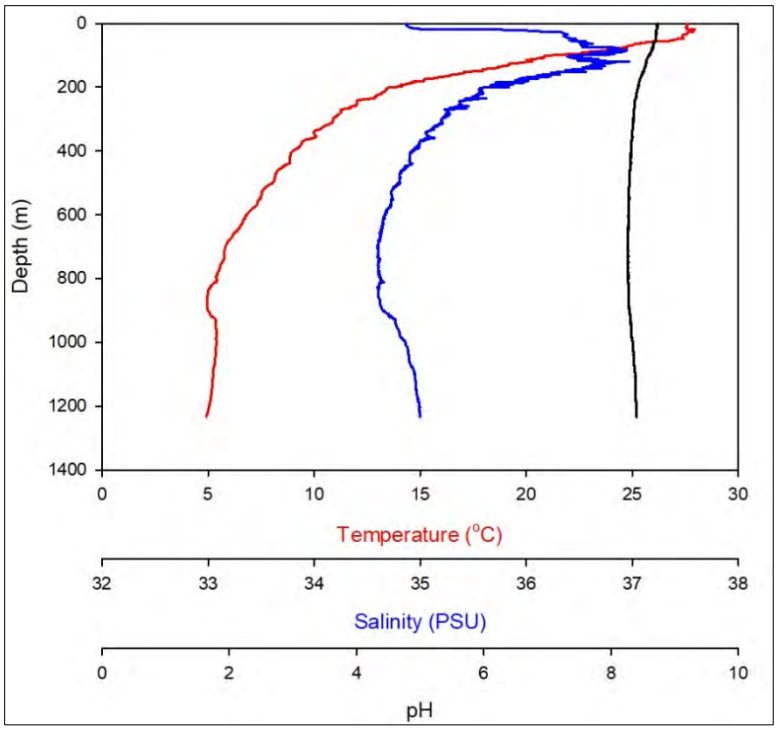

Figure 11. Representative water column profile for temperature, salinity, and pH from Station HH-7 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

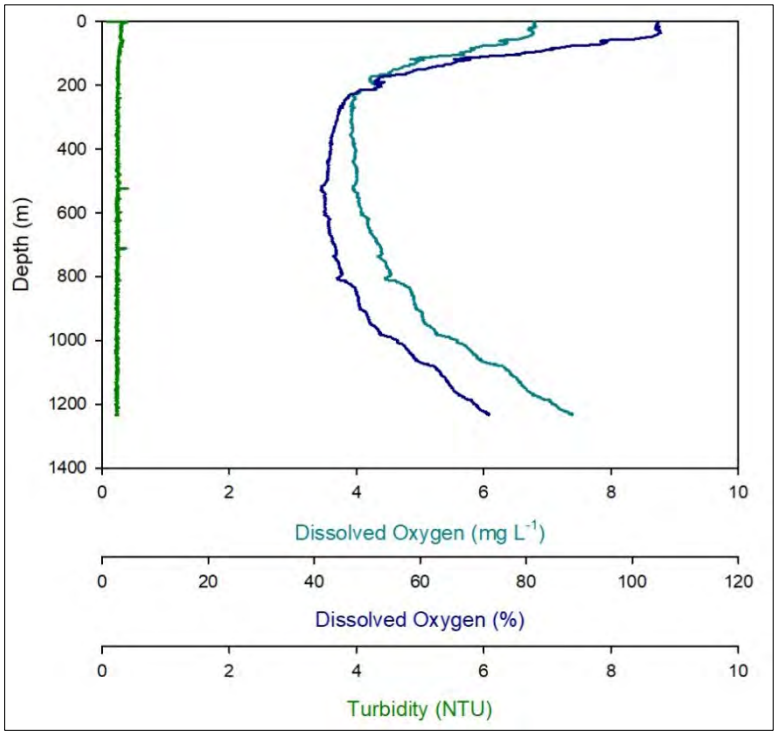

Figure 12 Representative water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-7 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

Seawater temperature ranged from 4.07°C to 28.19°C during the survey and had a similar trend at each station. Temperature changed very little in the upper 60 to 70 m of the water column. In this layer, as temperature decreased salinity increased which is expected in this well mixed layer. The top of the thermocline was observed below the well-mixed surface portion of the water column at approximately 70 m, seawater temperature continued to decrease with the lowest temperatures recorded at maximum depth for all stations. The steep decrease in water temperature from 70 m to about 200 m, with a temperature differential of approximately 15°C, coincides with the pycnocline separating the warmer, low-density surface waters and the colder, denser bottom of the water column.

Salinity ranged from 34.54 to 37.20 practical salinity units (PSU) during the survey with similar trends at each station. There was a distinctive surface lens of low salinity water above the high salinity layer with maximum of about 37 PSU that delineated the halocline depth at about 170 m. This salinity surface profile is most probably an artifact of low rain with lots of evaporation and movement of higher salinity and denser seawater within the upper water column as defined by the pycnocline. The lowest salinity values were measured at approximately 800 m depth of the water column for all stations. The salinity profile was relatively stable below 400 m.

The pH was generally stable throughout the water column ranging from 8.07 to 9.62. The average pH for open ocean seawater is around 8.2 with a generally extended range of 7.5 to 8.5 depending on local conditions (https://sfyl.ifas.ufl.edu/media/sfylifasufledu/miami-dade/documents/sea-grant/Temperature,-Salinity-and-pH.pdf, viewed 5-7-2020). It would not be expected to observe a pH well outside this typical pH range in the open ocean possibly with the exception of the presence of a localized point source. Therefore, it is thought there was a sensor glitch during the pH profile at Station HH-8 that accounted for an anomalously high near-bottom pH (**Appendix D**). Turbidity was low at all stations with an overall mean of 0.25 nephelometric turbidity units (NTU) during the survey.

DO concentration ranged from 3.90 to 8.47 mg L^{-1} during the survey and DO saturation ranged from 40.78% to 105.49%. As would be expected, the DO concentration and saturation profiles essentially mirror each other within the water column. The upper threshold of hypoxic conditions typically ranges from 2 to 5 mg L^{-1} (Gobler and Baumann, 2016) depending on the taxonomic grouping. Profiles show high DO levels in the upper 50-m depth layer coinciding with the well-mixed upper portion of the photic zone and at depths below approximately 1,000 m. The DO profiles reflect water column processes of primary productivity, respiration and mineralization. Typically, DO levels are highest at the near-surface where sunlight allows the highest rates of primary production (resulting in oxygen evolution). DO is greatest not at the surface of profiles but just below the water surface between 0 to 150 m due to the actinic effects of sunlight on photosynthesis. DO levels are lowest in the 200 to 800 m portion of the water column. In this layer, decreasing light availability depresses primary productivity and there is mineralization of organic matter which results in lower DO levels associated with oxygen consumption. Below approximately 800 m, DO levels increase from less than 5 to about 8 mg L^{-1} due to reduced microbial respiration in this layer and the physical properties of the water related to temperature and pressure. Similar trends can be observed along deepwater profiles obtained from the California Borderland where DO generally decreased up to depth of 700 m and then increased at 1,000 m (Torres et al., 2012). The general DO profiles were similar to those reported by 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019).

5.2.2 Total Organic Carbon

TOC in seawater could be used as an indicator for biological productivity, organic loading, and petroleum pollution. A study demonstrated TOC concentrations showed significant positive correlation with petroleum hydrocarbons in seawater (Emara, 1998). TOC concentrations were very low at all EBS stations and was detectable in the surface water at Station HH-1 with a level of 0.3 mg L^{-1}; all other

sampling locations were below the detection limit of 0.2 mg L^{-1}.These low TOC levels are similar to the concentrations of ≤1.2 mg L^{-1} for the Liza 2 Field Development (Benthic USA LLC., 2019). There are no internationally accepted toxicity reference values for TOC concentrations in seawater.

5.2.3 Total Suspended Solids

Concentrations of TSS in the water column at seawater sampling stations during the Hammerhead Development EBS are presented in **Table 13**. TSS is a water quality measure specific to understanding the level of particulate matter in the water column and are predominantly comprised of inorganic materials (e.g. sediment fine fractions). Deepwater open ocean TSS is expected to be low with occasional solids from organic sources such as water column planktors and decomposing materials. Deepsea near-bottom water generally has low TSS levels due to few disturbances that stir up the sediment on the seafloor. TSS levels were low in the EBS study area with most samples below the analytical laboratory reporting limits of 5 mg L^{-1}. These low TSS levels corroborate the reported low turbidity levels where turbidity is a visual property of the water quality that is affected by TSS.

Table 13. Concentrations of total suspended solids (TSS) in the water column at seawater sampling stations during the Hammerhead Development Environmental Baseline Survey. Bolded numbers display detected concentrations.

Station	Depth Strata	TSS (mg L^{-1})
HH-1	Near-surface	<5
	Mid-water	**7.5**
	Near-bottom	<5
HH-2	Near-surface	<5
	Mid-water	<5
	Near-bottom	<5
HH-3	Near-surface	<5
	Mid-water	**25**
	Near-bottom	<5
HH-4	Near-surface	<5
	Mid-water	**6.5**
	Near-bottom	<5
HH-5	Near-surface	<5
	Mid-water	<5
	Near-bottom	**5**
HH-6	Near-surface	**6.5**
	Mid-water	<5
	Near-bottom	<5
HH-7	Near-surface	**23.5**
	Mid-depth	<5
	Near-bottom	<5
HH-8	Near-surface	<5
	Mid-water	<5
	Near-bottom	<5

5.2.4 Hydrocarbons

Concentrations of TPH and PAHs were measured to generally assess the presence of petroleum-related contamination in the water column. Concentrations of hydrocarbons in the water column of the EBS study were very low with TPH levels at all sampling stations and depths being below the analytical detection limit of 13 µg L^{-1}. These results for TPH were the same as for the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019) with a similar TPH analytical detection limit. There is no internationally accepted toxicity reference value for TPH in seawater.

Similar to sediments, sixty-four PAHs, including the 16 USEPA priority PAHs, were analyzed in the seawater samples that constituted total PAH. Concentration of total PAH and the detectable USEPA priority pollutant PAHs in seawater are presented in **Table 14**; the respective CCC toxicity reference values (Buchman, 2008) are provided for individual PAHs, where available. PAH concentrations in seawater ranged from 0 to 24.1 ng L^{-1}. Highest total PAH concentration was observed in the surface waters at Station HH-2 that has sediments characterized by highly elevated TPH and PAHs levels. All PAH levels were well below CCC values, when applicable, indicating PAHs present in the water column do not represent a hazard to marine organisms and the general offshore marine ecosystem. There is no internationally accepted toxicity reference value for total PAHs in seawater.

Table 14. Concentration (ng L^{-1}) of total polycyclic aromatic hydrocarbons (PAHs) and the detectable United States Environmental Protection Agency priority pollutant PAHs with comparisons to Criterion Continuous Concentration (CCC) toxicity reference values (as available) in seawater at sampling stations during the Hammerhead Development Environmental Baseline Survey. **Bold** numbers display detected concentrations.

Station	Depth Strata	Acenaphthylene	Anthracene	Benzo(b)fluoranthene	Benzo(k,j)fluoranthene	Benzo(g,h,i)perylene	Benzo(a)pyrene	Fluoranthene	Naphthalene	Phenanthrene	Pyrene	Total PAHs
HH-1	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**2.05**	**2.75**	**2.67**	**3.51**	**12.8**
	Mid-water	**0.85**	<0.8	**1.26**	**1.44**	**1.08**	**1.11**	<1.1	**2.70**	**1.78**	<1.4	**15.5**
	Mid-water Dup	<1.2	<0.8	**1.06**	**1.11**	<2.5	<1.9	<1.1	<2.9	**2.48**	<1.4	**5.78**
	Near-bottom	<1.2	<0.8	**1.03**	**0.84**	<2.6	<2	<1.1	**2.31**	**1.44**	<1.4	**7.37**
HH-2	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**3.67**	**4.71**	**3.73**	**7.23**	**24.1**
	Mid-water	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**0.568**	**2.96**	**2.82**	**1.19**	**9.93**
	Near-bottom	<1.2	**1.37**	<2.4	<2.5	<2.5	<1.9	<1.1	<2.9	**1.52**	<1.4	**2.89**
HH-3	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**2.43**	**4.45**	**3.25**	**4.10**	**17.8**
	Mid-water	<1.2	<0.8	<2.4	<2.6	<2.6	<2	<1.1	<3	**1.99**	<1.4	**1.99**
	Near-bottom	<1.2	<0.8	<2.5	<2.6	<2.6	<2	**1.32**	**2.90**	**2.51**	**2.13**	**11.6**
HH-4	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**2.38**	**3.87**	**3.07**	**4.34**	**13.7**
	Mid-water	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	**2.82**	<2.3	<1.4	**4.88**
	Near-bottom	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	<2.9	<2.3	<1.4	0.0
HH-5	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**3.87**	**5.14**	**3.85**	**7.10**	**23.8**
	Mid-water	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	**2.31**	**1.69**	<1.4	**6.11**
	Near-bottom	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	**1.92**	<2.3	<1.4	**3.07**
HH-6	Near-surface	<1.2	**3.46**	<2.4	<2.5	<2.5	<1.9	**2.91**	**3.92**	**3.48**	**5.14**	**22.6**
	Mid-water	<1.2	**3.30**	<2.4	<2.5	<2.5	<1.9	<1.1	**3.05**	**3.28**	<1.4	**12.3**
	Near-bottom	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	<2.9	<2.3	<1.4	0.0
HH-7	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**2.30**	**3.58**	**3.66**	**3.80**	**16.5**
	Mid-water	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**0.61**	**2.78**	**2.51**	**1.20**	**8.84**
	Near-bottom	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	**1.96**	<2.3	<1.4	**3.05**
HH-8	Near-surface	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	**1.28**	**3.94**	**3.82**	**2.21**	**14.1**
	Mid-water	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	**2.87**	<2.3	<1.4	**2.87**
	Near-bottom	<1.2	<0.8	<2.4	<2.5	<2.5	<1.9	<1.1	<2.9	<2.3	<1.4	0.0
CCC value		-	-	4,600	-	-	-	11,000	-	1,400*	-	-

* = Canadian Water Quality Guidelines as sourced from Buchman (2008).

5.2.5 Metals

Concentration of metals with analytically detectable levels in the water column of the EBS study area are presented in **Table 15**. The respective toxicity reference values (Buchman, 2008) are also provided for metals, where available. Total aluminum and beryllium concentrations were below the analytical laboratory's reporting limit of 21.0 µg L^{-1} and 0.02 µg L^{-1}, respectively. Total metal concentrations within the water column were low with the exception of strontium and molybdenum. Strontium is one of the most abundant minerals in seawater and was at expected high levels of around 8,000 µg L^{-1} (https://www.lenntech.com/periodic/water/strontium/strontium-and-water.htm viewed 5-12-2020). All metal concentrations are reported as lower than the CCC toxicity reference values (Buchman, 2008) with a few exceptions of molybdenum. The levels of molybdenum in the EBS study area water column ranged from 10.3 to 35 µg L^{-1} that is elevated above the expected range in open ocean systems of 9.3 to 10.4 µg L^{-1} (Smedley and Kinniburgh, 2017). The source of the elevated levels of molybdenum are uncertain but could be influenced by regional mining activities (Smedley and Kinniburgh, 2017). Other than these exceptional molybdenum concentration, levels of all metals are relatively consistent throughout the EBS survey area and consistent with results for seawater metals during the 2018 Liza 2 Field Development EBS (Benthic USA LLC., 2019). Concentrations of cadmium, cobalt, iron, manganese, and silver were very low and below method detection limits at most of the EBS sampling stations (**Table 15**).

Table 15. Total metals concentrations with comparisons to Criterion Continuous Concentration (CCC) toxicity reference values (Buchman, 2008) in seawater at sampling stations during the Hammerhead Development Environmental Baseline Survey. Units presented in µg L^{-1} except for mercury (ng L^{-1}). Total aluminum and beryllium concentrations were below the analytical laboratory's reporting limit of 21.0 µg L^{-1} and 0.02 µg L^{-1}, respectively; results are not presented for these metals. Concentrations in red are in exceedance of the CCC.

Station	Depth Strata	Metal Analytes																		
		As	Ba	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sr	Tl	Sn	V	Zn
HH-1	Near-surface	1.26	8	0.009	0.17	<0.007	0.28	<8	0.504	<0.8	0.4	19.4	0.17	0.5	0.011	8,000	0.015	13	2.9	2.01
	Mid-water	1.3	6.5	0.004	0.16	<0.007	0.06	<8	0.184	<0.8	0.19	35	0.15	0.4	0.006	8,430	0.017	9	<1.1	<0.2
	Near-bottom	1.51	8.1	0.042	0.18	0.328	0.11	<8	0.059	<0.8	0.37	15.9	0.43	0.4	<0.004	7,950	0.014	<2	2.3	0.5
HH-2	Near-surface	1.44	6	<0.003	0.16	<0.007	0.08	<8	0.078	<0.8	0.15	13	0.15	0.4	<0.004	8,400	0.012	3	2.9	0.21
	Mid-water	1.2	6.6	<0.003	0.15	<0.007	0.17	21	0.227	<0.8	0.23	11.3	0.14	<0.4	<0.004	8,110	0.013	3	1.5	0.41
	Near-bottom	1.52	7.4	0.035	0.16	0.008	0.1	<8	0.041	<0.8	0.13	10.3	0.29	0.5	<0.004	7,920	0.013	3	2.3	0.36
HH-3	Near-surface	1.29	8.3	<0.003	0.16	<0.007	0.13	<8	0.209	1.4	0.22	10.9	0.16	0.4	<0.004	8,010	0.013	<2	1.7	0.91
	Mid-water	1.46	6.2	0.015	0.15	<0.007	0.07	<8	0.134	<0.8	0.15	10.9	0.2	0.5	<0.004	8,470	0.013	3	1.4	<0.2
	Near-bottom	1.48	6.1	<0.003	0.17	<0.007	0.4	19	0.112	1.8	0.31	11.1	0.17	0.5	<0.004	8,310	0.012	<2	<1.1	0.53
HH-4	Near-surface	1.28	7.8	0.005	0.16	<0.007	0.19	<8	0.181	1.5	0.17	11	0.16	0.4	<0.004	8,340	0.013	2	1.4	0.94
	Mid-water	1.38	7	0.005	0.15	<0.007	0.08	<8	0.101	<0.8	0.11	19.7	0.17	<0.4	0.009	8,060	0.016	12	1.8	0.25
	Near-bottom	1.41	8.5	0.057	0.17	<0.007	0.15	<8	0.086	<0.8	0.32	34.5	0.35	0.6	<0.004	8,000	0.014	9	2	0.49
HH-5	Near-surface	1.24	8	<0.003	0.14	<0.007	0.15	<8	0.156	<0.8	0.16	16.4	0.17	0.5	<0.004	7,710	0.011	2	1.4	0.73
	Mid-water	1.35	6.7	0.008	0.16	<0.007	0.08	9	0.045	<0.8	0.21	14.7	0.19	0.5	<0.004	7,890	0.012	2	2	<0.2
	Near-bottom	1.47	7.5	0.026	0.16	<0.007	0.1	<8	0.064	<0.8	0.22	12.9	0.26	0.5	<0.004	8,070	0.012	<2	2.2	<0.2
HH-6	Near-surface	1.24	7.4	<0.003	0.14	<0.007	0.12	<8	0.107	<0.8	0.16	12.3	0.16	<0.4	<0.004	7,880	0.011	<2	1.3	0.43
	Mid-water	1.45	6.2	<0.003	0.16	<0.007	0.07	<8	0.074	<0.8	0.14	12.3	0.16	<0.4	<0.004	8,420	0.011	3	2.6	<0.2
	Near-bottom	1.5	7.9	0.033	0.16	<0.007	0.09	<8	0.034	<0.8	0.21	11.8	0.3	<0.4	<0.004	7,920	0.012	3	1.1	<0.2
HH-7	Near-surface	1.24	7.2	<0.003	0.14	<0.007	0.12	<8	0.104	<0.8	0.25	12.1	0.17	<0.4	<0.004	7,640	0.012	<2	1.5	0.33
	Mid-water	1.44	7.8	<0.003	0.16	<0.007	0.07	<8	0.102	<0.8	0.11	11.7	0.17	<0.4	<0.004	8,330	0.011	<2	1.5	0.29
	Near-bottom	1.49	8.4	0.033	0.16	<0.007	0.1	<8	0.072	<0.8	0.22	10.4	0.3	0.4	<0.004	7,800	0.013	2	<1.1	0.29
HH-8	Near-surface	1.23	8.8	<0.003	0.16	<0.007	0.16	<8	0.147	<0.8	0.15	11.2	0.16	<0.4	<0.004	7,750	0.012	2	1.2	0.78
	Mid-water	1.44	5.8	<0.003	0.16	<0.007	0.06	<8	0.07	<0.8	0.14	11.7	0.15	<0.4	<0.004	8,090	0.011	4	2	<0.2
	Near-bottom	1.45	7.8	0.026	0.16	<0.007	0.12	<8	0.053	<0.8	0.13	11.3	0.29	<0.4	<0.004	7,920	0.011	2	1.8	0.44
CCC value		36	200*	8.8	--	1**	3.1	50*	8.1	100*	940	23**	8.2	71	--	--	17**	--	50*	81

-- = not applicable; Ag = silver; As = arsenic; Ba = barium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; Mn = manganese; Mo = molybdenum; Ni = nickel; Pb = lead; Se = selenium; Sn = tin; Sr = strontium; Tl = thallium; V = vanadium; Zn = zinc.
* British Columbia Water Quality Guidelines as sourced from Buchman (2008). ** Australia and New Zealand Environmental Concern Levels and Trigger Values as sourced from Buchman (2008).

5.3 BENTHIC HABITATS

Requisite programmatic imagery (i.e., video and still photographic grabs) were provided to Esso as an immediate post-survey deliverable. Representative images of the seafloor benthic habitat are provided to generally characterize the substrates at each of the sampling stations. No fish or invertebrate benthos were observed in the photographic data due primarily to the relatively small overall visual sampling area at each station that was estimated to be about 1 m^2.

All visually documented habitat was soft bottom substrate that supported a relatively depauperate biological assemblage as based on the sampling area viewed from the imagery. Photographic data document the EBS study area is characterized by soft sediments composed primarily of fine silt and clay fractions. Individual images provide small scale characterization of the study area sediments. These data are not suitable for interpretation of land-scape topographic features. No consolidated hard substrates were observed within the study area. Underwater conditions at the videographic sampling locations were generally very good with clear near-bottom visibility that was delimited by the artificial lighting provided by the camera system. A representative image and brief descriptive annotation describing the viewed benthic habit is presented in **Images 6** to **13**.

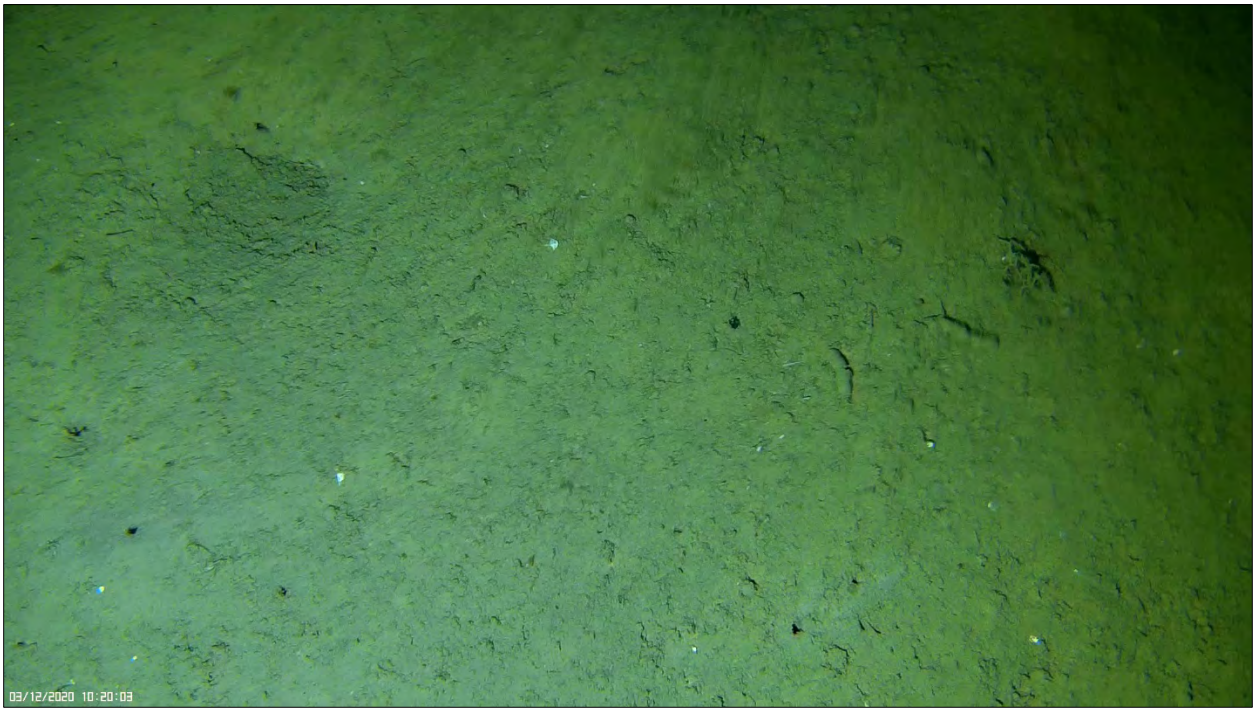

Image 6. Representative seafloor image at Station HH-01 with benthic habitat characterized by surficial sediment of predominantly silt and loose clay with incorporation of calcareous debris (e.g., pteropod tests). Loose organic materials, bioturbation (i.e., small burrows), what appear to be fecal casts, and subtle surface irregularities are visible in the image.

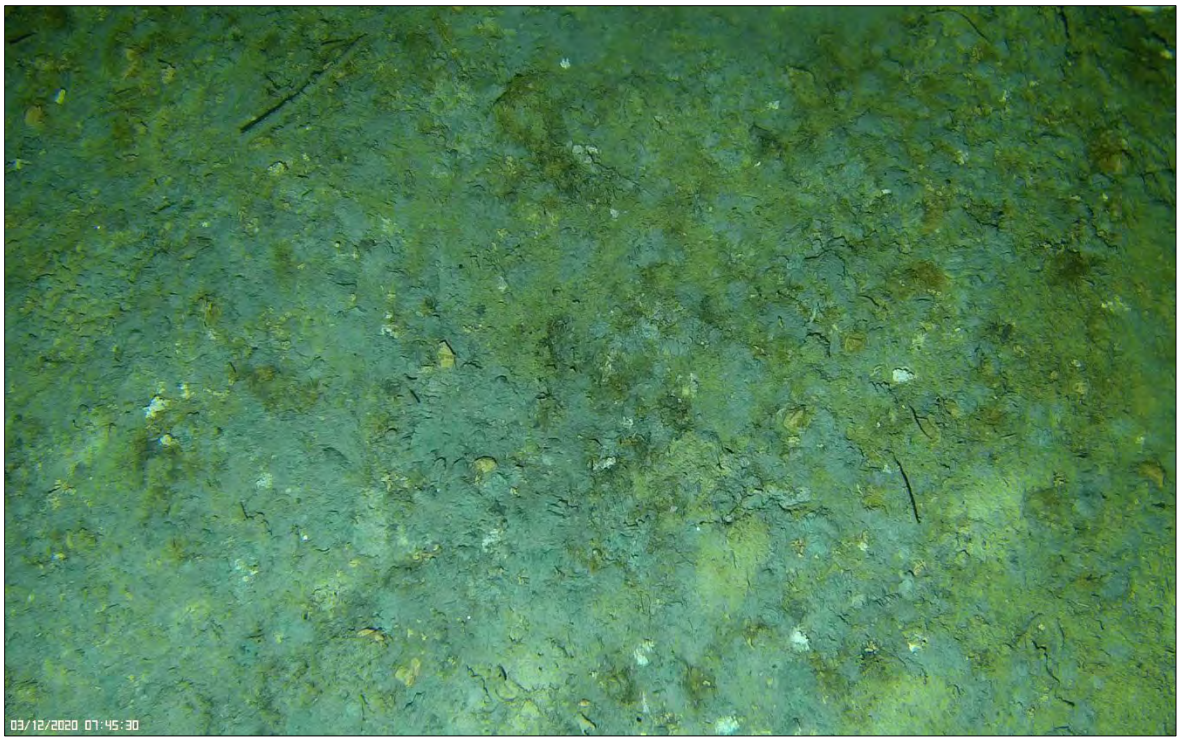

Image 7. Representative seafloor image at Station HH-02 with benthic habitat characterized by surficial sediment of predominantly silt and loose clay. Surficial sediments have an odd mottled appearance with formations of small clumps of clayey materials and incorporated organic materials. Based on the sediment sampling results at this station, it is very likely the content of the surficial sediments strongly influenced by discharges of drilling muds and cuttings.

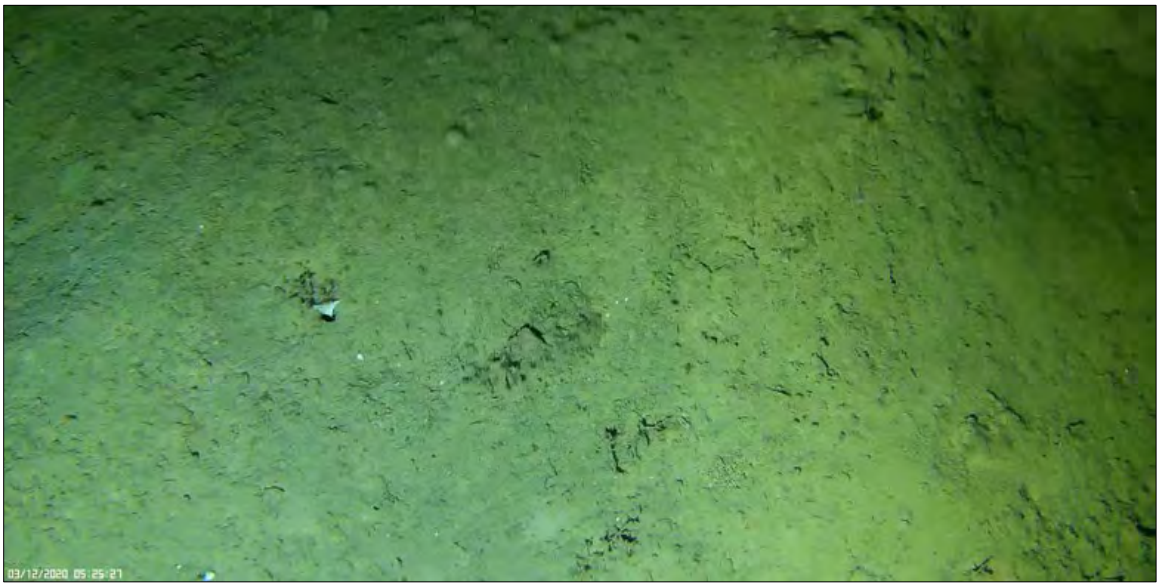

Image 8. Representative seafloor image at Station HH-03 with sediments predominantly silt and loose clay; irregular surface topography appears to be biologically active with subtle bioturbations and accumulated organic matter.

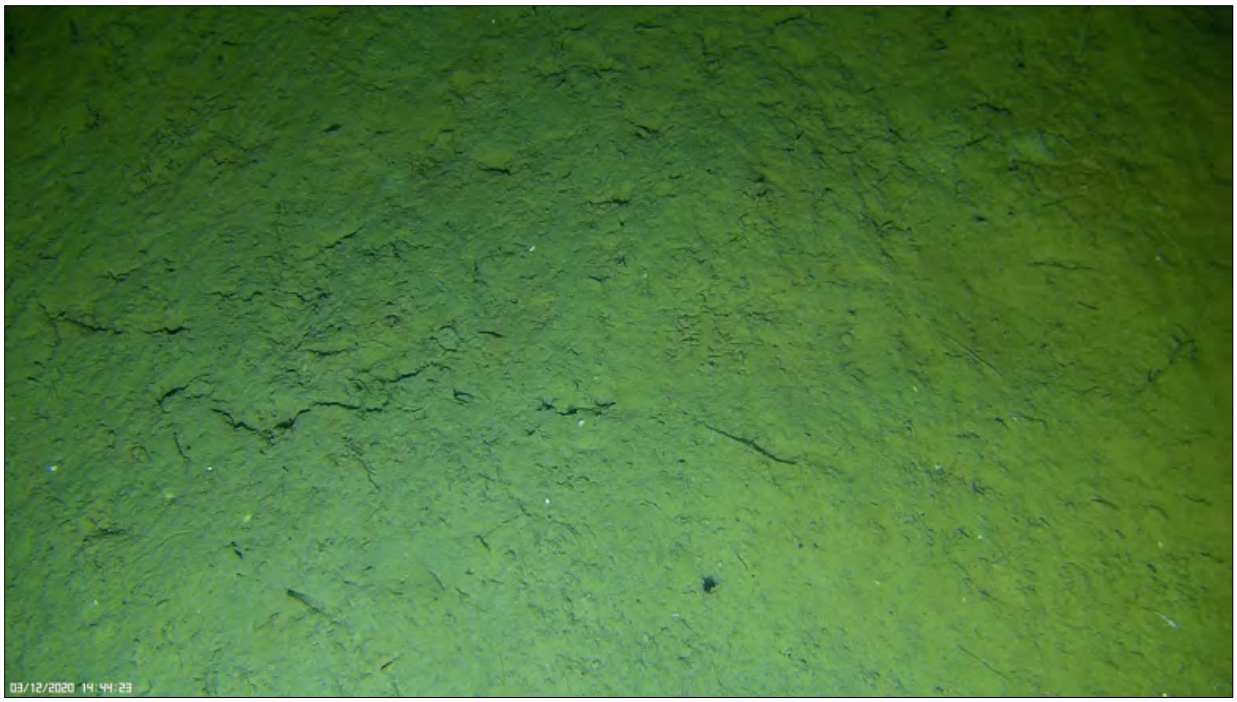

Image 9. Representative seafloor image at Station HH-04 with sediments predominantly silt and loose clay; irregular surface topography appears to be biologically active with subtle bioturbations (i.e., small burrows).

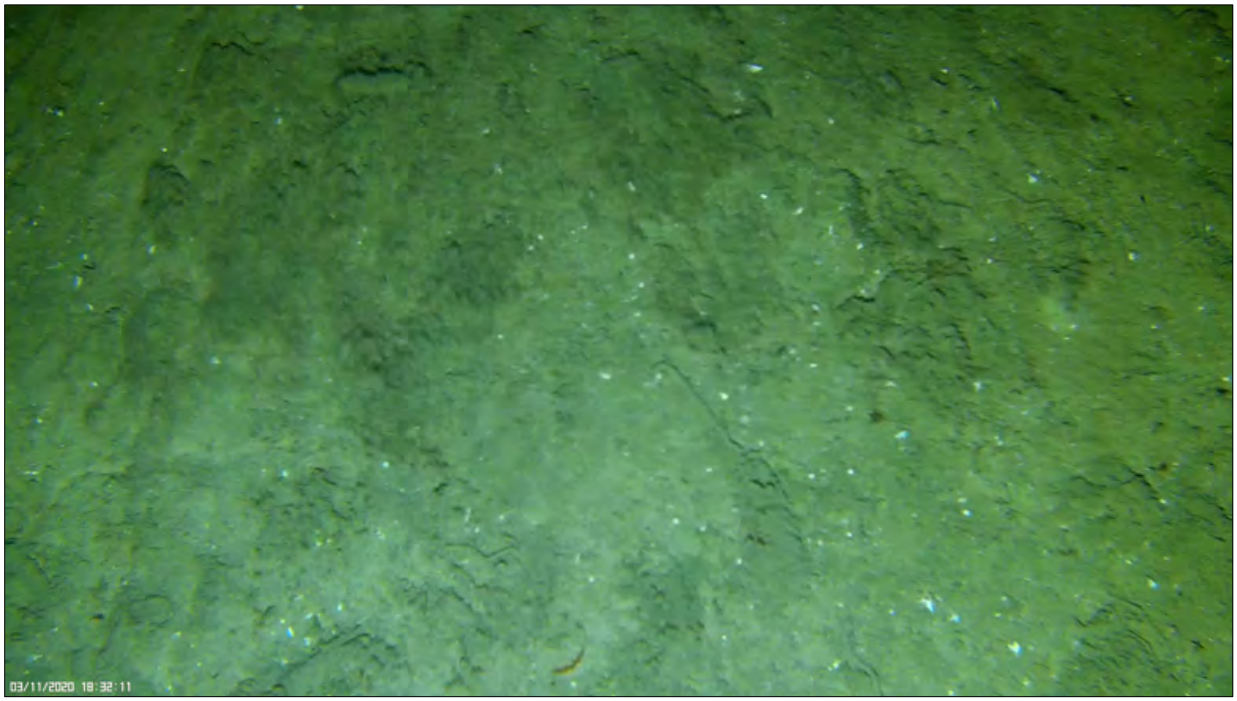

Image 10. Representative seafloor image at Station HH-05 with sediments composed of predominantly silt and loose clay with relatively high fraction of sand and incorporation of calcareous debris (e.g. pteropod tests). Substrate has a smooth surface topography with veneer of fine silt that appears to move with subtle near-bottom disturbances.

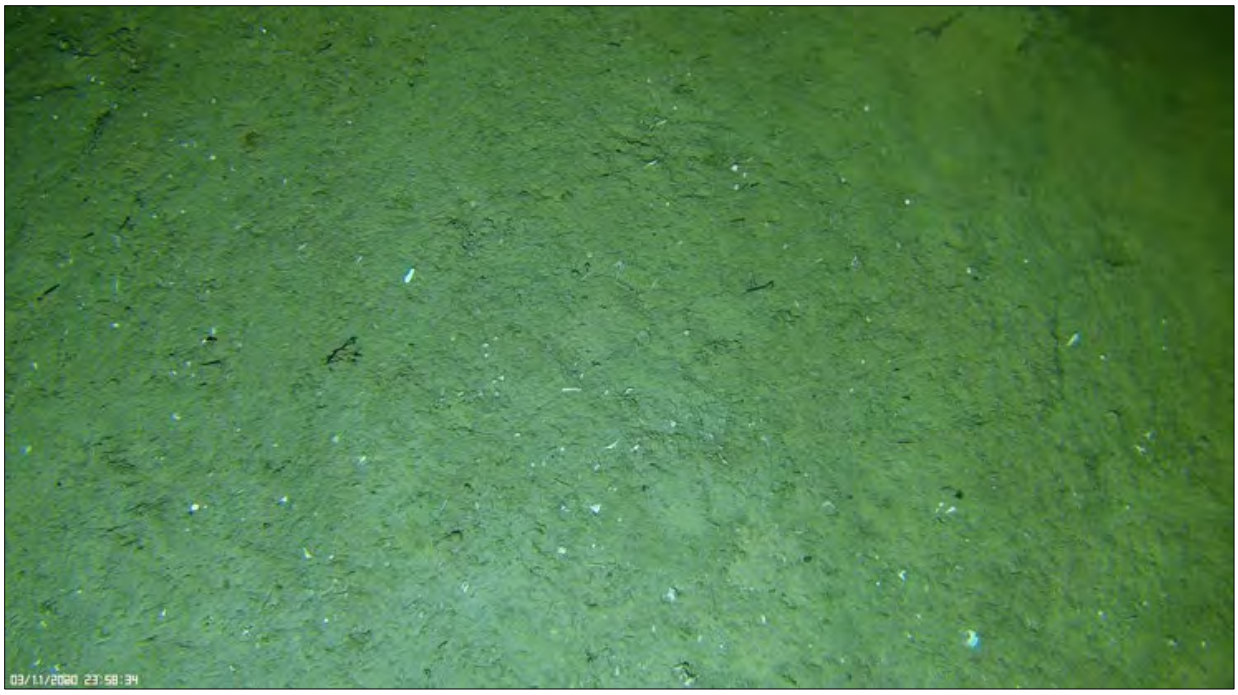

Image 11. Representative seafloor image at Station HH-06 with sediments composed of predominantly silt and loose clay with relatively high fraction of sand and incorporation of calcareous debris (e.g. pteropod tests). Substrate has a smooth surface topography with no visual indication of biological activity.

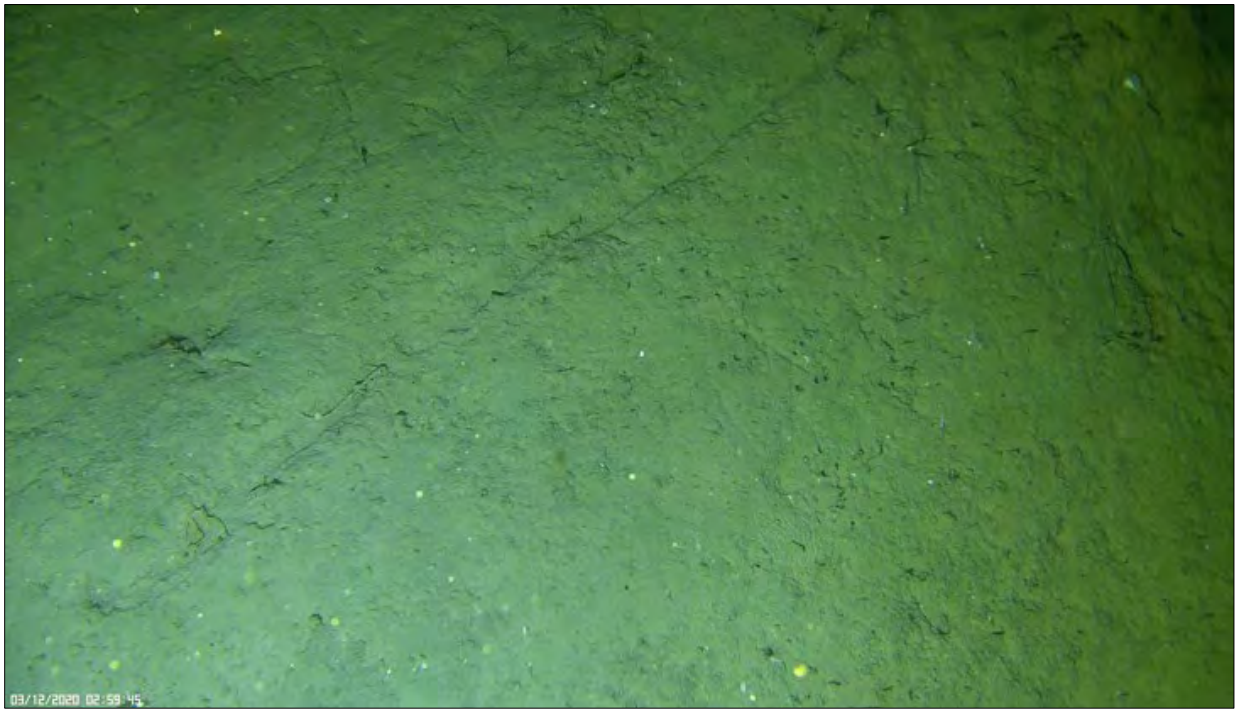

Image 12. Representative seafloor image at Station HH-07 with sediments composed of predominantly silt and clay with very low amounts of sand. Substrate surface topography has various indications of biological activity; however, these markings do not appear to be recent.

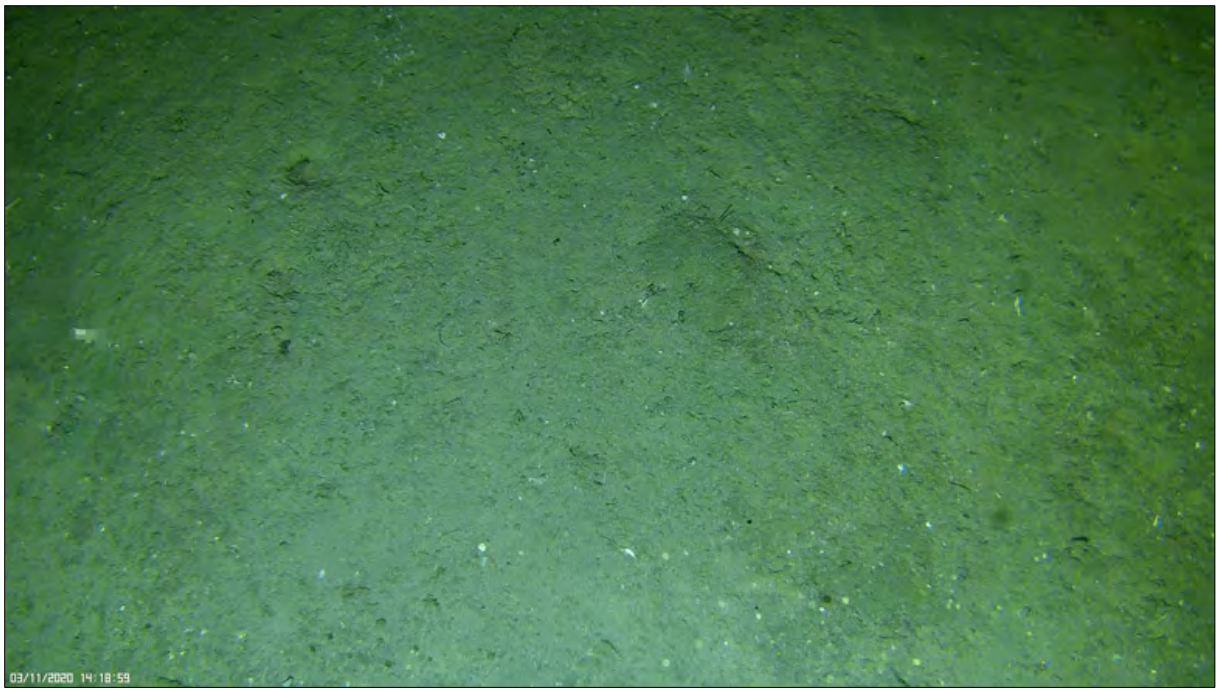

Image 13. Representative seafloor image at Station HH-08 with sediments composed of predominantly silt and loose clay with relatively high fraction of sand and incorporation of calcareous debris (e.g. pteropod tests). Substrate has a smooth surface topography with subtle visual indication of biological activity such as small depressions and mounds.

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6.0 Conclusions and Recommendations

The findings of the EBS are generally summarized to present the analytical results relevant to understanding potential impacts to the various aspects of the environment from ongoing and future offshore oil and gas activities. These findings provide the basis for recommendations to address informational data gaps and parameters most informative to understanding and detecting impacts. A general recommendation based on extensive experience conducting offshore oil and gas monitoring programs would be to focus on benthic sampling because that is where the impacts will be detectable. A minimal level of effort for water column sampling (e.g. three stations) would be adequate to provide the "snapshot" characterization of the water mass present within the study area and establish regional conditions. The continuous movement of regional water masses and flushing of potential inputs by oceanographic conditions does not facilitate using water column sampling to assess large-scale effects of development activities.

Sediment characteristics and analyte concentrations are similar to the previous regional study for the Liza 2 Field Development (Benthic USA LLC., 2019) and generally within the expected ranges for deep water offshore sediments, with a few exceptions.

TPH concentrations in sediment ranged from 3 to 1,233 $\mu g\ g^{-1}$ and were generally similar among all stations except Station HH-2. TPH concentrations exceeding 1,100 $\mu g\ g^{-1}$ were considerably elevated at Station HH-2 with levels hundredfold over the other EBS stations. Theses elevated TPH levels are very possibly due to the presence of synthetic based fluids in the sediments. Like TPH, the total PAH concentration was considerably elevated at Station HH-2. This high sediment hydrocarbon location could facilitate appropriate monitoring initially to understand the hydrocarbon source by using "fingerprint" sampling for operator-utilized non-aqueous drilling fluids and secondarily to evaluate persistence in the environment and recovery to ambient conditions.

Observed variability of sediment metals concentrations within the EBS study area are likely a function of sediment grain size, organic carbon content, and mineralogy. In addition, regional drilling activities appear to have influenced some metal analytes. Ba in sediment samples was elevated at Stations HH-1, HH-2, and HH-3 with concentrations greater than 1,000 ppm ($mg\ kg^{-1}$) may be indicative of drilling activities with discharge of drilling muds. Highest concentrations (albeit slightly higher) of As, Cd, Cu, Pb, and V were observed at Station HH-2 that had the highest levels of Ba and appears to be the result of drill mud deposition. Similar to the sediment hydrocarbons, these high sediment metal locations could facilitate appropriate monitoring to establish spatial gradients relative to previous drilling mud discharges and temporal effects concerning persistence in the environment and recovery to ambient conditions.

There was an approximate sevenfold increase in the mean Al concentration between this EBS (7.24%) and the 2018 Liza 2 Field Development EBS (1.15%) (Benthic USA LLC., 2019). The observed Al concentration during this Hammerhead Development EBS are most expected for deep water clay sediments (Turekian and Wedepohl, 1961, Salomons and Förstner, 1984, Wedepohl, 1995). The sources for the stark differences between this EBS and the 2018 EBS sediment Al concentrations are uncertain but could be influenced by analytical laboratories and associated methods between surveys, natural influx of aluminosilicate terrigenous sediments, and/or anthropogenic activities. To better understand potential regional variability concerning sediment mineral types and metals concentrations, all pre-drilling data could be used to establish a regional baseline; post-drill data would need to be evaluated within the evolving baseline to assess its applicability for use in establishing baseline. CSA has done this in the Eastern Mediterranean for the Leviatine Basin. This regional baseline can be applied to all sediment sampling parameters for assessing whether sediment analytical levels are within the range of regional natural variability.

The sediment metals regression plots were conducted to determine whether observed metal concentrations are regionally anomalous. The regression analysis was conducted to correlate sediment percent Al with other metals concentrations to assess the potential for influence by anthropogenic inputs. With the exception of the high barium samples, regression analysis show that all metal concentrations when plotted in correlation with sediment percent Al were within the 99% prediction interval; therefore, the regression analyses indicate EBS metal concentrations are considered regionally ambient and establish baseline conditions specific to these sediment metal analytes. Moving forward, the established 99% predication intervals could be used for future studies within the Hammerhead Development area to assess anomalous sediment metal concentrations.

The 8 box core samples collected from the survey area yielded 204 individuals and 37 total taxa from eight phyla. Most of the individuals (60.3%) were contributed by the annelids followed by arthropods (19.6%). Annelids were also represented by the most infaunal taxa (24) followed by arthropods (6). The overall infauna density ranged from 98.0 to 359.2 individuals per m^2 with a mean of 208.2 ± 79.3 individuals per m^2 across all stations. The diversity indices indicated that the assemblage has generally low species richness and diversity but high evenness across all stations indicating similar relative abundances among taxa and correspondingly low numerical dominance. Cluster analysis and the multidimensional scaling ordination do not reveal any discrete groups of infauna samples that would indicate spatial aggregation or other assemblage patterns.

Infauna, as a biological indicator of impacts, are an important component of monitoring programs because they are sedentary and typically respond to pollutant stresses. The level of EBS infauna sampling appears to be adequate for generally characterizing the regional assemblage. However, a more comprehensive characterization of the assemblage may be required for infauna data to detect potential effects of offshore activities within the study area. More infauna samples within the EBS study area with a random positioning for stations stratified based on water depth would greatly enhance the ability to characterize the assemblage relative to local variability (e.g. depth gradient), species diversity, and spatial patterns (i.e., distinct assemblage groupings).

This EBS documents the existing state of the seafloor marine environment with high definition videographic data. All visually documented habitat was soft bottom substrate that supported a relatively depauperate biological assemblage as based on the sampling area viewed from the imagery. The dearth of observable seafloor features both topographic and biological was due primarily to the relatively small overall visual sampling area at each station. To use visual data to characterize large-scale features, it is recommended that a towed or drift camera system be utilized for data collection.

It should be noted, the Hammerhead Development Environmental Baseline Survey did detect potential effects of previous regional drilling activities; however they appeared to be localized and with no probable biological significance.

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Appendices

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Appendix A:

Analytical Data Summaries for Sediment and Water Samples

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KaizenLAB
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ANALYSIS DATA REPORT

Customer: CSA Ocean Sciences Inc. **Customer Contact:** Mr. Rameez Persad

Customer's Address: Suite 108, Fitt Court, 9-11 Fitt Street, Woodbrook, (P.O. Box 7059, St. Anns), Port of Spain

Client Project #: 20-062 **Lab File #:** 428281

Item(s) Analyzed: Sediment Samples

Date of Sampling: 11-Mar-20 to 12-Mar-20 **Sampled By:** Client

Date of Receipt: 17-Mar-20 **Date of Testing:** 24-Mar-20 to 05-Apr-20

Report Date: 14-Apr-20

ANALYSIS RESULTS

Parameter Name	Units	Results			
		428281-1, NC21G20EBC 101 A	428281-2, NC21G20EBC 102 A	428281-3, NC21G20EBC 103 A	428281-4, NC21G20EBC 104 A
Grain Size <0.075mm	%	98.8	98.8	98.8	98.7
GrainSize >0.075mm	%	1.2	1.2	1.2	1.3
Texture (Fine/Coarse)	n/a	Fine	Fine	Fine	Fine
Clay	%	56.2	51.2	56.2	43.7
Silt	%	28.8	42.5	41.3	50.0
Sand	%	15.0	6.3	2.5	6.3
Texture	n/a	Clay	Silty clay	Silty clay	Silty clay

Parameter Name	Units	Results			
		428281-5, NC21G20EBC 105 A	428281-6, NC21G20EBC 106 A	428281-7, NC21G20EBC 107 A	428281-8, NC21G20EBC 108 A
Grain Size <0.075mm	%	63.8	91.0	98.8	70.9
GrainSize >0.075mm	%	36.2	9.0	1.2	29.1
Texture (Fine/Coarse)	n/a	Fine	Fine	Fine	Fine
Clay	%	53.7	46.2	58.7	40.0
Silt	%	25.0	30.0	38.8	28.7
Sand	%	21.3	23.8	2.5	31.3
Texture	n/a	Clay	Clay	Clay	Clay

** Detailed Test Methodologies and QA/QC data available upon request.*

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ANALYSIS RESULTS

***Test Methodologies:**	Grain size, Particle Size Distribution: Modified from soil sampling and methods of analysis M.R. Carter 2008

Comments:	Grain size and Particle Size were analysed at Kaizen Lab (Calgary) and Accredited under the Canadian Association for Laboratory Association Inc. The results in this test report relate only to the items received and tested.

Report Authorized by: Devika Rooplal

Devika Rooplal

Divisional Manager (In Training)

This test report shall not be reproduced except in full, without written approval of the laboratory.

Job	Lab Code	Sample	Date Collected	Matrix	Sample Type	Component	Result	Units	Result Notes	Reporting Limit	Detection Limit	Extraction Method	Method
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Carbon, Total Organic	0.83	%		0.1	0.02	METHOD	9060
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Carbon, Total Organic	0.98	%		0.1	0.02	METHOD	9060
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Carbon, Total Organic	0.77	%		0.1	0.02	METHOD	9060
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Carbon, Total Organic	1.09	%		0.1	0.02	METHOD	9060
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Carbon, Total Organic	0.4	%		0.1	0.02	METHOD	9060
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Carbon, Total Organic	0.68	%		0.1	0.02	METHOD	9060
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Carbon, Total Organic	0.82	%		0.1	0.02	METHOD	9060
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Carbon, Total Organic	0.44	%		0.1	0.02	METHOD	9060
3532	K2002362-MB	METHOD BLANK	NA	Sediment	MB1	Carbon, Total Organic	ND	%	U	0.1	0.02	METHOD	9060
3532	K2002362-LCS	LAB CONTROL SAMPLE	NA	Sediment	LCS1	Carbon, Total Organic	0.48	%		0.1	0.02	METHOD	9060
3532	K2002362-001DUP	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	DUP1	Carbon, Total Organic	0.84	%		0.1	0.02	METHOD	9060
3532	K2002362-001MS	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	MS1	Carbon, Total Organic	4.75	%		0.1	0.02	METHOD	9060
3532	K2002362-001DMS	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	DMS1	Carbon, Total Organic	4.73	%		0.1	0.02	METHOD	9060
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Aluminum, Total	83700	mg/Kg		24		FBA	6010C
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Arsenic, Total	9.5	mg/Kg		4		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Barium, Total	1260	mg/Kg		9.7		FBA	6010C
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Beryllium, Total	1.97	mg/Kg		0.16		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Cadmium, Total	ND	mg/Kg	U	0.16		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Chromium, Total	48.9	mg/Kg		1.6		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Cobalt, Total	10.7	mg/Kg		0.16		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Copper, Total	17.8	mg/Kg		0.8		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Iron, Total	37600	mg/Kg		97		FBA	6010C
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Lead, Total	19.8	mg/Kg		0.4		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Manganese, Total	708	mg/Kg		0.4		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Molybdenum, Total	1.16	mg/Kg		0.4		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Nickel, Total	34.1	mg/Kg		1.6		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	8		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.16		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Strontium, Total	396	mg/Kg		4.9		FBA	6010C
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Thallium, Total	0.72	mg/Kg		0.16		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Tin, Total	2.73	mg/Kg		0.8		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Vanadium, Total	94.2	mg/Kg		1.6		EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A	3/12/2020	Sediment	SMPL	Zinc, Total	84.1	mg/Kg		4		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Aluminum, Total	81400	mg/Kg		23		FBA	6010C
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Arsenic, Total	11.5	mg/Kg		3.6		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Barium, Total	16200	mg/Kg		9.3		FBA	6010C
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Beryllium, Total	1.91	mg/Kg		0.14		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Cadmium, Total	0.18	mg/Kg		0.14		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Chromium, Total	51.5	mg/Kg		1.4		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Cobalt, Total	10.3	mg/Kg		0.14		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Copper, Total	22	mg/Kg		0.71		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Iron, Total	38100	mg/Kg		93		FBA	6010C
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Lead, Total	29.5	mg/Kg		0.36		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Manganese, Total	455	mg/Kg		0.36		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Molybdenum, Total	1.58	mg/Kg		0.36		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Nickel, Total	30.5	mg/Kg		1.4		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.1		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.14		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Strontium, Total	659	mg/Kg		4.6		FBA	6010C
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Thallium, Total	0.74	mg/Kg		0.14		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Tin, Total	2.82	mg/Kg		0.71		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Vanadium, Total	100	mg/Kg		1.4		EPA 3052	6020A
3532	K2002362-003	3532|03_20|HH-2|SED|A	3/12/2020	Sediment	SMPL	Zinc, Total	114	mg/Kg		3.6		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Aluminum, Total	81700	mg/Kg		25		FBA	6010C
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Arsenic, Total	10.7	mg/Kg		3.9		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Barium, Total	3100	mg/Kg		10		FBA	6010C
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Beryllium, Total	1.95	mg/Kg		0.15		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Cadmium, Total	ND	mg/Kg	U	0.15		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Chromium, Total	49.2	mg/Kg		1.5		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Cobalt, Total	11.6	mg/Kg		0.15		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Copper, Total	18.2	mg/Kg		0.77		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Iron, Total	37900	mg/Kg		100		FBA	6010C
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Lead, Total	20.7	mg/Kg		0.39		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Manganese, Total	906	mg/Kg		0.39		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Molybdenum, Total	1.62	mg/Kg		0.39		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Nickel, Total	35.8	mg/Kg		1.5		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.7		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.15		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Strontium, Total	429	mg/Kg		5		FBA	6010C
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Thallium, Total	0.75	mg/Kg		0.15		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Tin, Total	2.67	mg/Kg		0.77		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Vanadium, Total	95.1	mg/Kg		1.5		EPA 3052	6020A
3532	K2002362-005	3532|03_20|HH-3|SED|A	3/12/2020	Sediment	SMPL	Zinc, Total	88.9	mg/Kg		3.9		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Aluminum, Total	84600	mg/Kg		25		FBA	6010C
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Arsenic, Total	9.2	mg/Kg		3.9		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Barium, Total	451	mg/Kg		10		FBA	6010C
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Beryllium, Total	2.03	mg/Kg		0.16		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Cadmium, Total	0.16	mg/Kg		0.16		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Chromium, Total	52.1	mg/Kg		1.6		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Cobalt, Total	10.5	mg/Kg		0.16		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Copper, Total	16.9	mg/Kg		0.78		EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Iron, Total	39000	mg/Kg		100		FBA	6010C
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Lead, Total	21.2	mg/Kg		0.39		EPA 3052	6020A

3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Manganese, Total	766	mg/Kg		0.39	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Molybdenum, Total	1.64	mg/Kg		0.39	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Nickel, Total	34.3	mg/Kg		1.6	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.8	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Strontium, Total	348	mg/Kg		5	FBA	6010C
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Thallium, Total	0.78	mg/Kg		0.16	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Tin, Total	2.85	mg/Kg		0.78	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Vanadium, Total	95.9	mg/Kg		1.6	EPA 3052	6020A
3532	K2002362-007	3532|03_20|HH-4|SED|A	3/12/2020	Sediment	SMPL	Zinc, Total	89.1	mg/Kg		3.9	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Aluminum, Total	38500	mg/Kg		22	FBA	6010C
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Arsenic, Total	7.5	mg/Kg		3.8	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Barium, Total	250	mg/Kg		8.9	FBA	6010C
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Beryllium, Total	0.24	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Cadmium, Total	ND	mg/Kg	U	0.15	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Chromium, Total	18.4	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Cobalt, Total	5.76	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Copper, Total	10.6	mg/Kg		0.75	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Iron, Total	19200	mg/Kg		89	FBA	6010C
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Lead, Total	9.59	mg/Kg		0.38	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Manganese, Total	313	mg/Kg		0.38	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Molybdenum, Total	0.5	mg/Kg		0.38	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Nickel, Total	15.5	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.5	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.15	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Strontium, Total	583	mg/Kg		4.4	FBA	6010C
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Thallium, Total	0.39	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Tin, Total	1.35	mg/Kg		0.75	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Vanadium, Total	51.6	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-009	3532|03_20|HH-5|SED|A	3/11/2020	Sediment	SMPL	Zinc, Total	43.2	mg/Kg		3.8	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Aluminum, Total	68600	mg/Kg		24	FBA	6010C
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Arsenic, Total	8.5	mg/Kg		3.8	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Barium, Total	374	mg/Kg		9.7	FBA	6010C
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Beryllium, Total	1.11	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Cadmium, Total	0.15	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Chromium, Total	34.4	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Cobalt, Total	9.17	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Copper, Total	17.5	mg/Kg		0.75	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Iron, Total	31400	mg/Kg		97	FBA	6010C
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Lead, Total	16.9	mg/Kg		0.38	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Manganese, Total	484	mg/Kg		0.38	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Molybdenum, Total	0.76	mg/Kg		0.38	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Nickel, Total	27.2	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.5	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.15	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Strontium, Total	565	mg/Kg		4.8	FBA	6010C
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Thallium, Total	0.63	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Tin, Total	2.29	mg/Kg		0.75	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Vanadium, Total	82.8	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-011	3532|03_20|HH-6|SED|A	3/12/2020	Sediment	SMPL	Zinc, Total	71	mg/Kg		3.8	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Aluminum, Total	81300	mg/Kg		22	FBA	6010C
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Arsenic, Total	11.1	mg/Kg		3.7	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Barium, Total	486	mg/Kg		8.7	FBA	6010C
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Beryllium, Total	1.92	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Cadmium, Total	0.15	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Chromium, Total	46.4	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Cobalt, Total	10.8	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Copper, Total	19	mg/Kg		0.74	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Iron, Total	37300	mg/Kg		87	FBA	6010C
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Lead, Total	21.8	mg/Kg		0.37	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Manganese, Total	782	mg/Kg		0.37	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Molybdenum, Total	1.25	mg/Kg		0.37	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Nickel, Total	35.8	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.4	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.15	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Strontium, Total	422	mg/Kg		4.4	FBA	6010C
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Thallium, Total	0.8	mg/Kg		0.15	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Tin, Total	2.94	mg/Kg		0.74	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Vanadium, Total	100	mg/Kg		1.5	EPA 3052	6020A
3532	K2002362-013	3532|03_20|HH-7|SED|A	3/12/2020	Sediment	SMPL	Zinc, Total	95.5	mg/Kg		3.7	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Aluminum, Total	48600	mg/Kg		24	FBA	6010C
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Arsenic, Total	7.6	mg/Kg		3.9	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Barium, Total	322	mg/Kg		9.4	FBA	6010C
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Beryllium, Total	0.47	mg/Kg		0.16	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Cadmium, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Chromium, Total	19.1	mg/Kg		1.6	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Cobalt, Total	6.48	mg/Kg		0.16	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Copper, Total	13.2	mg/Kg		0.78	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Iron, Total	23700	mg/Kg		94	FBA	6010C
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Lead, Total	11.3	mg/Kg		0.39	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Manganese, Total	357	mg/Kg		0.39	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Molybdenum, Total	0.55	mg/Kg		0.39	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Nickel, Total	17.9	mg/Kg		1.6	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A	3/11/2020	Sediment	SMPL	Selenium, Total	ND	mg/Kg	U	7.8	EPA 3052	6020A

3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Silver, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Strontium, Total	603	mg/Kg		4.7	FBA	6010C
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Thallium, Total	0.45	mg/Kg		0.16	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Tin, Total	1.67	mg/Kg		0.78	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Vanadium, Total	62.7	mg/Kg		1.6	EPA 3052	6020A
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Zinc, Total	50.7	mg/Kg		3.9	EPA 3052	6020A
3532	KQ2004016-01	METHOD BLANK	NA		Sediment	MB1	Aluminum, Total	46	mg/Kg		25	FBA	6010C
3532	KQ2004016-01	METHOD BLANK	NA		Sediment	MB1	Barium, Total	ND	mg/Kg	U	10	FBA	6010C
3532	KQ2004016-01	METHOD BLANK	NA		Sediment	MB1	Iron, Total	ND	mg/Kg	U	100	FBA	6010C
3532	KQ2004016-01	METHOD BLANK	NA		Sediment	MB1	Strontium, Total	ND	mg/Kg	U	5	FBA	6010C
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Arsenic, Total	ND	mg/Kg	U	4	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Beryllium, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Cadmium, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Chromium, Total	ND	mg/Kg	U	1.6	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Cobalt, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Copper, Total	ND	mg/Kg	U	0.8	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Lead, Total	ND	mg/Kg	U	0.4	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Manganese, Total	ND	mg/Kg	U	0.4	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Molybdenum, Total	ND	mg/Kg	U	0.4	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Nickel, Total	ND	mg/Kg	U	1.6	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Selenium, Total	ND	mg/Kg	U	8	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Silver, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Thallium, Total	ND	mg/Kg	U	0.16	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Tin, Total	ND	mg/Kg	U	0.8	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Vanadium, Total	ND	mg/Kg	U	1.6	EPA 3052	6020A
3532	KQ2004018-01	METHOD BLANK	NA		Sediment	MB1	Zinc, Total	ND	mg/Kg	U	4	EPA 3052	6020A
3532	KQ2004016-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Aluminum, Total	55000	mg/Kg		25	FBA	6010C
3532	KQ2004016-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Barium, Total	25200	mg/Kg		10	FBA	6010C
3532	KQ2004016-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Iron, Total	50700	mg/Kg		100	FBA	6010C
3532	KQ2004016-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Strontium, Total	25700	mg/Kg		5	FBA	6010C
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Arsenic, Total	197	mg/Kg		4	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Beryllium, Total	9.52	mg/Kg		0.16	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Cadmium, Total	9.01	mg/Kg		0.16	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Chromium, Total	37.1	mg/Kg		1.6	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Cobalt, Total	89.1	mg/Kg		0.16	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Copper, Total	46.6	mg/Kg		0.8	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Lead, Total	97.6	mg/Kg		0.4	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Manganese, Total	97.2	mg/Kg		0.4	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Molybdenum, Total	187	mg/Kg		0.4	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Nickel, Total	96.6	mg/Kg		1.6	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Selenium, Total	205	mg/Kg		8	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Silver, Total	9.76	mg/Kg		0.16	EPA 3052	6020A

3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Thallium, Total	40.4	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Tin, Total	79.6	mg/Kg			0.8	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Vanadium, Total	93.5	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-02	LAB CONTROL SAMPLE	NA		Sediment	LCS1	Zinc, Total	96.3	mg/Kg			4	EPA 3052	6020A
3532	KQ2004016-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Aluminum, Total	83100	mg/Kg			23	FBA	6010C
3532	KQ2004016-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Barium, Total	1350	mg/Kg			9.3	FBA	6010C
3532	KQ2004016-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Iron, Total	37900	mg/Kg			93	FBA	6010C
3532	KQ2004016-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Strontium, Total	400	mg/Kg			4.7	FBA	6010C
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Arsenic, Total	9.2	mg/Kg			4	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Beryllium, Total	1.93	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Cadmium, Total	ND	mg/Kg	U		0.16	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Chromium, Total	49.9	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Cobalt, Total	10.3	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Copper, Total	16.9	mg/Kg			0.8	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Lead, Total	20.1	mg/Kg			0.4	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Manganese, Total	699	mg/Kg			0.4	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Molybdenum, Total	1.27	mg/Kg			0.4	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Nickel, Total	33.4	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Selenium, Total	ND	mg/Kg	U		8	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Silver, Total	ND	mg/Kg	U		0.16	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Thallium, Total	0.73	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Tin, Total	2.7	mg/Kg			0.8	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Vanadium, Total	96.4	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-04	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Zinc, Total	89.3	mg/Kg			4	EPA 3052	6020A
3532	KQ2004016-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Aluminum, Total	131000	mg/Kg			23	FBA	6010C
3532	KQ2004016-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Barium, Total	24500	mg/Kg			9.4	FBA	6010C
3532	KQ2004016-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Iron, Total	84000	mg/Kg			94	FBA	6010C
3532	KQ2004016-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Strontium, Total	23900	mg/Kg			4.7	FBA	6010C
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Arsenic, Total	194	mg/Kg			4	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Beryllium, Total	10.8	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Cadmium, Total	9.39	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Chromium, Total	89.9	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Cobalt, Total	92	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Copper, Total	59.4	mg/Kg			0.79	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Lead, Total	110	mg/Kg			0.4	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Manganese, Total	1030	mg/Kg	#		0.4	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Molybdenum, Total	188	mg/Kg			0.4	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Nickel, Total	119	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Selenium, Total	195	mg/Kg			7.9	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Silver, Total	9.41	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Thallium, Total	39.5	mg/Kg			0.16	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Tin, Total	83.6	mg/Kg			0.79	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Vanadium, Total	178	mg/Kg			1.6	EPA 3052	6020A
3532	KQ2004018-05	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	MS1	Zinc, Total	172	mg/Kg			4	EPA 3052	6020A
3532	K2002362-001	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	SMPL	Solids, Total	28.6	%				NONE	SM 2540 G
3532	K2002362-003	3532|03_20|HH-2|SED|A		3/12/2020	Sediment	SMPL	Solids, Total	32.8	%				NONE	SM 2540 G
3532	K2002362-005	3532|03_20|HH-3|SED|A		3/12/2020	Sediment	SMPL	Solids, Total	29.1	%				NONE	SM 2540 G
3532	K2002362-007	3532|03_20|HH-4|SED|A		3/12/2020	Sediment	SMPL	Solids, Total	27.5	%				NONE	SM 2540 G
3532	K2002362-009	3532|03_20|HH-5|SED|A		3/11/2020	Sediment	SMPL	Solids, Total	44	%				NONE	SM 2540 G
3532	K2002362-011	3532|03_20|HH-6|SED|A		3/12/2020	Sediment	SMPL	Solids, Total	33.6	%				NONE	SM 2540 G
3532	K2002362-013	3532|03_20|HH-7|SED|A		3/12/2020	Sediment	SMPL	Solids, Total	30	%				NONE	SM 2540 G
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Solids, Total	44.3	%				NONE	SM 2540 G
3532	K2002362-MB	METHOD BLANK	NA		Sediment	MB1	Solids, Total	0	%				NONE	SM 2540 G
3532	K2002362-001DUP	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	DUP1	Solids, Total	28.6	%				NONE	SM 2540 G
3532	K2002362-001	3532|03_20|HH-1|SED|A		3/12/2020	Sediment	SMPL	Mercury, Total	50.2	ng/g			2.8	METHOD	1631E
3532	K2002362-003	3532|03_20|HH-2|SED|A		3/12/2020	Sediment	SMPL	Mercury, Total	49.8	ng/g			2.5	METHOD	1631E
3532	K2002362-005	3532|03_20|HH-3|SED|A		3/12/2020	Sediment	SMPL	Mercury, Total	45.7	ng/g			3.2	METHOD	1631E
3532	K2002362-007	3532|03_20|HH-4|SED|A		3/12/2020	Sediment	SMPL	Mercury, Total	37.5	ng/g			3	METHOD	1631E
3532	K2002362-009	3532|03_20|HH-5|SED|A		3/11/2020	Sediment	SMPL	Mercury, Total	31.5	ng/g			1.8	METHOD	1631E
3532	K2002362-011	3532|03_20|HH-6|SED|A		3/12/2020	Sediment	SMPL	Mercury, Total	54.3	ng/g			2.7	METHOD	1631E
3532	K2002362-013	3532|03_20|HH-7|SED|A		3/12/2020	Sediment	SMPL	Mercury, Total	62.2	ng/g			2.9	METHOD	1631E
3532	K2002362-015	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	SMPL	Mercury, Total	37.5	ng/g			1.9	METHOD	1631E
3532	K2002362-MB1	METHOD BLANK 1	NA		Sediment	MB1	Mercury, Total	ND	ng/g	U		1	METHOD	1631E
3532	K2002362-MB2	METHOD BLANK 2	NA		Sediment	MB2	Mercury, Total	ND	ng/g	U		1	METHOD	1631E
3532	K2002362-MB3	METHOD BLANK 3	NA		Sediment	MB3	Mercury, Total	ND	ng/g	U		1	METHOD	1631E
3532	K2002362-015MS	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	MS1	Mercury, Total	514	ng/g			9.2	METHOD	1631E
3532	K2002362-015DMS	3532|03_20|HH-8|SED|A		3/11/2020	Sediment	DMS1	Mercury, Total	522	ng/g			9.3	METHOD	1631E
3532	K2002362-QCS1	QUALITY CONTROL SAMPLE	NA		Sediment	QCS1	Mercury, Total	430	ng/g			1	METHOD	1631E
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Aluminum, Total	24800	mg/Kg				NONE	6010C
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Barium, Total	215	mg/Kg				NONE	6010C
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Iron, Total	20100	mg/Kg				NONE	6010C
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Arsenic, Total	6.17	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Cadmium, Total	0.145	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Chromium, Total	33	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Copper, Total	9.02	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Lead, Total	11.1	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Manganese, Total	179	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Nickel, Total	20.4	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Vanadium, Total	39.3	mg/Kg				NONE	6020A
3532	KQ2004018-03	STANDARD REFERNCE MATERAIL	NA		Sediment	SRM1	Zinc, Total	43.1	mg/Kg				NONE	6020A

Job	Lab Code	Sample	Date Collected	Matrix	Sample Type	Component	Result	Units	Result Notes	Reporting Limit	Detection Limit	Extraction Method	Method
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	0.3	mg/L	J	1	0.2	NONE	9060A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	7.5	mg/L		5		NONE	SM 2540 D
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	25	mg/L		5		NONE	SM 2540 D
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-019	3532|03_20|HH-4|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-MB1	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002363-MB1	METHOD BLANK	NA	Ocean Water	MB1	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-MB2	METHOD BLANK	NA	Ocean Water	MB2	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002363-MB2	METHOD BLANK	NA	Ocean Water	MB2	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002363-MB3	METHOD BLANK	NA	Ocean Water	MB3	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002363-MB4	METHOD BLANK	NA	Ocean Water	MB4	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002363-LCS1	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	23.1	mg/L		0.5	0.07	NONE	9060A
3532	K2002363-LCS1	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Solids, Total Suspended (TSS)	398	mg/L		20		NONE	SM 2540 D
3532	K2002363-LCS2	LAB CONTROL SAMPLE	NA	Ocean Water	LCS2	Carbon, Total Organic	23.1	mg/L		0.5	0.07	NONE	9060A
3532	K2002363-LCS3	LAB CONTROL SAMPLE	NA	Ocean Water	LCS3	Carbon, Total Organic	23.2	mg/L		0.5	0.07	NONE	9060A
3532	K2002363-LCS4	LAB CONTROL SAMPLE	NA	Ocean Water	LCS4	Carbon, Total Organic	23.2	mg/L		0.5	0.07	NONE	9060A
3532	K2002363-001DUP	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	0.3	mg/L	J	1	0.2	NONE	9060A
3532	K2002363-003DUP	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-005DUP	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-007DUP	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-009DUP	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-011DUP	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-013DUP	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-015DUP	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-017DUP	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-019DUP	3532|03_20|HH-4|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-001MS1	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	28.3	mg/L	*	1	0.2	NONE	9060A
3532	K2002363-001MS2	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	28.3	mg/L	*	1	0.2	NONE	9060A
3532	K2002363-001MS3	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	28.7	mg/L	*	1	0.2	NONE	9060A
3532	K2002363-001MS4	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	29	mg/L	*	1	0.2	NONE	9060A
3532	K2002363-001QUAD	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-003QUAD	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-005QUAD	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-007QUAD	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-009QUAD	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-011QUAD	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-013QUAD	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-015QUAD	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-017QUAD	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-019QUAD	3532|03_20|HH-4|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-001TRP	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-003TRP	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-005TRP	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002363-007TRP	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A

3532	K2002363-009TRP	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE		9060A
3532	K2002363-011TRP	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE		9060A
3532	K2002363-013TRP	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE		9060A
3532	K2002363-015TRP	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE		9060A
3532	K2002363-017TRP	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE		9060A
3532	K2002363-019TRP	3532|03_20|HH-4|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE		9060A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.26	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Barium, Total	8	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.009	UG/L	J	0.02	0.003	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.17	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.28	UG/L		0.1	0.02	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.504	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	19.4	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.17	UG/L	J	0.2	0.03	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.5	UG/L	J	1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Silver, Total	0.011	UG/L	J	0.02	0.004	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8000	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.015	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Tin, Total	13	UG/L	J	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	2.9	UG/L	J	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-001	3532|03_20|HH-1|SW_S|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	2.01	UG/L		0.5	0.2	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.3	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total	6.5	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.004	UG/L	J	0.02	0.003	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.06	UG/L	J	0.1	0.02	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.184	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	35	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.15	UG/L	J	0.2	0.03	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.4	UG/L	J	1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total	0.006	UG/L	J	0.02	0.004	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8430	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.017	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total	9	UG/L	J	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	ND	UG/L	U	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-003	3532|03_20|HH-1|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	ND	UG/L	U	0.5	0.2	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.51	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total	8.1	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.042	UG/L		0.02	0.003	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.18	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	0.328	UG/L		0.02	0.007	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.11	UG/L		0.1	0.02	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.059	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	15.9	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.43	UG/L		0.2	0.03	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.4	UG/L	J	1	0.4	EPA CLP ILM04.0		6020A

3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	7950	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.014	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Tin, Total	ND	UG/L	U	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	2.3	UG/L	J	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-005	3532|03_20|HH-1|SW_B|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	0.5	UG/L	J	0.5	0.2	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.44	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Barium, Total	6	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.08	UG/L	J	0.1	0.02	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.078	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	13	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.15	UG/L	J	0.2	0.03	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.4	UG/L	J	1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8400	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.012	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Tin, Total	3	UG/L	J	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	2.9	UG/L	J	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-007	3532|03_20|HH-2|SW_S|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	0.21	UG/L	J	0.5	0.2	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.2	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total	6.6	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.15	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.17	UG/L		0.1	0.02	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total	21	UG/L	J	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.227	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11.3	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.14	UG/L	J	0.2	0.03	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8110	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.013	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total	3	UG/L	J	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.5	UG/L	J	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-009	3532|03_20|HH-2|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	0.41	UG/L	J	0.5	0.2	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.52	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total	7.4	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.035	UG/L		0.02	0.003	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	0.008	UG/L	J	0.02	0.007	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.1	UG/L	J	0.1	0.02	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.041	UG/L	J	0.05	0.02	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	10.3	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.29	UG/L		0.2	0.03	EPA 1640		6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.5	UG/L	J	1	0.4	EPA CLP ILM04.0		6020A

3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	7920	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.013	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Tin, Total	3	UG/L	J	21	2	EPA CLP ILM04.0	6010C
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	2.3	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002363-011	3532|03_20|HH-2|SW_B|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	0.36	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.29	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Barium, Total	8.3	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.13	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.209	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	1.4	UG/L	J	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	10.9	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.16	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.4	UG/L	J	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8010	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.013	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Tin, Total	ND	UG/L	U	21	2	EPA CLP ILM04.0	6010C
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.7	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002363-013	3532|03_20|HH-3|SW_S|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	0.91	UG/L		0.5	0.2	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.46	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total	6.2	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.015	UG/L	J	0.02	0.003	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.15	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.07	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.134	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	10.9	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.2	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.5	UG/L	J	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8470	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.013	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total	3	UG/L	J	21	2	EPA CLP ILM04.0	6010C
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.4	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002363-015	3532|03_20|HH-3|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	ND	UG/L	U	0.5	0.2	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.48	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total	6.1	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.17	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.4	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Iron, Total	19	UG/L	J	21	8	EPA CLP ILM04.0	6010C
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.112	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	1.8	UG/L	J	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11.1	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.17	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.5	UG/L	J	1	0.4	EPA CLP ILM04.0	6020A

3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Strontium, Total	8310	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Thallium, Total	0.012	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Tin, Total	ND	UG/L	U	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total	ND	UG/L	U	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	0.53	UG/L		0.5	0.2	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0		6010C
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.28	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Barium, Total	7.8	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.005	UG/L	J	0.02	0.003	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Copper, Total	0.19	UG/L		0.1	0.02	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0		6010C
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Lead, Total	0.181	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Manganese, Total	1.5	UG/L	J	4	0.8	EPA CLP ILM04.0		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11	UG/L		8.4	2.1	EPA CLP ILM04.0		6010C
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Nickel, Total	0.16	UG/L	J	0.2	0.03	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Selenium, Total	0.4	UG/L	J	1	0.4	EPA CLP ILM04.0		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Strontium, Total	8340	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Thallium, Total	0.013	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Tin, Total	2	UG/L	J	21	2	EPA CLP ILM04.0		6010C
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.4	UG/L	J	4.2	1.1	EPA CLP ILM04.0		6010C
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	0.94	UG/L		0.5	0.2	EPA 1640		6020A
3532	KQ2004063-02	METHOD BLANK	NA		Ocean Water	MB1	Aluminum, Total	ND	UG/L	U	21	4	EPA CLP ILM04.0		6010C
3532	KQ2004063-02	METHOD BLANK	NA		Ocean Water	MB1	Iron, Total	ND	UG/L	U	21	3	EPA CLP ILM04.0		6010C
3532	KQ2004063-02	METHOD BLANK	NA		Ocean Water	MB1	Molybdenum, Total	ND	UG/L	U	8.4	0.9	EPA CLP ILM04.0		6010C
3532	KQ2004063-02	METHOD BLANK	NA		Ocean Water	MB1	Strontium, Total	ND	UG/L	U	1.1	0.2	EPA CLP ILM04.0		6010C
3532	KQ2004063-02	METHOD BLANK	NA		Ocean Water	MB1	Tin, Total	ND	UG/L	U	21	3	EPA CLP ILM04.0		6010C
3532	KQ2004063-02	METHOD BLANK	NA		Ocean Water	MB1	Vanadium, Total	ND	UG/L	U	4.2	1.1	EPA CLP ILM04.0		6010C
3532	KQ2004066-01	METHOD BLANK	NA		Ocean Water	MB1	Barium, Total	ND	UG/L	U	0.05	0.02	EPA CLP ILM04.0		6020A
3532	KQ2004066-01	METHOD BLANK	NA		Ocean Water	MB1	Manganese, Total	0.08	UG/L	J	0.2	0.04	EPA CLP ILM04.0		6020A
3532	KQ2004067-02	METHOD BLANK	NA		Ocean Water	MB1	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Arsenic, Total	ND	UG/L	U	0.5	0.06	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Chromium, Total	ND	UG/L	U	0.2	0.02	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Copper, Total	ND	UG/L	U	0.1	0.02	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Lead, Total	ND	UG/L	U	0.05	0.02	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Nickel, Total	ND	UG/L	U	0.2	0.03	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Thallium, Total	ND	UG/L	U	0.02	0.008	EPA 1640		6020A
3532	KQ2004069-01	METHOD BLANK	NA		Ocean Water	MB1	Zinc, Total	ND	UG/L	U	0.5	0.2	EPA 1640		6020A
3532	KQ2004063-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Aluminum, Total	5520	UG/L		22	4	EPA CLP ILM04.0		6010C
3532	KQ2004063-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Iron, Total	2650	UG/L		22	3	EPA CLP ILM04.0		6010C
3532	KQ2004063-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Molybdenum, Total	1060	UG/L		8.7	1	EPA CLP ILM04.0		6010C
3532	KQ2004063-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Strontium, Total	10200	UG/L		1.1	0.2	EPA CLP ILM04.0		6010C
3532	KQ2004063-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Tin, Total	10300	UG/L		22	3	EPA CLP ILM04.0		6010C
3532	KQ2004063-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Vanadium, Total	1310	UG/L		4.4	1.1	EPA CLP ILM04.0		6010C
3532	KQ2004066-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Barium, Total	106	UG/L		0.052	0.021	EPA CLP ILM04.0		6020A
3532	KQ2004066-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Manganese, Total	24.7	UG/L		0.21	0.04	EPA CLP ILM04.0		6020A
3532	KQ2004067-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Selenium, Total	53.7	UG/L		1	0.4	EPA CLP ILM04.0		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Arsenic, Total	1.96	UG/L		0.5	0.06	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Beryllium, Total	1.26	UG/L		0.02	0.007	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Cadmium, Total	2.06	UG/L		0.02	0.003	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Chromium, Total	1.98	UG/L		0.2	0.02	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Cobalt, Total	1.97	UG/L		0.02	0.007	EPA 1640		6020A

3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Copper, Total	2	UG/L		0.1	0.02	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Lead, Total	1.99	UG/L		0.05	0.02	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Nickel, Total	1.97	UG/L		0.2	0.03	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Silver, Total	1.02	UG/L		0.02	0.004	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Thallium, Total	1.97	UG/L		0.02	0.008	EPA 1640		6020A
3532	KQ2004069-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Zinc, Total	2.04	UG/L		0.5	0.2	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Arsenic, Total	1.89	UG/L		0.5	0.06	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Beryllium, Total	1.24	UG/L		0.02	0.007	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Cadmium, Total	1.98	UG/L		0.02	0.003	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Chromium, Total	1.97	UG/L		0.2	0.02	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Cobalt, Total	1.91	UG/L		0.02	0.007	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Copper, Total	1.95	UG/L		0.1	0.02	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Lead, Total	1.96	UG/L		0.05	0.02	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Nickel, Total	2.02	UG/L		0.2	0.03	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Silver, Total	0.976	UG/L		0.02	0.004	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Thallium, Total	1.93	UG/L		0.02	0.008	EPA 1640		6020A
3532	KQ2004069-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Zinc, Total	1.94	UG/L		0.5	0.2	EPA 1640		6020A
3532	KQ2004063-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Aluminum, Total	ND	UG/L	U	21	4	EPA CLP	ILM04.0	6010C
3532	KQ2004063-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Iron, Total	4	UG/L	J	21	3	EPA CLP	ILM04.0	6010C
3532	KQ2004063-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Molybdenum, Total	10.4	UG/L	#	8.4	0.9	EPA CLP	ILM04.0	6010C
3532	KQ2004063-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Strontium, Total	7980	UG/L		1.1	0.2	EPA CLP	ILM04.0	6010C
3532	KQ2004063-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Tin, Total	7	UG/L	J#	21	3	EPA CLP	ILM04.0	6010C
3532	KQ2004063-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Vanadium, Total	2.4	UG/L	J	4.2	1.1	EPA CLP	ILM04.0	6010C
3532	KQ2004066-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Barium, Total	7.9	UG/L		1	0.4	EPA CLP	ILM04.0	6020A
3532	KQ2004066-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP	ILM04.0	6020A
3532	KQ2004067-03	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DUP1	Selenium, Total	0.5	UG/L	J	1	0.4	EPA CLP	ILM04.0	6020A
3532	KQ2004063-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Aluminum, Total	1570	UG/L		22	4	EPA CLP	ILM04.0	6010C
3532	KQ2004063-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Iron, Total	936	UG/L		22	3	EPA CLP	ILM04.0	6010C
3532	KQ2004063-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Molybdenum, Total	977	UG/L		8.9	1	EPA CLP	ILM04.0	6010C
3532	KQ2004063-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Strontium, Total	17300	UG/L		1.1	0.2	EPA CLP	ILM04.0	6010C
3532	KQ2004063-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Tin, Total	8700	UG/L		22	3	EPA CLP	ILM04.0	6010C
3532	KQ2004063-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Vanadium, Total	510	UG/L		4.4	1.1	EPA CLP	ILM04.0	6010C
3532	KQ2004066-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Barium, Total	2180	UG/L		1	0.4	EPA CLP	ILM04.0	6020A
3532	KQ2004066-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Manganese, Total	495	UG/L		4.1	0.8	EPA CLP	ILM04.0	6020A
3532	KQ2004067-04	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Selenium, Total	52.8	UG/L		1	0.4	EPA CLP	ILM04.0	6020A
3532	K2002363-001	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.4	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-003	3532|03_20|HH-1|SW_M|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.19	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-005	3532|03_20|HH-1|SW_B|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.37	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-007	3532|03_20|HH-2|SW_S|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.15	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-009	3532|03_20|HH-2|SW_M|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.23	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-011	3532|03_20|HH-2|SW_B|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.13	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-013	3532|03_20|HH-3|SW_S|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.22	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-015	3532|03_20|HH-3|SW_M|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.15	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-017	3532|03_20|HH-3|SW_B|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.31	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-019	3532|03_20|HH-4|SW_S|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.17	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-MB1	METHOD BLANK 1	NA		Ocean Water	MB1	Mercury, Total	0.14	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-MB2	METHOD BLANK 2	NA		Ocean Water	MB2	Mercury, Total	0.11	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-MB3	METHOD BLANK 3	NA		Ocean Water	MB3	Mercury, Total	0.06	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002363-001MS	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	MS1	Mercury, Total	52.6	ng/L		0.5	0.06	METHOD		1631E
3532	K2002363-001DMS	3532|03_20|HH-1|SW_S|01		3/13/2020	Ocean Water	DMS1	Mercury, Total	52.1	ng/L		0.5	0.06	METHOD		1631E
3532	K2002363-QCS1	QUALITY CONTROL SAMPLE	NA		Ocean Water	QCS1	Mercury, Total	4.85	ng/L		0.5	0.09	METHOD		1631E

Job	Lab Code	Sample	Date Collected	Matrix	Sample Type	Component	Result	Units	Result Notes	Reporting Limit	Detection Limit	Extraction Meth	Method
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	6.5	mg/L		5		NONE	SM 2540 D
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	5	mg/L		5		NONE	SM 2540 D
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	6.5	mg/L		5		NONE	SM 2540 D
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-020	3532|03_20|HH-7|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	23.5	mg/L		5		NONE	SM 2540 D
3532	K2002369-MB1	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB1	METHOD BLANK	NA	Ocean Water	MB1	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-MB2	METHOD BLANK	NA	Ocean Water	MB2	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB2	METHOD BLANK	NA	Ocean Water	MB2	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002369-MB3	METHOD BLANK	NA	Ocean Water	MB3	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB4	METHOD BLANK	NA	Ocean Water	MB4	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB5	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB6	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB7	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-MB8	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002369-LCS1	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	23.1	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS1	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Solids, Total Suspended (TSS)	406	mg/L		20		NONE	SM 2540 D
3532	K2002369-LCS2	LAB CONTROL SAMPLE	NA	Ocean Water	LCS2	Carbon, Total Organic	23.1	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS3	LAB CONTROL SAMPLE	NA	Ocean Water	LCS3	Carbon, Total Organic	23.2	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS4	LAB CONTROL SAMPLE	NA	Ocean Water	LCS4	Carbon, Total Organic	23.2	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS5	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	22.6	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS6	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	22.6	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS7	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	22.5	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-LCS8	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	22.6	mg/L		0.5	0.07	NONE	9060A
3532	K2002369-001DUP	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-003DUP	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-005DUP	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-007DUP	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-009DUP	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-011DUP	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-016DUP	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-018DUP	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-020DUP	3532|03_20|HH-7|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-001MS1	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	32.8	mg/L	*	1	0.2	NONE	9060A
3532	K2002369-001MS2	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	29.9	mg/L	*	1	0.2	NONE	9060A
3532	K2002369-001MS3	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	32.2	mg/L	*	1	0.2	NONE	9060A
3532	K2002369-001MS4	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	30	mg/L	*	1	0.2	NONE	9060A
3532	K2002369-001QUAD	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-003QUAD	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-005QUAD	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-007QUAD	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-009QUAD	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-011QUAD	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-016QUAD	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-018QUAD	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-020QUAD	3532|03_20|HH-7|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-001TRP	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-003TRP	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-005TRP	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-007TRP	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-009TRP	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-011TRP	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-016TRP	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-018TRP	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002369-020TRP	3532|03_20|HH-7|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A

3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM04	6010C
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.38	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total		7	UG/L		1	0.4	EPA CLP ILM04	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total		0.005	UG/L	J	0.02	0.003	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.15	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.08	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM04	6010C
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.101	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM04	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		19.7	UG/L		8.4	2.1	EPA CLP ILM04	6010C
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.17	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP ILM04	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total		0.009	UG/L	J	0.02	0.004	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		8060	UG/L		1.1	0.2	EPA CLP ILM04	6010C
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.016	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total		12	UG/L	J	21	2	EPA CLP ILM04	6010C
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		1.8	UG/L	J	4.2	1.1	EPA CLP ILM04	6010C
3532	K2002369-001	3532|03_20|HH-4|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total		0.25	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM04	6010C
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.41	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total		8.5	UG/L		1	0.4	EPA CLP ILM04	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total		0.057	UG/L		0.02	0.003	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.17	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.15	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM04	6010C
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.086	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM04	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		34.5	UG/L		8.4	2.1	EPA CLP ILM04	6010C
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.35	UG/L		0.2	0.03	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Selenium, Total		0.6	UG/L	J	1	0.4	EPA CLP ILM04	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		8000	UG/L		1.1	0.2	EPA CLP ILM04	6010C
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.014	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Tin, Total		9	UG/L	J	21	2	EPA CLP ILM04	6010C
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		2	UG/L	J	4.2	1.1	EPA CLP ILM04	6010C
3532	K2002369-003	3532|03_20|HH-4|SW_B|01	3/13/2020	Ocean Water	SMPL	Zinc, Total		0.49	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM04	6010C
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.24	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Barium, Total		8	UG/L		1	0.4	EPA CLP ILM04	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND		UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.14	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.15	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM04	6010C
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.156	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM04	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		16.4	UG/L		8.4	2.1	EPA CLP ILM04	6010C
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.17	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Selenium, Total		0.5	UG/L	J	1	0.4	EPA CLP ILM04	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		7710	UG/L		1.1	0.2	EPA CLP ILM04	6010C
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.011	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Tin, Total		2	UG/L	J	21	2	EPA CLP ILM04	6010C
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		1.4	UG/L	J	4.2	1.1	EPA CLP ILM04	6010C
3532	K2002369-005	3532|03_20|HH-5|SW_S|01	3/13/2020	Ocean Water	SMPL	Zinc, Total		0.73	UG/L		0.5	0.2	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM04	6010C
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.35	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total		6.7	UG/L		1	0.4	EPA CLP ILM04	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total		0.008	UG/L	J	0.02	0.003	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.08	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total		9	UG/L	J	21	8	EPA CLP ILM04	6010C

3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.045	UG/L	J	0.05	0.02	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM0.	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		14.7	UG/L		8.4	2.1	EPA CLP ILM0.	6010C
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.19	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total		0.5	UG/L	J	1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		7890	UG/L		1.1	0.2	EPA CLP ILM0.	6010C
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.012	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total		2	UG/L	J	21	2	EPA CLP ILM0.	6010C
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		2	UG/L	J	4.2	1.1	EPA CLP ILM0.	6010C
3532	K2002369-007	3532|03_20|HH-5|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	ND		UG/L	U	0.5	0.2	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM0.	6010C
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.47	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total		7.5	UG/L		1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total		0.026	UG/L		0.02	0.003	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.1	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM0.	6010C
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.064	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM0.	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		12.9	UG/L		8.4	2.1	EPA CLP ILM0.	6010C
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.26	UG/L		0.2	0.03	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Selenium, Total		0.5	UG/L	J	1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		8070	UG/L		1.1	0.2	EPA CLP ILM0.	6010C
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.012	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Tin, Total	ND		UG/L	U	21	2	EPA CLP ILM0.	6010C
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		2.2	UG/L	J	4.2	1.1	EPA CLP ILM0.	6010C
3532	K2002369-009	3532|03_20|HH-5|SW_B|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	ND		UG/L	U	0.5	0.2	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM0.	6010C
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.24	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Barium, Total		7.4	UG/L		1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND		UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.14	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.12	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM0.	6010C
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.107	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM0.	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		12.3	UG/L		8.4	2.1	EPA CLP ILM0.	6010C
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.16	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		7880	UG/L		1.1	0.2	EPA CLP ILM0.	6010C
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.011	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Tin, Total	ND		UG/L	U	21	2	EPA CLP ILM0.	6010C
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		1.3	UG/L	J	4.2	1.1	EPA CLP ILM0.	6010C
3532	K2002369-011	3532|03_20|HH-6|SW_S|01	3/13/2020	Ocean Water	SMPL	Zinc, Total		0.43	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Aluminum, Total		2.7	UG/L	J	4	0.5	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Arsenic, Total	ND		UG/L	U	0.5	0.09	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Barium, Total		0.896	UG/L		0.05	0.02	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.005	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Cadmium, Total	ND		UG/L	U	0.02	0.008	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Chromium, Total		0.03	UG/L	J	0.2	0.03	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Copper, Total		0.4	UG/L		0.1	0.05	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Iron, Total		3.8	UG/L		2	0.3	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Lead, Total		0.318	UG/L		0.02	0.006	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Manganese, Total		0.13	UG/L	J	0.2	0.04	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Molybdenum, Total		0.18	UG/L		0.1	0.03	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Nickel, Total	ND		UG/L	U	0.2	0.04	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.2	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Strontium, Total		129	UG/L		0.2	0.07	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Thallium, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Tin, Total	ND		UG/L	U	0.1	0.03	EPA CLP ILM0.	6020A

3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Vanadium, Total		0.05	UG/L	J	0.2	0.04	EPA CLP ILM0.	6020A
3532	K2002369-013	3532|03_20|EB|DIW|MET|01	3/13/2020	Water	SMPL	Zinc, Total		2.5	UG/L		2	0.5	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Aluminum, Total		1.9	UG/L	J	4	0.5	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Arsenic, Total	ND		UG/L	U	0.5	0.09	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Barium, Total		0.146	UG/L		0.05	0.02	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.005	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Cadmium, Total	ND		UG/L	U	0.02	0.008	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Chromium, Total	ND		UG/L	U	0.2	0.03	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Copper, Total		0.42	UG/L		0.1	0.05	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Iron, Total		5.1	UG/L		2	0.3	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Lead, Total		0.196	UG/L		0.02	0.006	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Manganese, Total		0.13	UG/L	J	0.2	0.04	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Molybdenum, Total	ND		UG/L	U	0.1	0.03	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Nickel, Total		0.04	UG/L	J	0.2	0.04	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.2	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Strontium, Total		0.82	UG/L		0.2	0.07	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Thallium, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Tin, Total	ND		UG/L	U	0.1	0.03	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Vanadium, Total	ND		UG/L	U	0.2	0.04	EPA CLP ILM0.	6020A
3532	K2002369-014	3532|03_20|FB|DIW|MET|01	3/13/2020	Water	SMPL	Zinc, Total		1.6	UG/L	J	2	0.5	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Aluminum, Total		260	UG/L	J	400	50	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Arsenic, Total	ND		UG/L	U	50	9	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Barium, Total	ND		UG/L	U	5	2	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Beryllium, Total	ND		UG/L	U	2	0.5	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Cadmium, Total	ND		UG/L	U	2	0.8	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Chromium, Total	ND		UG/L	U	20	3	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Cobalt, Total	ND		UG/L	U	2	0.9	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Copper, Total	ND		UG/L	U	10	5	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Iron, Total		70	UG/L	J	200	30	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Lead, Total	ND		UG/L	U	2	0.6	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Manganese, Total	ND		UG/L	U	20	4	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Molybdenum, Total	ND		UG/L	U	10	3	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Nickel, Total	ND		UG/L	U	20	4	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Selenium, Total	ND		UG/L	U	100	20	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Silver, Total	ND		UG/L	U	2	0.9	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Strontium, Total		9	UG/L	J	20	7	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Thallium, Total	ND		UG/L	U	2	0.9	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Tin, Total	ND		UG/L	U	10	3	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Vanadium, Total	ND		UG/L	U	20	4	EPA CLP ILM0.	6020A
3532	K2002369-015	3532|03_20|HNO3|HC|01	3/13/2020	Water	SMPL	Zinc, Total	ND		UG/L	U	200	50	EPA CLP ILM0.	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM0.	6010C
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.45	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total		6.2	UG/L		1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND		UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total		0.07	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM0.	6010C
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total		0.074	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM0.	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total		12.3	UG/L		8.4	2.1	EPA CLP ILM0.	6010C
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total		0.16	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total		8420	UG/L		1.1	0.2	EPA CLP ILM0.	6010C
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total		0.011	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total		3	UG/L	J	21	2	EPA CLP ILM0.	6010C
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total		2.6	UG/L	J	4.2	1.1	EPA CLP ILM0.	6010C
3532	K2002369-016	3532|03_20|HH-6|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	ND		UG/L	U	0.5	0.2	EPA 1640	6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM0.	6010C
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.5	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total		7.9	UG/L		1	0.4	EPA CLP ILM0.	6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total		0.033	UG/L		0.02	0.003	EPA 1640	6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total		0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640	6020A

3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Copper, Total		0.09	UG/L	J	0.1	0.02	EPA 1640		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM0.		6010C
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Lead, Total		0.034	UG/L	J	0.05	0.02	EPA 1640		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM0.		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Molybdenum, Total		11.8	UG/L		8.4	2.1	EPA CLP ILM0.		6010C
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Nickel, Total		0.3	UG/L		0.2	0.03	EPA 1640		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP ILM0.		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Strontium, Total		7920	UG/L		1.1	0.2	EPA CLP ILM0.		6010C
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Thallium, Total		0.012	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Tin, Total		3	UG/L	J	21	2	EPA CLP ILM0.		6010C
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total		1.1	UG/L	J	4.2	1.1	EPA CLP ILM0.		6010C
3532	K2002369-018	3532|03_20|HH-6|SW_B|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	ND		UG/L	U	0.5	0.2	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND		UG/L	U	21	5	EPA CLP ILM0.		6010C
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Arsenic, Total		1.24	UG/L		0.5	0.06	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Barium, Total		7.2	UG/L		1	0.4	EPA CLP ILM0.		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND		UG/L	U	0.02	0.003	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Chromium, Total		0.14	UG/L	J	0.2	0.02	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Copper, Total		0.12	UG/L		0.1	0.02	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Iron, Total	ND		UG/L	U	21	8	EPA CLP ILM0.		6010C
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Lead, Total		0.104	UG/L		0.05	0.02	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP ILM0.		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Molybdenum, Total		12.1	UG/L		8.4	2.1	EPA CLP ILM0.		6010C
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Nickel, Total		0.17	UG/L	J	0.2	0.03	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP ILM0.		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Strontium, Total		7640	UG/L		1.1	0.2	EPA CLP ILM0.		6010C
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Thallium, Total		0.012	UG/L	J	0.02	0.008	EPA 1640		6020A
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Tin, Total	ND		UG/L	U	21	2	EPA CLP ILM0.		6010C
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total		1.5	UG/L	J	4.2	1.1	EPA CLP ILM0.		6010C
3532	K2002369-020	3532|03_20|HH-7|SW_S|01		3/13/2020	Ocean Water	SMPL	Zinc, Total		0.33	UG/L	J	0.5	0.2	EPA 1640		6020A
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Aluminum, Total	ND		UG/L	U	21	4	EPA CLP ILM0.		6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Iron, Total	ND		UG/L	U	21	3	EPA CLP ILM0.		6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Molybdenum, Total	ND		UG/L	U	8.4	0.9	EPA CLP ILM0.		6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Tin, Total	ND		UG/L	U	21	3	EPA CLP ILM0.		6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Vanadium, Total	ND		UG/L	U	4.2	1.1	EPA CLP ILM0.		6010C
3532	KQ2004070-01	METHOD BLANK	NA		Ocean Water	MB1	Barium, Total	ND		UG/L	U	0.05	0.02	EPA CLP ILM0.		6020A
3532	KQ2004070-01	METHOD BLANK	NA		Ocean Water	MB1	Manganese, Total	ND		UG/L	U	0.2	0.04	EPA CLP ILM0.		6020A
3532	KQ2004071-02	METHOD BLANK	NA		Ocean Water	MB1	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP ILM0.		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Arsenic, Total	ND		UG/L	U	0.5	0.06	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Beryllium, Total	ND		UG/L	U	0.02	0.007	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Cadmium, Total	ND		UG/L	U	0.02	0.003	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Chromium, Total	ND		UG/L	U	0.2	0.02	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Cobalt, Total	ND		UG/L	U	0.02	0.007	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Copper, Total	ND		UG/L	U	0.1	0.02	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Lead, Total	ND		UG/L	U	0.05	0.02	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Nickel, Total	ND		UG/L	U	0.2	0.03	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Silver, Total	ND		UG/L	U	0.02	0.004	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Thallium, Total	ND		UG/L	U	0.02	0.008	EPA 1640		6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Zinc, Total	ND		UG/L	U	0.5	0.2	EPA 1640		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Aluminum, Total		1.2	UG/L	J	4	0.5	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Arsenic, Total	ND		UG/L	U	0.5	0.09	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Barium, Total	ND		UG/L	U	0.05	0.02	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Beryllium, Total	ND		UG/L	U	0.02	0.005	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Cadmium, Total	ND		UG/L	U	0.02	0.008	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Chromium, Total	ND		UG/L	U	0.2	0.03	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Cobalt, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Copper, Total	ND		UG/L	U	0.1	0.05	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Iron, Total		0.8	UG/L	J	2	0.3	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Lead, Total	ND		UG/L	U	0.02	0.006	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Manganese, Total	ND		UG/L	U	0.2	0.04	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Molybdenum, Total	ND		UG/L	U	0.1	0.03	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Nickel, Total		0.05	UG/L	J	0.2	0.04	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Selenium, Total	ND		UG/L	U	1	0.2	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Silver, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Strontium, Total	ND		UG/L	U	0.2	0.07	EPA CLP ILM0.		6020A
3532	KQ2004120-01	METHOD BLANK	NA		Ocean Water	MB1	Thallium, Total	ND		UG/L	U	0.02	0.009	EPA CLP ILM0.		6020A

3532	KQ2004120-01	METHOD BLANK	NA	Ocean Water	MB1	Tin, Total	ND	UG/L	U	0.1	0.03	EPA CLP ILM0	6020A
3532	KQ2004120-01	METHOD BLANK	NA	Ocean Water	MB1	Vanadium, Total	ND	UG/L	U	0.2	0.04	EPA CLP ILM0	6020A
3532	KQ2004120-01	METHOD BLANK	NA	Ocean Water	MB1	Zinc, Total	ND	UG/L	U	2	0.5	EPA CLP ILM0	6020A
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Aluminum, Total	5760	UG/L		22	4	EPA CLP ILM0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Iron, Total	2570	UG/L		22	3	EPA CLP ILM0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Molybdenum, Total	1080	UG/L		8.7	1	EPA CLP ILM0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Strontium, Total	10400	UG/L		1.1	0.2	EPA CLP ILM0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Tin, Total	10500	UG/L		22	3	EPA CLP ILM0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Vanadium, Total	1330	UG/L		4.4	1.1	EPA CLP ILM0	6010C
3532	KQ2004070-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Barium, Total	101	UG/L		0.052	0.021	EPA CLP ILM0	6020A
3532	KQ2004070-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Manganese, Total	24.1	UG/L		0.21	0.04	EPA CLP ILM0	6020A
3532	KQ2004071-01	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Selenium, Total	54.5	UG/L		1	0.4	EPA CLP ILM0	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Arsenic, Total	1.91	UG/L		0.5	0.06	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Beryllium, Total	1.24	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Cadmium, Total	1.95	UG/L		0.02	0.003	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Chromium, Total	1.95	UG/L		0.2	0.02	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Cobalt, Total	1.91	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Copper, Total	1.9	UG/L		0.1	0.02	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Lead, Total	1.9	UG/L		0.05	0.02	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Nickel, Total	2.08	UG/L		0.2	0.03	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Silver, Total	0.966	UG/L		0.02	0.004	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Thallium, Total	1.89	UG/L		0.02	0.008	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Zinc, Total	1.95	UG/L		0.5	0.2	EPA 1640	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Aluminum, Total	100	UG/L		4.2	0.5	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Arsenic, Total	51.7	UG/L		0.52	0.09	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Barium, Total	106	UG/L		0.052	0.021	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Beryllium, Total	2.55	UG/L		0.021	0.005	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Cadmium, Total	24.8	UG/L		0.021	0.008	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Chromium, Total	10.6	UG/L		0.21	0.03	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Cobalt, Total	24.5	UG/L		0.021	0.009	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Copper, Total	12.8	UG/L		0.1	0.05	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Iron, Total	53.9	UG/L		2.1	0.3	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Lead, Total	51.2	UG/L		0.021	0.006	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Manganese, Total	26.1	UG/L		0.21	0.04	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Molybdenum, Total	25	UG/L		0.1	0.03	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Nickel, Total	26.3	UG/L		0.21	0.04	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Selenium, Total	54.5	UG/L		1	0.2	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Silver, Total	13.1	UG/L		0.021	0.009	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Strontium, Total	27.1	UG/L		0.21	0.07	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Thallium, Total	52.5	UG/L		0.021	0.009	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Tin, Total	26.9	UG/L		0.1	0.03	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Vanadium, Total	25.5	UG/L		0.21	0.04	EPA CLP ILM0	6020A
3532	KQ2004120-02	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Zinc, Total	26.9	UG/L		2.1	0.5	EPA CLP ILM0	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Arsenic, Total	1.82	UG/L		0.5	0.06	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Beryllium, Total	1.19	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Cadmium, Total	1.87	UG/L		0.02	0.003	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Chromium, Total	1.86	UG/L		0.2	0.02	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Cobalt, Total	1.81	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Copper, Total	1.83	UG/L		0.1	0.02	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Lead, Total	1.82	UG/L		0.05	0.02	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Nickel, Total	1.98	UG/L		0.2	0.03	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Silver, Total	0.92	UG/L		0.02	0.004	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Thallium, Total	1.79	UG/L		0.02	0.008	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Zinc, Total	1.87	UG/L		0.5	0.2	EPA 1640	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Aluminum, Total	96.8	UG/L		4.2	0.5	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Arsenic, Total	49.5	UG/L		0.52	0.09	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Barium, Total	101	UG/L		0.052	0.021	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Beryllium, Total	2.44	UG/L		0.021	0.005	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Cadmium, Total	23.3	UG/L		0.021	0.008	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Chromium, Total	9.95	UG/L		0.21	0.03	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Cobalt, Total	23.3	UG/L		0.021	0.009	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Copper, Total	12.2	UG/L		0.1	0.05	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Iron, Total	52.2	UG/L		2.1	0.3	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Lead, Total	48.7	UG/L		0.021	0.006	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Manganese, Total	24.7	UG/L		0.21	0.04	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Molybdenum, Total	23.8	UG/L		0.1	0.03	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Nickel, Total	25.2	UG/L		0.21	0.04	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Selenium, Total	51.7	UG/L		1	0.2	EPA CLP ILM0	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA	Ocean Water	DLCS1	Silver, Total	12.2	UG/L		0.021	0.009	EPA CLP ILM0	6020A

3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA		Ocean Water	DLCS1	Strontium, Total		25.8	UG/L		0.21	0.07	EPA CLP	ILM0.	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA		Ocean Water	DLCS1	Thallium, Total		50.4	UG/L		0.021	0.009	EPA CLP	ILM0.	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA		Ocean Water	DLCS1	Tin, Total		25.4	UG/L		0.1	0.03	EPA CLP	ILM0.	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA		Ocean Water	DLCS1	Vanadium, Total		24.6	UG/L		0.21	0.04	EPA CLP	ILM0.	6020A
3532	KQ2004120-03	DUPLICATE LAB CONTROL S	NA		Ocean Water	DLCS1	Zinc, Total		25.3	UG/L		2.1	0.5	EPA CLP	ILM0.	6020A
3532	KQ2004064-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Aluminum, Total	ND		UG/L	U	21	4	EPA CLP	ILM0.	6010C
3532	KQ2004064-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Iron, Total	ND		UG/L	U	21	3	EPA CLP	ILM0.	6010C
3532	KQ2004064-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Molybdenum, Total		10.8	UG/L	#	8.4	0.9	EPA CLP	ILM0.	6010C
3532	KQ2004064-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Strontium, Total		8190	UG/L		1.1	0.2	EPA CLP	ILM0.	6010C
3532	KQ2004064-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Tin, Total		3	UG/L	J#	21	3	EPA CLP	ILM0.	6010C
3532	KQ2004064-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Vanadium, Total		2	UG/L	J	4.2	1.1	EPA CLP	ILM0.	6010C
3532	KQ2004070-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Barium, Total		5.6	UG/L	*	1	0.4	EPA CLP	ILM0.	6020A
3532	KQ2004070-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Manganese, Total	ND		UG/L	U	4	0.8	EPA CLP	ILM0.	6020A
3532	KQ2004071-03	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	DUP1	Selenium, Total	ND		UG/L	U	1	0.4	EPA CLP	ILM0.	6020A
3532	KQ2004064-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Aluminum, Total		1560	UG/L		22	4	EPA CLP	ILM0.	6010C
3532	KQ2004064-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Iron, Total		908	UG/L		22	3	EPA CLP	ILM0.	6010C
3532	KQ2004064-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Molybdenum, Total		982	UG/L		8.9	1	EPA CLP	ILM0.	6010C
3532	KQ2004064-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Strontium, Total		17800	UG/L		1.1	0.2	EPA CLP	ILM0.	6010C
3532	KQ2004064-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Tin, Total		8620	UG/L		22	3	EPA CLP	ILM0.	6010C
3532	KQ2004064-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Vanadium, Total		512	UG/L		4.4	1.1	EPA CLP	ILM0.	6010C
3532	KQ2004070-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Barium, Total		2110	UG/L		1	0.4	EPA CLP	ILM0.	6020A
3532	KQ2004070-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Manganese, Total		484	UG/L		4.1	0.8	EPA CLP	ILM0.	6020A
3532	KQ2004071-04	3532|03_20|HH-4|SW_M|01		3/13/2020	Ocean Water	MS1	Selenium, Total		50.6	UG/L		1	0.4	EPA CLP	ILM0.	6020A
3532	K2002369-001	3532|03_20|HH-4|sw_m|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.11	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-003	3532|03_20|HH-4|sw_b|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.32	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-005	3532|03_20|HH-5|sw_s|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.16	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-007	3532|03_20|HH-5|sw_m|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.21	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-009	3532|03_20|HH-5|sw_b|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.22	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-011	3532|03_20|HH-6|sw_s|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.16	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-013	3532|03_20|EB|diw|met|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.08	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-014	3532|03_20|FB|diw|met|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.13	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-015	3532|03_20|HNO3|hc|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		1.7	ng/L	J	9.25	1.11	METHOD		1631E
3532	K2002369-016	3532|03_20|HH-6|sw_m|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.14	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-018	3532|03_20|HH-6|sw_b|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.21	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-020	3532|03_20|HH-7|sw_s|01		3/13/2020	Ocean Water	SMPL	Mercury, Total		0.25	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-MB1	Method Blank 1	NA		Ocean Water	MB1	Mercury, Total		0.11	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-MB2	Method Blank 2	NA		Ocean Water	MB2	Mercury, Total		0.07	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-MB3	Method Blank 3	NA		Ocean Water	MB3	Mercury, Total		0.11	ng/L	J	0.5	0.06	METHOD		1631E
3532	K2002369-001MS	3532|03_20|HH-4|sw_m|01		3/13/2020	Ocean Water	MS1	Mercury, Total		53	ng/L		0.5	0.06	METHOD		1631E
3532	K2002369-001DMS	3532|03_20|HH-4|sw_m|01		3/13/2020	Ocean Water	DMS1	Mercury, Total		51.9	ng/L		0.5	0.06	METHOD		1631E
3532	K2002369-QCS1	Quality Control Sample	NA		Ocean Water	QCS1	Mercury, Total		4.53	ng/L		0.5	0.09	METHOD		1631E

Job	Lab Code	Sample	Date Collected	Matrix	Sample Type	Component	Result	Units	Result Notes	Reporting Limit	Detection Limit	Extraction Method	Method
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-006	3532|03_20|HH-8|SW_S|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-008	3532|03_20|HH-8|SW_M|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-010	3532|03_20|HH-8|SW_B|01	3/13/2020	Ocean Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01	3/13/2020	Ocean Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-012	3532|03_20|H2SO4|TOC|01	3/13/2020	Water	SMPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-013	3532-TSS-DI BLANK	3/13/2020	Water	SMPL	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-MB1	METHOD BLANK	NA	Ocean Water	MB1	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002371-MB1	METHOD BLANK	NA	Ocean Water	MB1	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-MB2	METHOD BLANK	NA	Ocean Water	MB2	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002371-MB2	METHOD BLANK	NA	Ocean Water	MB2	Solids, Total Suspended (TSS)	ND	mg/L	U	5		NONE	SM 2540 D
3532	K2002371-MB3	METHOD BLANK	NA	Ocean Water	MB3	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002371-MB4	METHOD BLANK	NA	Ocean Water	MB4	Carbon, Total Organic	ND	mg/L	U	0.5	0.07	NONE	9060A
3532	K2002371-LCS1	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Carbon, Total Organic	22.6	mg/L		0.5	0.07	NONE	9060A
3532	K2002371-LCS1	LAB CONTROL SAMPLE	NA	Ocean Water	LCS1	Solids, Total Suspended (TSS)	406	mg/L		20		NONE	SM 2540 D
3532	K2002371-LCS2	LAB CONTROL SAMPLE	NA	Ocean Water	LCS2	Carbon, Total Organic	22.6	mg/L		0.5	0.07	NONE	9060A
3532	K2002371-LCS3	LAB CONTROL SAMPLE	NA	Ocean Water	LCS3	Carbon, Total Organic	22.5	mg/L		0.5	0.07	NONE	9060A
3532	K2002371-LCS4	LAB CONTROL SAMPLE	NA	Ocean Water	LCS4	Carbon, Total Organic	22.6	mg/L		0.5	0.07	NONE	9060A
3532	K2002371-002DUP	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-004DUP	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-006DUP	3532|03_20|HH-8|SW_S|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-008DUP	3532|03_20|HH-8|SW_M|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-010DUP	3532|03_20|HH-8|SW_B|01	3/13/2020	Ocean Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-012DUP	3532|03_20|H2SO4|TOC|01	3/13/2020	Water	DUP1	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-002MS1	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	26.8	mg/L	*	1	0.2	NONE	9060A
3532	K2002371-002MS2	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	26.4	mg/L	*	1	0.2	NONE	9060A
3532	K2002371-002MS3	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	26.5	mg/L	*	1	0.2	NONE	9060A
3532	K2002371-002MS4	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	MS1	Carbon, Total Organic	26.2	mg/L	*	1	0.2	NONE	9060A
3532	K2002371-002QUAD	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-004QUAD	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-006QUAD	3532|03_20|HH-8|SW_S|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-008QUAD	3532|03_20|HH-8|SW_M|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-010QUAD	3532|03_20|HH-8|SW_B|01	3/13/2020	Ocean Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-012QUAD	3532|03_20|H2SO4|TOC|01	3/13/2020	Water	QUAD	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-002TRP	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-004TRP	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-006TRP	3532|03_20|HH-8|SW_S|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-008TRP	3532|03_20|HH-8|SW_M|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-010TRP	3532|03_20|HH-8|SW_B|01	3/13/2020	Ocean Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-012TRP	3532|03_20|H2SO4|TOC|01	3/13/2020	Water	TPL	Carbon, Total Organic	ND	mg/L	U	1	0.2	NONE	9060A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.44	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Barium, Total	7.8	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.07	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.102	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11.7	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.17	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	8330	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.011	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Tin, Total	ND	UG/L	U	21	2	EPA CLP ILM04.0	6010C
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.5	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002371-002	3532|03_20|HH-7|SW_M|01	3/13/2020	Ocean Water	SMPL	Zinc, Total	0.29	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.49	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Barium, Total	8.4	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.033	UG/L		0.02	0.003	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Copper, Total	0.1	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Lead, Total	0.072	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Molybdenum, Total	10.4	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Nickel, Total	0.3	UG/L		0.2	0.03	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Selenium, Total	0.4	UG/L	J	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Strontium, Total	7800	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Thallium, Total	0.013	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002371-004	3532|03_20|HH-7|SW_B|01	3/13/2020	Ocean Water	SMPL	Tin, Total	2	UG/L	J	21	2	EPA CLP ILM04.0	6010C

3532	K2002371-004	3532|03_20|HH-7|SW_B|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total	ND	UG/L	U	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002371-004	3532|03_20|HH-7|SW_B|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	0.29	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.23	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Barium, Total	8.8	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Copper, Total	0.16	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Lead, Total	0.147	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11.2	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Nickel, Total	0.16	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Strontium, Total	7750	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Thallium, Total	0.012	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Tin, Total	2	UG/L	J	21	2	EPA CLP ILM04.0	6010C
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.2	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	0.78	UG/L		0.5	0.2	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.44	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Barium, Total	5.8	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Copper, Total	0.06	UG/L	J	0.1	0.02	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Lead, Total	0.07	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11.7	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Nickel, Total	0.15	UG/L	J	0.2	0.03	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Strontium, Total	8090	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Thallium, Total	0.011	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Tin, Total	4	UG/L	J	21	2	EPA CLP ILM04.0	6010C
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total	2	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	ND	UG/L	U	0.5	0.2	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Aluminum, Total	ND	UG/L	U	21	5	EPA CLP ILM04.0	6010C
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Arsenic, Total	1.45	UG/L		0.5	0.06	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Barium, Total	7.8	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Cadmium, Total	0.026	UG/L		0.02	0.003	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Chromium, Total	0.16	UG/L	J	0.2	0.02	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Copper, Total	0.12	UG/L		0.1	0.02	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Iron, Total	ND	UG/L	U	21	8	EPA CLP ILM04.0	6010C
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Lead, Total	0.053	UG/L		0.05	0.02	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Manganese, Total	ND	UG/L	U	4	0.8	EPA CLP ILM04.0	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Molybdenum, Total	11.3	UG/L		8.4	2.1	EPA CLP ILM04.0	6010C
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Nickel, Total	0.29	UG/L		0.2	0.03	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Strontium, Total	7920	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Thallium, Total	0.011	UG/L	J	0.02	0.008	EPA 1640	6020A
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Tin, Total	2	UG/L	J	21	2	EPA CLP ILM04.0	6010C
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Vanadium, Total	1.8	UG/L	J	4.2	1.1	EPA CLP ILM04.0	6010C
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Zinc, Total	0.44	UG/L	J	0.5	0.2	EPA 1640	6020A
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Aluminum, Total	ND	UG/L	U	21	4	EPA CLP ILM04.0	6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Iron, Total	ND	UG/L	U	21	3	EPA CLP ILM04.0	6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Molybdenum, Total	ND	UG/L	U	8.4	0.9	EPA CLP ILM04.0	6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Tin, Total	ND	UG/L	U	21	3	EPA CLP ILM04.0	6010C
3532	KQ2004064-02	METHOD BLANK	NA		Ocean Water	MB1	Vanadium, Total	ND	UG/L	U	4.2	1.1	EPA CLP ILM04.0	6010C
3532	KQ2004070-01	METHOD BLANK	NA		Ocean Water	MB1	Barium, Total	ND	UG/L	U	0.05	0.02	EPA CLP ILM04.0	6020A
3532	KQ2004070-01	METHOD BLANK	NA		Ocean Water	MB1	Manganese, Total	ND	UG/L	U	0.2	0.04	EPA CLP ILM04.0	6020A
3532	KQ2004071-02	METHOD BLANK	NA		Ocean Water	MB1	Selenium, Total	ND	UG/L	U	1	0.4	EPA CLP ILM04.0	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Arsenic, Total	ND	UG/L	U	0.5	0.06	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Beryllium, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Cadmium, Total	ND	UG/L	U	0.02	0.003	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Chromium, Total	ND	UG/L	U	0.2	0.02	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Cobalt, Total	ND	UG/L	U	0.02	0.007	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Copper, Total	ND	UG/L	U	0.1	0.02	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Lead, Total	ND	UG/L	U	0.05	0.02	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Nickel, Total	ND	UG/L	U	0.2	0.03	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Silver, Total	ND	UG/L	U	0.02	0.004	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Thallium, Total	ND	UG/L	U	0.02	0.008	EPA 1640	6020A
3532	KQ2004072-01	METHOD BLANK	NA		Ocean Water	MB1	Zinc, Total	ND	UG/L	U	0.5	0.2	EPA 1640	6020A
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Aluminum, Total	5760	UG/L		22	4	EPA CLP ILM04.0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Iron, Total	2570	UG/L		22	3	EPA CLP ILM04.0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Molybdenum, Total	1080	UG/L		8.7	1	EPA CLP ILM04.0	6010C

3532	KQ2004064-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Strontium, Total	10400	UG/L		1.1	0.2	EPA CLP ILM04.0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Tin, Total	10500	UG/L		22	3	EPA CLP ILM04.0	6010C
3532	KQ2004064-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Vanadium, Total	1330	UG/L		4.4	1.1	EPA CLP ILM04.0	6010C
3532	KQ2004070-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Barium, Total	101	UG/L		0.052	0.021	EPA CLP ILM04.0	6020A
3532	KQ2004070-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Manganese, Total	24.1	UG/L		0.21	0.04	EPA CLP ILM04.0	6020A
3532	KQ2004071-01	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Selenium, Total	54.5	UG/L		1	0.4	EPA CLP ILM04.0	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Arsenic, Total	1.91	UG/L		0.5	0.06	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Beryllium, Total	1.24	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Cadmium, Total	1.95	UG/L		0.02	0.003	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Chromium, Total	1.95	UG/L		0.2	0.02	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Cobalt, Total	1.91	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Copper, Total	1.9	UG/L		0.1	0.02	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Lead, Total	1.9	UG/L		0.05	0.02	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Nickel, Total	2.08	UG/L		0.2	0.03	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Silver, Total	0.966	UG/L		0.02	0.004	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Thallium, Total	1.89	UG/L		0.02	0.008	EPA 1640	6020A
3532	KQ2004072-02	LAB CONTROL SAMPLE	NA		Ocean Water	LCS1	Zinc, Total	1.95	UG/L		0.5	0.2	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Arsenic, Total	1.82	UG/L		0.5	0.06	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Beryllium, Total	1.19	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Cadmium, Total	1.87	UG/L		0.02	0.003	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Chromium, Total	1.86	UG/L		0.2	0.02	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Cobalt, Total	1.81	UG/L		0.02	0.007	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Copper, Total	1.83	UG/L		0.1	0.02	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Lead, Total	1.82	UG/L		0.05	0.02	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Nickel, Total	1.98	UG/L		0.2	0.03	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Silver, Total	0.92	UG/L		0.02	0.004	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Thallium, Total	1.79	UG/L		0.02	0.008	EPA 1640	6020A
3532	KQ2004072-03	DUPLICATE LAB CONTROL SAMPLE	NA		Ocean Water	DLCS1	Zinc, Total	1.87	UG/L		0.5	0.2	EPA 1640	6020A
3532	K2002371-002	3532|03_20|HH-7|SW_M|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.11	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-004	3532|03_20|HH-7|SW_B|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.22	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-006	3532|03_20|HH-8|SW_S|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.15	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-008	3532|03_20|HH-8|SW_M|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.14	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-010	3532|03_20|HH-8|SW_B|01		3/13/2020	Ocean Water	SMPL	Mercury, Total	0.13	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-MB1	METHOD BLANK 1	NA		Ocean Water	MB1	Mercury, Total	0.11	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-MB2	METHOD BLANK 2	NA		Ocean Water	MB2	Mercury, Total	0.07	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-MB3	METHOD BLANK 3	NA		Ocean Water	MB3	Mercury, Total	0.11	ng/L	J	0.5	0.06	METHOD	1631E
3532	K2002371-QCS1	QUALITY CONTROL SAMPLE	NA		Ocean Water	QCS1	Mercury, Total	4.53	ng/L		0.5	0.09	METHOD	1631E

TDI Brooks

TDI-Brooks International, Inc.

"Providing Scientific Services On A Global Basis"

B&B Client Number: J20453

Client Address: CSA Ocean Sciences Inc.
Attn: Steve Viada
8502 SW Kansas Ave
Stuart, Florida 34997

Contact Mike Gaskins for questions concerning these data.

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B&B Laboratories, Inc.

CSA Ocean Sciences, Inc.
Job #3532
Hammerhead EBS-Guyana

Technical Report 20-3961

Determination of:

Aliphatic, Total Petroleum Hydrocarbons (TPH), and Polycyclic Aromatic Hydrocarbons (PAH) in Sediment and Water Samples

Please take a moment and answer a quick survey. We would like to know how we can improve our services.

Narrative

B&B Laboratories, Inc.

Case Narrative

Sample Receipt and Storage

B&B Laboratories received a total of 10 ice chests in two separate shipments containing samples that were sent via FedEx by Steve Viada of CSA Ocean Sciences Inc. on March 16, 2020. Eight of the ten ice chests arrived in College Station (SDG # SDG20031701) sealed and in good condition. The remaining two of the ten ice chests arrived in College Station (SDG # SDG20031801) sealed and in good condition. Refer to the Supporting Documents section for the Sample Receiving/Integrity Report pages for sample discrepancies and the Sample Custody Corrective Action Report (SCCAR). Client was notified of discrepancies via email.

Cooler Number	Temperature	Samples Received	Sample Custody Corrective Action Report (SCCAR)
SDG20031701			
1	Cooler: 6.6°C Temp. Blank: NA	6 Water Samples	NA
2	Cooler: 5.0°C Temp. Blank: NA	6 Water Samples	NA
3	Cooler: 7.3°C Temp. Blank: NA	6 Water Samples	NA
4	Cooler: 3.9°C Temp. Blank: NA	6 Water Samples	NA
5	Cooler: 5.8°C Temp. Blank: NA	6 Water Samples	NA
6	Cooler: 5.3°C Temp. Blank: NA	6 Water Samples	NA
7	Cooler: 11.4°C Temp. Blank: NA	3 Water Samples, 2 Solvent Blanks	NA
8	Cooler: 8.0°C Temp. Blank: NA	16 Sediment Samples	NA
SDG20031801			
1	Cooler: 7.8°C Temp. Blank: NA	6 Water Samples	NA
2	Cooler: 8.9°C Temp. Blank: NA	6 Water Samples	NA

The water and sediment samples were collected on March 11-13, 2020 for CSA Ocean Sciences Job #3532. The water and sediment samples were logged-in according to B&B Laboratories standard operating procedure (B&B 1009) and stored in an access-controlled refrigerator (4.0°C) and freezer (≤ -16.0°C), respectively, prior to analysis.

The samples were analyzed for aliphatic hydrocarbons and Total Petroleum Hydrocarbons (TPH) by GC/FID and for Polycyclic Aromatic Hydrocarbons (PAHs) by GC/MS (SIM).

The analytical results for aliphatic hydrocarbons/TPH for the water samples, and the aliphatic hydrocarbons/TPH and alkylated PAHs with select biomarkers data for the sediment samples are included in this report.

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Standard Operating Procedures

The sample preparation, extraction, and analytical methods employed for aliphatic hydrocarbons/TPH and PAH are listed in Table 1.

Table 1. Standard Operating Procedures for each analytical test.

Matrix	Sample Preparation	Extraction	Aliphatic Hydrocarbons/TPH	PAH
Water	B&B 1012	B&B 1011	B&B 1016	NA
Sediment	B&B 1012	B&B 1003	B&B 1016	B&B 1006

Sample Preparation and Extraction

Extraction of waters for Aliphatic, Aromatic, Chlorinated Hydrocarbons and Total Petroleum Hydrocarbons (Synopsis of SOP 1011)

This standard operating procedure provides a precise and accurate method for extraction, isolation and concentration of selected organic compounds from water samples. Final extracts can be used for the quantitative determination of polycyclic aromatic hydrocarbons (PAHs), aliphatic hydrocarbons, total petroleum hydrocarbon (TPH), and chlorinated hydrocarbons (including planar PCBs) by chromatographic procedures. This procedure is also used to extract water for gravimetric determination of extractable organic material (EOM). The extraction procedure is modified from EPA Method 3510 (separatory funnel method).

Water samples are serially extracted with dichloromethane in separatory funnels and the extracts are concentrated to a final volume of 0.5 to 4 mL. The protocol is designed for 1-liter water samples, but water samples of other sizes may be collected and extracted by appropriately adjusting the volume of dichloromethane used during the extraction process.

Extraction of Sediments for Aliphatic, Aromatic and Chlorinated Hydrocarbons and Total Petroleum Hydrocarbons (Synopsis of SOP 1003)

This standard operating procedure provides an accurate and precise method for extraction, isolation, and concentration of selected organic compounds from soil and sediment samples. It achieves analyte recoveries equivalent to those from Soxhlet extraction, using less solvent and taking significantly less time. Final extracts can be used in the quantitative determination of polycyclic aromatic hydrocarbons (PAHs), aliphatic hydrocarbons, total petroleum hydrocarbon (TPH), and chlorinated hydrocarbons (including planar PCBs) by chromatographic procedures. This procedure is also used to extract soil and sediment samples for gravimetric determination of extractable organic material (EOM).

An automated extraction apparatus (Dionex ASE200 Accelerated Solvent Extractor) is used to extract various organics from 1 to 15 g (usually 15 g if adequate material is present) of pre-dried sample. The extractions are performed using 100% dichloromethane inside stainless-steel extraction cells held at elevated temperature and solvent pressure. The extracted compounds dissolved in the hot solvent are collected in 60-mL glass vials. Extracts are concentrated to a volume of 1 - 3 mL, using an evaporative solvent reduction apparatus (Zymark TurboVap II or water bath), and if necessary, processed through a clean-up column in order to minimize matrix interference. Extracts are then concentrated to a final volume of 1 mL and submitted for determination of TPH, aliphatic, aromatic, and chlorinated hydrocarbon analytes using B&B SOPs 1016, 1006, 1007, and 1078, respectively.

Determination of Percent Moisture in Tissues, Soils and Sediment

Percent moisture (weight/weight basis) is determined in samples by measuring the loss in mass of the sample due to drying at 105°C to a constant weight. Typically, between one and two grams of sample are used for the determination. Wet and dried samples are weighed to the nearest milligram. This procedure is documented in B&B SOP 1098, *Percent Moisture Determination.*

Analytical Methods

Aromatic Hydrocarbon Determination by Selected Ion Monitoring – Gas Chromatography/Mass Spectrometry (Synopsis of SOP 1006)

This quantitative method is for the determination of polycyclic aromatic hydrocarbons (PAHs) and their alkylated homologues in extracts of water, sediment, biological tissue, products, oiled samples. Quantitation is performed by capillary gas chromatography/mass spectrometry (GC/MS) in selected ion

monitoring mode (SIM). The gas chromatograph is temperature-programmed and operated in splitless mode. The capillary column is an Agilent Technologies DB-5MS (60 m long by 0.25 mm ID and 0.25 μm film thickness), or equivalent. Carrier flow is by electronic pressure control. The autosampler is capable of making 1 to 5 μL injections. The mass spectrometer is capable of scanning from 35 to 500 m/z every second or less, utilizing 70 volts electron energy in electron impact ionization mode. The data acquisition system allows continuous acquisition and storage of all data during analysis and is capable of displaying ion abundance versus time or scan number.

Calibration solutions are prepared at six concentrations ranging from 20 to 5,000 ng/mL by diluting reference standard solutions containing the analytes of interest. For each analyte of interest, a relative response factor (RRF) is determined for each calibration level. The 6 response factors are then averaged to produce a mean relative response factor for each analyte.

Aliphatic and Total Petroleum Hydrocarbon Determination by Gas Chromatography/Flame Ionization Detection (Synopsis of SOP 1016)

The quantitative method described in this document is for the determination of aliphatic hydrocarbons and total petroleum hydrocarbons in extracts of water, sediment, biological tissue, products and oiled samples. The samples are analyzed by high resolution, capillary gas chromatography with flame ionization detection (GC/FID). Normal alkanes with 8 to 40 carbons (*n*-C_8 to *n*-C_{40}), and the isoprenoids pristane and phytane are determined with this procedure. The gas chromatograph is temperature-programmed and operated in split mode. The capillary column is a Restek Scientific RTX-1 (30 m long by 0.25 mm ID and 0.25 μm film thickness), or equivalent. Carrier flow is regulated by electronic pressure control. The autosampler is capable of making 1 to 5 μl injections. Dual columns and FIDs are used. The data is acquired using Agilent OpenLab CDS and is processed using Agilent MSD Chemstation.

A calibration curve is established by analyzing each of 6 calibration standards (1.25, 10, 25, 40, 50 and 100 μg/ml), and fitting the data to a straight line using the average response factors. For each analyte of interest, a relative response factor (RRF) is determined for each calibration level. All 6 response factors are then averaged to produce a mean relative response factor for each analyte. If an individual aliphatic hydrocarbon is not in the calibration solutions, a RRF is estimated from the average RRF of the hydrocarbon eluting immediately before the compound.

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Data Reporting

The reporting units for each analyte are listed in Table 2. Data Qualifier Definitions are listed in Table 3. The method detection limits (MDLs) for each analyte are listed in Table 4.

Table 2. Analytical reporting units.

Matrix	Aliphatics/TPH	PAH
Water	µg/L	NA
Sediment	µg/dry g	ng/dry g

Table 3. Data Qualifier Definitions.

Qualifier	Definition
B	Analyte detected in the method blank greater than 3X MDL
D	Diluted Value
E	Analyte concentration exceeds the calibration range of the GC/MS for that specific analysis.
I	Analytical interference
J	Analyte detected below the method detection limit
L	Loss due to matrix effect
NA	Not Applicable
U	Analyte not detected
X	Analyte <3X MDL
X	Analyte <2X MDL for TOC analysis
Y	Spiked level of analyte <50% of the native concentration
*	Outside QA limits, refer to narrative

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Table 4. Method Detection Limits

Aliphatics	**Water MDL**
Unit of measure	µg/L
n-C9	0.288
n-C10	0.252
n-C11	0.251
n-C12	0.266
n-C13	0.258
i-c15	0.256
n-C14	0.277
i-c16	0.234
n-C15	0.256
n-C16	0.234
i-c18	0.100
n-C17	0.174
Pristane	0.190
n-C18	0.100
Phytane	0.201
n-C19	0.073
n-C20	0.077
n-C21	0.081
n-C22	0.150
n-C23	0.117
n-C24	0.069
n-C25	0.066
n-C26	0.070
n-C27	0.069
n-C28	0.077
n-C29	0.087
n-C30	0.081
n-C31	0.126
n-C32	0.083
n-C33	0.282
n-C34	0.106
n-C35	0.112
n-C36	0.113
n-C37	0.148
n-C38	0.127
n-C39	0.160
n-C40	0.144
Total Petroleum Hydrocarbons	13.0
Total Resolved Hydrocarbons	13.0
Unresolved Complex Mixture	13.0

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Table 4 (continued). Method Detection Limits

Aliphatics	**Sediment MDL**
Unit of measure	µg/dry g
n-C9	0.012
n-C10	0.021
n-C11	0.016
n-C12	0.019
n-C13	0.045
i-c15	0.016
n-C14	0.013
i-c16	0.004
n-C15	0.016
n-C16	0.004
i-c18	0.004
n-C17	0.003
Pristane	0.003
n-C18	0.004
Phytane	0.006
n-C19	0.005
n-C20	0.012
n-C21	0.004
n-C22	0.003
n-C23	0.008
n-C24	0.005
n-C25	0.007
n-C26	0.008
n-C27	0.011
n-C28	0.011
n-C29	0.021
n-C30	0.013
n-C31	0.015
n-C32	0.012
n-C33	0.021
n-C34	0.016
n-C35	0.015
n-C36	0.016
n-C37	0.017
n-C38	0.019
n-C39	0.019
n-C40	0.019
Total Petroleum Hydrocarbons	1.40
Total Resolved Hydrocarbons	1.40
Unresolved Complex Mixture	1.40

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Table 4 (continued). Method Detection Limits

PAHs Unit of measure	Sediment MDL ng/dry g
cis/trans Decalin	0.132
C1-Decalins	0.263
C2-Decalins	0.263
C3-Decalins	0.263
C4-Decalins	0.263
Naphthalene	0.342
C1-Naphthalenes	1.03
C2-Naphthalenes	0.684
C3-Naphthalenes	0.684
C4-Naphthalenes	0.684
Benzothiophene	0.090
C1-Benzothiophenes	0.180
C2-Benzothiophenes	0.180
C3-Benzothiophenes	0.180
C4-Benzothiophenes	0.180
Biphenyl	0.294
Acenaphthylene	0.041
Acenaphthene	0.103
Dibenzofuran	0.204
Fluorene	0.183
C1-Fluorenes	0.367
C2-Fluorenes	0.367
C3-Fluorenes	0.367
Carbazole	0.150
Anthracene	0.115
Phenanthrene	0.208
C1-Phenanthrenes/Anthracenes	0.077
C2-Phenanthrenes/Anthracenes	0.285
C3-Phenanthrenes/Anthracenes	0.285
C4-Phenanthrenes/Anthracenes	0.285
Dibenzothiophene	0.116
C1-Dibenzothiophenes	0.064
C2-Dibenzothiophenes	0.232
C3-Dibenzothiophenes	0.232
C4-Dibenzothiophenes	0.232
Fluoranthene	0.333
Pyrene	0.136
C1-Fluoranthenes/Pyrenes	0.469
C2-Fluoranthenes/Pyrenes	0.469
C3-Fluoranthenes/Pyrenes	0.469
C4-Fluoranthenes/Pyrenes	0.469
Naphthobenzothiophene	0.128
C1-Naphthobenzothiophenes	0.256
C2-Naphthobenzothiophenes	0.256
C3-Naphthobenzothiophenes	0.256
C4-Naphthobenzothiophenes	0.256

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Table 4 (continued). Method Detection Limits

PAHs Unit of measure	Sediment MDL ng/dry g
Benz(a)anthracene	0.192
Chrysene/Triphenylene	0.116
C1-Chrysenes	0.232
C2-Chrysenes	0.232
C3-Chrysenes	0.232
C4-Chrysenes	0.232
Benzo(b)fluoranthene	0.203
Benzo(k,j)fluoranthene	0.098
Benzo(a)fluoranthene	0.098
Benzo(e)pyrene	0.177
Benzo(a)pyrene	0.101
Perylene	1.27
Indeno(1,2,3-c,d)pyrene	0.050
Dibenzo(a,h)anthracene	0.064
Benzo(g,h,i)perylene	0.088
2-Methylnaphthalene	1.30
1-Methylnaphthalene	0.546
2,6-Dimethylnaphthalene	0.261
1,6,7-Trimethylnaphthalene	0.127
1-Methylfluorene	0.191
4-Methyldibenzothiophene	0.091
2/3-Methyldibenzothiophene	0.091
1-Methyldibenzothiophene	0.091
3-Methylphenanthrene	0.097
2-Methylphenanthrene	0.097
2-Methylanthracene	0.097
4/9-Methylphenanthrene	0.097
1-Methylphenanthrene	0.097
3,6-Dimethylphenanthrene	0.110
Retene	0.231
2-Methylfluoranthene	0.223
Benzo(b)fluorene	0.125
C29-Hopane	0.575
18a-Oleanane	0.575
C30-Hopane	0.575
C20-TAS	0.575
C21-TAS	0.575
C26(20S)-TAS	0.575
C26(20R)/C27(20S)-TAS	0.575
C28(20S)-TAS	0.575
C27(20R)-TAS	0.575
C28(20R)-TAS	0.575

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Quality Assurance/Quality Control – Water and Sediment

The quality assurance/quality control procedure for the water samples for this program included the analyses of a method blank, blank spike/blank spike duplicate, and reference oil (SRM2779) per analytical batch of no more than 20 samples.

The quality assurance/quality control procedure for the sediment samples this program included the analyses of a method blank, blank spike, matrix spike/matrix spike duplicate, laboratory duplicate, and reference oil (SRM2779) per analytical batch of no more than 19 samples. All QC samples are subject to the identical preparation and analysis steps as samples. The appropriate surrogate solution is added to every sample including quality control samples. The data are corrected based on surrogate recovery up to 100%. Refer to Tables 5 and 6 for Method Performance Criteria for n-alkanes and PAH, respectively.

Quality Assurance/Quality Control Variances

Aliphatic and Total Petroleum Hydrocarbons (TPH)	Water
QA/QC Parameter:	**Observation:**
• Initial Calibration (Six-Point)	No variances observed.
• Initial Calibration Verification	No variances observed.
• Continuing Calibration Verification	No variances observed.
• Surrogate Recoveries	No variances observed.
• Method Blank	ENV4074A passed, but perylene detected > 3x method detection limit (MDL)
• Blank Spike/Blank Spike Duplicate	No variances observed.
• Additional QC Batch Information	No variances observed.
Aliphatic and Total Petroleum Hydrocarbons (TPH)	Sediment
QA/QC Parameter:	**Observation:**
• Initial Calibration (Six-Point)	No variances observed.
• Initial Calibration Verification	No variances observed.
• Continuing Calibration Verification	No variances observed.
• Surrogate Recoveries	No variances observed.
• Method Blank	No variances observed.
• Blank Spike	No variances observed.
• Matrix Spike/Matrix Spike Duplicate	No variances observed.
• Duplicate	No variances observed.
• Additional QC Batch Information	No variances observed.

Polycyclic Aromatic Hydrocarbons (PAHs)	Sediment
QA/QC Parameter:	**Observation:**
• Initial Calibration (Six-Point)	No variances observed.
• Initial Calibration Verification	No variances observed.
• Continuing Calibration Verification	No variances observed.
• Surrogate Recoveries	No variances observed.
• Method Blank	No variances observed.
• Blank Spike	No variances observed.
• Matrix Spike/Matrix Spike Duplicate	No variances observed.
• Duplicate	No variances observed.
• Additional QC Batch Information	No variances observed.

TABLE 5. Method Performance Criteria for Alkanes/Isoprenoids Compounds and Total Petroleum Hydrocarbons

Element or Sample Type	Minimum Frequency	Measurement Quality Objective/ Acceptance Criteria	Corrective Action
Initial Calibration (all target analytes, see Table 2)	Prior to every sequence, or as needed based on continuing calibration/verification check.	6-point calibration curve %RSD ≤ 15%	Resolve before proceeding.
Continuing Calibration Verification (CCV)	Beginning, end, and every 10 injections (12 hour intervals)	%D ≤ 20%	Perform Instrument Maintenance. Re-analyze affected samples.
Initial Calibration Verification (ICV, Second Source CCV)	Per initial calibration	%R target analytes 80-120%	Resolve before proceeding.
NIST SRM2779 Reference Oil (Instrument SRM)	One per batch per GC sequence	Baseline resolution of n-C17 from pristine, and analytes must be ±3σ of laboratory derived mean	Resolve before proceeding.
Performance Evaluation Mixture (PEM)	One per batch per GC sequence	%R 75-125% for all surrogates	Resolve before proceeding.
Matrix Spike/Matrix Spike Duplicate (Sediments, Soils, Tissues only)	One per batch/every 20 client samples	%R 40% - 120% for target analytes; average %R 60-120% for valid spikes, RPD ≤30%. No more than 2 analytes may exceed 40-120%	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.
Blank Spike/Blank Spike Duplicate	One per batch/every 20 client samples	%R 40% - 120% for target analytes; RPD ≤30%. No more than 2 analytes may exceed 40-120%	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.
Method Blank	One per batch/every 20 client samples	No more than 2 analytes to exceed 3x MDL unless analyte not detected in associated sample(s) or analyte concentration >10x blank value	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.
Laboratory Duplicate (not required for aqueous samples)	One per batch/every 20 client samples	RPD ≤ 30% if analyte concentration is 3x greater than the MDL, no more than 2 individual analyte RPDs with conc. 3x MDL can exceed 35%.	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.
Mass Discrimination	Initial calibration and CCVs (mid-level)	Ratio for the raw areas of n-C36 / n-C20 ≥0.70	Resolve before proceeding.
Internal Standard (IS)	Every sample	50% - 200% of the area of the IS in the associated calibration standard	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.
Surrogates	Every sample	%R 40-120%	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.

TABLE 6. Method Performance Criteria for Extended PAH (Parent and Alkyl Homologs) and Related Compounds

Element or Sample Type	Minimum Frequency	Measurement Quality Objective/ Acceptance Criteria	Corrective Action
Tuning	Prior to every sequence	As specified in Section 7.1	Resolve before proceeding.
Initial Calibration (All parent PAH and selected alkyl homologue PAH)	Prior to every sequence, or as needed based on CCV	6-point calibration, RSD ≤ 20%	Resolve before proceeding.
Continuing Calibration Verification (CCV)	Beginning, end, and every 6-9 injections (12 hour intervals)	%D ≤ 25%, No more than 2 analytes can be between 25% and 35%	Perform instrument maintenance. Re-analyze affected samples.
Initial Calibration Verification (ICV, Second Source CCV)	Per initial calibration	%R target analytes 80-120%	Resolve before proceeding.
If available, use SRMs for appropriate matrices	One per batch/every 20 client samples	Within ±30% of NIST 95% uncertainty range for analytes within the quantitation range. No more than 2 analytes may exceed this criterion.	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed..
SRM 2779 Gulf of Mexico Reference Oil Standard	One per batch/every 20 client samples	Peak resolution >80% of 4/9-methylphenanthrene from 1-methylphenanthrene (m/z 192). Within ±20% of NIST 95% uncertainty range for analytes within the quantitation range. No more than 2 analytes may exceed this criterion.	Evaluate impact to data, discuss with lab manager to determine if corrective action is needed.
Matrix Spike/Matrix Spike Duplicate (Sediments, Soils, Tissues only)	One per batch/every 20 client samples	%R 40% - 120% for target analytes, except biphenyl (40%-140%), decalin (25%-120%) and perylene (10-120%); RPD ≤30%, average %R 60-120% for valid spikes. No more than 2 analytes may exceed 40-120% recovery or >30% RPD.	Evaluate impact to data, discuss with lab manager, determine if corrective action is needed.
Blank Spike/Blank Spike Duplicate	One per batch/every 20 client samples	See MS/MSD criteria above.	Evaluate impact to data, discuss with lab manager, determine if corrective action is needed.

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TABLE 6 (Continued). Method Performance Criteria for Extended PAH (Parent and Alkyl Homologs) and Related Compounds

Element or Sample Type	Minimum Frequency	Measurement Quality Objective/ Acceptance Criteria	Corrective Action
Method Blank	One per batch/every 20 client samples	No more than 2 analytes to exceed 3x target MDL unless analyte not detected in associated sample(s) or analyte concentration >10x blank value	Evaluate impact to data, discuss with lab manager, determine if corrective action is needed.
Laboratory Duplicate (not required for aqueous samples)	One per batch/every 20 client samples	RPD ≤ 30% if analyte concentration is 3x greater than the MDL, no more than 2 individual analyte RPDs with conc. 3x MDL can exceed 30%.	Evaluate impact to data, discuss with lab manager, and determine if corrective action is needed.
Mass Discrimination	Initial calibration and CCVs (mid-level)	Ratio for the concentration of Benzo[g,h,i]perylene to phenanthrene ≥0.70	Resolve before proceeding.
Internal Standard (IS)	Every sample	50% - 200% of the area of the IS in the associated calibration standard	Evaluate impact to data, discuss with lab manager, and determine if corrective action is needed.
Surrogates	Every sample	%R 40-120% except d12-perylene which is 10-120%	Evaluate impact to data, discuss with lab manager, and determine if corrective action is needed.

B&B Laboratories makes no representation or certifications as to the method of sample collection, sample identification, or transporting/handling procedure used prior to the receipt of samples by B&B Laboratories. To the best of my knowledge, the information contained in this report is accurate and complete.

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We appreciate the opportunity to serve your analytical needs and please do not hesitate to contact us should you have any questions.

_____

Michael A. Gaskins Date
Laboratory Manager

Sediment Samples

Total Petroleum Hydrocarbons/ Aliphatic Hydrocarbons/ Concentrations

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5231.D	CSA5233.D	CSA5235.D	CSA5237.D
Sample ID	3532|03_20|HH-1|sed|hc|A	3532|03_20|HH-2|sed|hc|A	3532|03_20|HH-3|sed|hc|A	3532|03_20|HH-4|sed|hc|A
Matrix	Sediment	Sediment	Sediment	Sediment
Collection Date	03/12/20	03/12/20	03/12/20	03/12/20
Received Date	03/17/20	03/17/20	03/17/20	03/17/20
Extraction Date	04/08/20	04/08/20	04/08/20	04/08/20
Extraction Batch	ENV4078	ENV4078	ENV4078	ENV4078
Date Acquired	13-Apr-2020, 22:32	14-Apr-2020, 23:28	14-Apr-2020, 01:56	14-Apr-2020, 03:04
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Dry Weight (g)	15.06	15.07	15.02	15.03
Sample Wet Weight (g)	52.53	44.36	53.18	53.72
% Dry	29	34	28	28
% Moisture	71	66	72	72
Dilution	1X	10X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q
n-C9	0.055		0.077	J	0.067		0.061	
n-C10	0.043		0.079	J	0.035		0.015	J
n-C11	0.010	J	<0.016	U	0.012	J	0.017	
n-C12	0.012	J	0.089	J	0.015	J	0.014	J
n-C13	0.010	J	0.405	J	0.013	J	0.010	J
i-C15	0.008	J	3.488		0.017		0.014	J
n-C14	0.017		1.951		0.024		0.015	
i-C16	0.026		0.412		0.027		0.022	
n-C15	0.024		7.031		0.028		0.025	
n-C16	0.014		6.503		0.019		0.021	
i-C18	0.004	J	0.470		0.008		0.006	
n-C17	0.052		3.421		0.057		0.068	
Pristane	0.002	J	3.082		0.004		0.003	J
n-C18	0.058		4.574		0.063		0.065	
Phytane	0.003	J	2.181		0.005	J	0.005	J
n-C19	0.033		2.908		0.019		0.036	
n-C20	0.014		0.135		0.017		0.016	
n-C21	0.020		0.197		0.012		0.021	
n-C22	0.017		0.087		0.021		0.023	
n-C23	0.022		0.097		0.024		0.028	
n-C24	0.018		0.101		0.018		0.017	
n-C25	0.024		0.114		0.027		0.031	
n-C26	0.019		0.093		0.018		0.021	
n-C27	0.047		0.134		0.046		0.055	
n-C28	0.031		0.080	J	0.019		0.023	
n-C29	0.110		0.254		0.082		0.124	
n-C30	0.034		0.284		0.034		0.043	
n-C31	0.485		1.644		0.340		0.717	
n-C32	0.027		0.088	J	0.023		0.037	
n-C33	0.129		0.344		0.119		0.167	
n-C34	0.022		0.085	J	0.022		0.029	
n-C35	0.109		<0.015	U	0.048		0.127	
n-C36	0.019		<0.016	U	0.012	J	0.013	J
n-C37	0.028		<0.017	U	0.018		0.027	
n-C38	0.019	J	<0.019	U	0.010	J	0.010	J
n-C39	0.023		<0.019	U	0.010	J	0.021	
n-C40	0.020		<0.019	U	<0.019	U	0.010	J
Total Alkanes	1.6		40.4		1.3		2.0	
Total Petroleum Hydrocarbons	10		1110		10		14	
Total Resolved Hydrocarbons	4		1069		3		8	
Unresolved Complex Mixture	6		41		8		6	
EOM (µg/dry g)	NA		NA		NA		NA	

Surrogate (Su)	Su Recovery (%)		Su Recovery (%)		Su Recovery (%)		Su Recovery (%)	
n-dodecane-d26	69		93	D	62		67	
n-eicosane-d42	90		95	D	78		87	
n-triacontane-d62	90		93	D	76		86	

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5239.D	CSA5241.D	CSA5243.D	CSA5245.D
Sample ID	3532|03_20|HH-5|sed|hc|A	3532|03_20|HH-6|sed|hc|A	3532|03_20|HH-7|sed|hc|A	3532|03_20|HH-8|sed|hc|A
Matrix	Sediment	Sediment	Sediment	Sediment
Collection Date	03/11/20	03/12/20	03/12/20	03/11/20
Received Date	03/17/20	03/17/20	03/17/20	03/17/20
Extraction Date	04/08/20	04/08/20	04/08/20	04/08/20
Extraction Batch	ENV4078	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020, 04:12	14-Apr-2020, 05:20	14-Apr-2020, 06:28	14-Apr-2020, 07:36
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Dry Weight (g)	15.03	15.05	15.04	15.00
Sample Wet Weight (g)	31.41	46.72	52.09	35.00
% Dry	48	32	29	43
% Moisture	52	68	71	57
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q
n-C9	0.058		0.058		0.058		0.059	
n-C10	0.030		0.060		0.051		0.025	
n-C11	0.006	J	0.016	J	0.010	J	0.007	J
n-C12	0.008	J	0.020		0.016	J	0.010	J
n-C13	0.006	J	0.013	J	0.012	J	0.006	J
i-C15	0.010	J	0.015	J	0.008	J	0.007	J
n-C14	0.010	J	0.022		0.016		0.011	J
i-C16	0.021		0.022		0.024		0.020	
n-C15	0.015	J	0.023		0.026		0.016	J
n-C16	0.012		0.018		0.017		0.012	
i-C18	0.004	J	0.007		0.007		0.005	
n-C17	0.024		0.014		0.024		0.023	
Pristane	0.003	J	0.004		0.003	J	0.002	J
n-C18	0.028		0.040		0.048		0.025	
Phytane	0.003	J	0.012		0.007		0.004	J
n-C19	0.017		0.018		0.033		0.019	
n-C20	0.010	J	0.015		0.015		0.010	J
n-C21	0.028		0.020		0.019		0.030	
n-C22	0.011		0.015		0.026		0.010	
n-C23	0.012		0.017		0.038		0.013	
n-C24	0.011		0.015		0.041		0.011	
n-C25	0.016		0.021		0.051		0.015	
n-C26	0.011		0.013		0.045		0.011	
n-C27	0.027		0.033		0.066		0.027	
n-C28	0.014		0.017		0.042		0.014	
n-C29	0.065		0.092		0.124		0.071	
n-C30	0.019		0.030		0.048		0.021	
n-C31	0.216		0.341		0.292		0.197	
n-C32	0.017		0.033		0.037		0.021	
n-C33	0.067		0.099		0.116		0.068	
n-C34	0.016	J	0.024		0.022		0.017	
n-C35	0.055		0.072		0.080		0.032	
n-C36	0.005	J	0.011	J	0.012	J	<0.016	U
n-C37	0.011	J	0.013	J	0.019		0.008	J
n-C38	0.005	J	0.014	J	0.010	J	<0.019	U
n-C39	<0.019	U	0.011	J	0.012	J	<0.019	U
n-C40	<0.019	U	0.009	J	0.010	J	<0.019	U
Total Alkanes	0.9		1.3		1.5		0.8	
Total Petroleum Hydrocarbons	3		11		9		4	
Total Resolved Hydrocarbons	1	J	4		4		1	J
Unresolved Complex Mixture	3		7		5		3	
EOM (µg/dry g)	NA		NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	72	71	68	80
n-eicosane-d42	94	92	86	95
n-triacontane-d62	94	90	83	93

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4078A.D
Sample ID	Method Blank
Matrix	Sediment
Collection Date	NA
Received Date	NA
Extraction Date	04/08/20
Extraction Batch	ENV4078
Date Acquired	13-Apr-2020, 16:52
Method	B&B SOP1016
Sample Dry Weight (g)	15.00
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/dry g)	Q	Q	3X MDL Conc. (µg/dry g)	Actual MDL Conc. (µg/dry g)
n-C9	<0.012	U		0.037	0.012
n-C10	<0.021	U		0.064	0.021
n-C11	<0.016	U		0.049	0.016
n-C12	<0.019	U		0.056	0.019
n-C13	<0.045	U		0.134	0.045
i-C15	<0.016	U		0.049	0.016
n-C14	<0.013	U		0.039	0.013
i-C16	<0.004	U		0.013	0.004
n-C15	<0.016	U		0.049	0.016
n-C16	<0.004	U		0.013	0.004
i-C18	<0.004	U		0.011	0.004
n-C17	<0.003	U		0.010	0.003
Pristane	<0.003	U		0.008	0.003
n-C18	<0.004	U		0.011	0.004
Phytane	<0.006	U		0.018	0.006
n-C19	<0.005	U		0.015	0.005
n-C20	<0.012	U		0.037	0.012
n-C21	<0.004	U		0.012	0.004
n-C22	<0.003	U		0.010	0.003
n-C23	<0.008	U		0.024	0.008
n-C24	<0.005	U		0.016	0.005
n-C25	<0.007	U		0.021	0.007
n-C26	<0.008	U		0.023	0.008
n-C27	<0.011	U		0.032	0.011
n-C28	<0.011	U		0.033	0.011
n-C29	<0.021	U		0.064	0.021
n-C30	<0.013	U		0.038	0.013
n-C31	<0.015	U		0.044	0.015
n-C32	<0.012	U		0.035	0.012
n-C33	<0.021	U		0.064	0.021
n-C34	<0.016	U		0.049	0.016
n-C35	<0.015	U		0.044	0.015
n-C36	<0.016	U		0.047	0.016
n-C37	<0.017	U		0.052	0.017
n-C38	<0.019	U		0.057	0.019
n-C39	<0.019	U		0.056	0.019
n-C40	<0.019	U		0.056	0.019
Total Alkanes					
Total Petroleum Hydrocarbons	<1.4	U		4.20	1.40
Total Resolved Hydrocarbons	<1.4	U		4.20	1.40
Unresolved Complex Mixture	<1.4	U		4.20	1.40
EOM (µg/dry g)	NA			300	100

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	86
n-eicosane-d42	95
n-triacontane-d62	94

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4078B.D
Sample ID	Blank Spike
Matrix	Sediment
Collection Date	NA
Received Date	NA
Extraction Date	04/08/20
Extraction Batch	ENV4078
Date Acquired	13-Apr-2020, 18:00
Method	B&B SOP1016
Sample Dry Weight (g)	1.00
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/dry g)	Recovery (%)	Q	Spike Amount (µg)
n-C9	7.64	76		10.0
n-C10	8.17	81		10.1
n-C11	8.87	88		10.0
n-C12	9.23	93		9.9
n-C13	9.60	96		10.0
n-C14	9.84	100		9.9
n-C15	9.94	98		10.1
n-C16	10.1	101		10.0
n-C17	10.4	103		10.1
Pristane	10.2	103		9.96
n-C18	10.1	101		9.9
Phytane	9.67	98		9.9
n-C19	10.0	100		10.0
n-C20	10.1	101		10.0
n-C21	10.1	100		10.1
n-C22	10.2	103		9.91
n-C23	10.0	100		10.03
n-C24	10.9	108		10.03
n-C25	10.1	100		10.1
n-C26	9.67	96		10.0
n-C27	9.90	98		10.1
n-C28	10.4	104		10.0
n-C29	10.2	102		10.05
n-C30	10.1	101		10.0
n-C31	10.4	103		10.1
n-C32	9.72	98		9.92
n-C33	10.0	99		10.1
n-C34	10.3	102		10.1
n-C35	10.0	101		10.0
n-C36	10.5	105		10.1
n-C37	9.84	98		10.1
n-C38	10.4	103		10.1
n-C39	9.58	96		10.0
n-C40	10.7	107		10.0
Average %Recovery		99		

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	86
n-eicosane-d42	95
n-triacontane-d62	94

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Matrix Spike Report

Laboratory ID	CSA5239.D	ENV4078C.D	ENV4078D.D
		Matrix Spike	Matrix Spike Duplicate
Sample ID	3532|03_20|HH-5|sed|hc|A	(3532|03_20|HH-5|sed|hc|A)	(3532|03_20|HH-5|sed|h
Matrix	Sediment	Sediment	Sediment
Collection Date	03/11/20	03/11/20	03/11/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	04/08/20	04/08/20	04/08/20
Extraction Batch	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020, 04:12	13-Apr-2020, 19:08	13-Apr-2020, 20:16
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Dry Weight (g)	15.03	15.06	15.03
Sample Wet Weight (g)	31.41	31.47	31.41
% Dry	48	48	48
% Moisture	52	52	52
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q	Recovery (%)	Q	Q	Su. Corrected Conc. (µg/dry g)	Q	Recovery (%)	Q	Q	RPD (%)	Q	Spike Amount (µg)
n-C9	0.058		0.464		61			0.411		53			12		10.0
n-C10	0.030		0.534		75			0.485		68			10		10.1
n-C11	0.006	J	0.562		83			0.532		79			5		10.0
n-C12	0.008	J	0.584		88			0.566		85			3		9.9
n-C13	0.006	J	0.605		90			0.599		89			1		10.0
i-C15	0.010	J	NA					NA							
n-C14	0.010	J	0.629		94			0.631		95			0		9.9
i-C16	0.021		NA					NA							
n-C15	0.015	J	0.644		94			0.650		95			1		10.1
n-C16	0.012		0.667		98			0.670		98			0		10.0
i-C18	0.004	J	NA					NA							
n-C17	0.024		0.700		101			0.705		102			1		10.1
Pristane	0.003	J	0.668		101			0.677		102			1		9.96
n-C18	0.028		0.681		99			0.715		104			5		9.9
Phytane	0.003	J	0.633		96			0.638		97			1		9.9
n-C19	0.017		0.672		99			0.675		99			0		10.0
n-C20	0.010	J	0.669		99			0.686		101			3		10.0
n-C21	0.028		0.686		99			0.692		99			1		10.1
n-C22	0.011		0.673		101			0.681		102			1		9.91
n-C23	0.012		0.664		98			0.673		99			1		10.03
n-C24	0.011		0.714		106			0.725		107			2		10.03
n-C25	0.016		0.669		98			0.681		99			2		10.1
n-C26	0.011		0.642		95			0.649		96			1		10.0
n-C27	0.027		0.668		96			0.677		97			1		10.1
n-C28	0.014		0.690		102			0.699		103			1		10.0
n-C29	0.065		0.715		97			0.727		99			2		10.05
n-C30	0.019		0.673		98			0.682		99			1		10.0
n-C31	0.216		0.879		99			0.893		101			2		10.1
n-C32	0.017		0.649		96			0.661		98			2		9.92
n-C33	0.067		0.707		96			0.735		100			4		10.1
n-C34	0.016	J	0.688		100			0.727		106			6		10.1
n-C35	0.055		0.718		100			0.730		102			2		10.0
n-C36	0.005	J	0.696		103			0.707		105			2		10.1
n-C37	0.011	J	0.656		96			0.668		98			2		10.1
n-C38	0.005	J	0.681		101			0.693		102			2		10.1
n-C39	<0.019	U	0.635		96			0.644		97			1		10.0
n-C40	<0.019	U	0.700		106			0.708		107			1		10.0
Average %Recovery					96					96					

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	72	82	78
n-eicosane-d42	94	96	96
n-triacontane-d62	94	94	94

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Laboratory Duplicate Report

Laboratory ID	CSA5233.D	ENV4078E.D
Sample ID	3532|03_20|HH-2|sed|hc|A	Duplicate (3532|03_20|HH-2|sed|hc|A)
Matrix	Sediment	Sediment
Collection Date	03/12/20	03/12/20
Received Date	03/17/20	03/17/20
Extraction Date	04/08/20	04/08/20
Extraction Batch	ENV4078	ENV4078
Date Acquired	14-Apr-2020, 23:28	14-Apr-2020, 22:20
Method	B&B SOP1016	B&B SOP1016
Sample Dry Weight (g)	15.07	15.08
Sample Wet Weight (g)	44.36	44.39
% Dry	34	34
% Moisture	66	66
Dilution	10X	10X

Target Compounds	Su. Corrected Conc. (µg/dry g)	Q	Su. Corrected Conc. (µg/dry g)	Q	RPD (%)	Q	Q	MDL (µg/dry g)	3X MDL (µg/dry g)
n-C9	0.077	J	0.087	J	12			0.012	0.037
n-C10	0.079	J	0.056	J	34		X	0.021	0.064
n-C11	<0.016	U	0.021	J	0		X	0.016	0.049
n-C12	0.089	J	0.093	J	4			0.019	0.056
n-C13	0.405	J	0.468		14			0.045	0.134
i-C15	3.488		3.857		10			0.016	0.049
n-C14	1.951		1.817		7			0.013	0.039
i-C16	0.412		0.417		1			0.004	0.013
n-C15	7.031		7.447		6			0.016	0.049
n-C16	6.503		6.814		5			0.004	0.013
i-C18	0.470		0.460		2			0.004	0.011
n-C17	3.421		3.516		3			0.003	0.010
Pristane	3.082		3.010		2			0.003	0.008
n-C18	4.574		4.675		2			0.004	0.011
Phytane	2.181		2.434		11			0.006	0.018
n-C19	2.908		3.375		15			0.005	0.015
n-C20	0.135		0.158		16			0.012	0.037
n-C21	0.197		0.212		7			0.004	0.012
n-C22	0.087		0.084		4			0.003	0.010
n-C23	0.097		0.118		20			0.008	0.024
n-C24	0.101		0.090		12			0.005	0.016
n-C25	0.114		0.106		7			0.007	0.021
n-C26	0.093		0.070	J	28			0.008	0.023
n-C27	0.134		0.132		2			0.011	0.032
n-C28	0.080	J	0.072	J	11			0.011	0.033
n-C29	0.254		0.265		4			0.021	0.064
n-C30	0.284		0.312		9			0.013	0.038
n-C31	1.644		1.905		15			0.015	0.044
n-C32	0.088	J	0.094	J	7			0.012	0.035
n-C33	0.344		0.364		6			0.021	0.064
n-C34	0.085	J	0.034	J	86		X	0.016	0.049
n-C35	<0.015	U	<0.015	U	0			0.015	0.044
n-C36	<0.016	U	<0.016	U	0			0.016	0.047
n-C37	<0.017	U	<0.017	U	0			0.017	0.052
n-C38	<0.019	U	<0.019	U	0			0.019	0.057
n-C39	<0.019	U	<0.019	U	0			0.019	0.056
n-C40	<0.019	U	<0.019	U	0			0.019	0.056
Total Alkanes	40.4		42.6		5				
Total Petroleum Hydrocarbons	1110		1233		11			1.40	4.20
Total Resolved Hydrocarbons	1069		1186		10			1.40	4.20
Unresolved Complex Mixture	41		47		14			1.40	4.20
EOM (µg/dry g)	NA		NA						

Surrogate (Su)	Su Recovery (%)		Su Recovery (%)	
n-dodecane-d26	93	D	93	D
n-eicosane-d42	95	D	94	D
n-triacontane-d62	93	D	91	D

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	FID60124F.D
Sample ID	ALI-SRM2779-20-06-1
Matrix	Reference Oil
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	NA
Date Acquired	14-Apr-2020, 08:44
Method	B&B SOP1016
Sample Weight (mg)	20.0
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/mg)	Q	Q	Dev. (%)	B&B Average	- 3 σ Conc. (µg/mg)	+ 3 σ Conc. (µg/mg)
n-C9	9.86			16	11.8	9.72	13.9
n-C10	9.52			12	10.8	8.96	12.7
n-C11	8.71			10	9.72	8.17	11.3
n-C12	7.28			13	8.35	6.96	9.74
n-C13	7.96			5	7.56	5.75	9.38
i-C15	1.22			22	1.56	1.08	2.05
n-C14	5.85			13	6.70	5.60	7.80
i-C16	2.09			16	2.50	2.01	2.99
n-C15	5.69			10	6.29	5.29	7.30
n-C16	4.77			10	5.29	4.35	6.23
i-C18	1.51			4	1.57	1.22	1.93
n-C17	4.09			8	4.47	3.70	5.23
Pristane	2.11			13	2.42	1.99	2.84
n-C18	3.45			4	3.61	3.14	4.08
Phytane	1.55			1	1.53	1.24	1.82
n-C19	3.10			6	3.28	2.66	3.90
n-C20	2.65			6	2.81	2.37	3.25
n-C21	2.11			9	2.33	1.95	2.72
n-C22	1.81			11	2.04	1.70	2.39
n-C23	1.62			12	1.83	1.53	2.13
n-C24	1.54			6	1.64	1.35	1.92
n-C25	1.21			12	1.37	1.17	1.57
n-C26	0.987			14	1.15	0.967	1.33
n-C27	0.827			10	0.918	0.772	1.06
n-C28	0.759			3	0.780	0.635	0.925
n-C29	0.695			8	0.753	0.643	0.863
n-C30	0.583			11	0.658	0.547	0.769
n-C31	0.525			4	0.547	0.457	0.638
n-C32	0.410			16	0.486	0.407	0.565
n-C33	0.461			1	0.467	0.375	0.559
n-C34	0.401			5	0.422	0.350	0.493
n-C35	0.315	J		8	0.342	0.278	0.407
n-C36	0.185	J		8	0.201	0.156	0.246
n-C37	0.181	J		12	0.207	0.158	0.256
n-C38	0.145	J		14	0.169	0.129	0.208
n-C39	0.139	J		13	0.160	0.124	0.196
n-C40	0.160	J		4	0.154	0.118	0.190
Total Petroleum Hydrocarbons	513			11	574	452	695

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	100
n-eicosane-d42	98
n-triacontane-d62	90

Total Petroleum Hydrocarbons Chromatograms

```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4078\FID60124 2020-04-13 08-5
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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 13-Apr-2020, 22:32     using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-1|sed|hc|A
Misc Info  :
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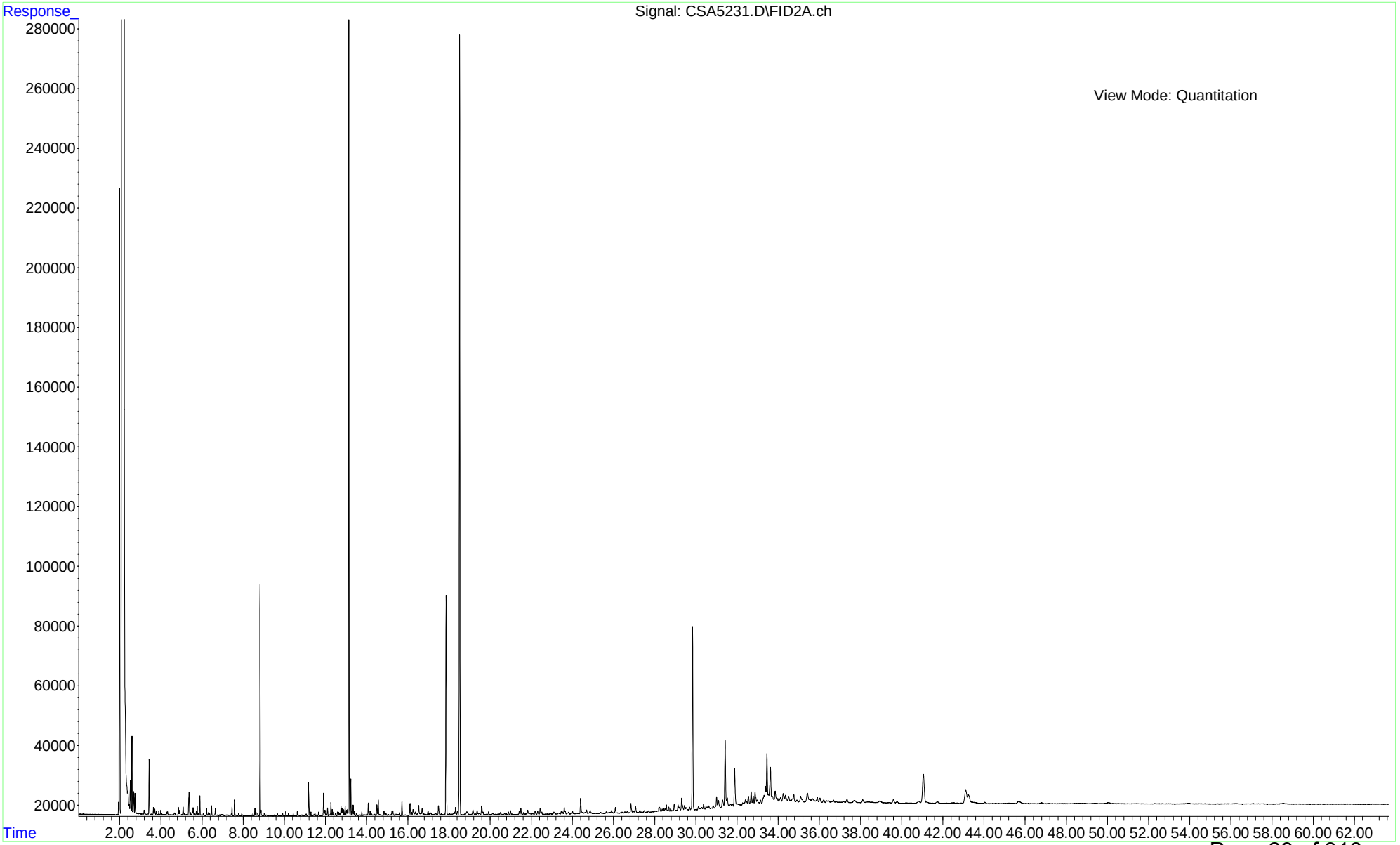

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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 14-Apr-2020, 23:28     using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-2|sed|hc|A
Misc Info  :
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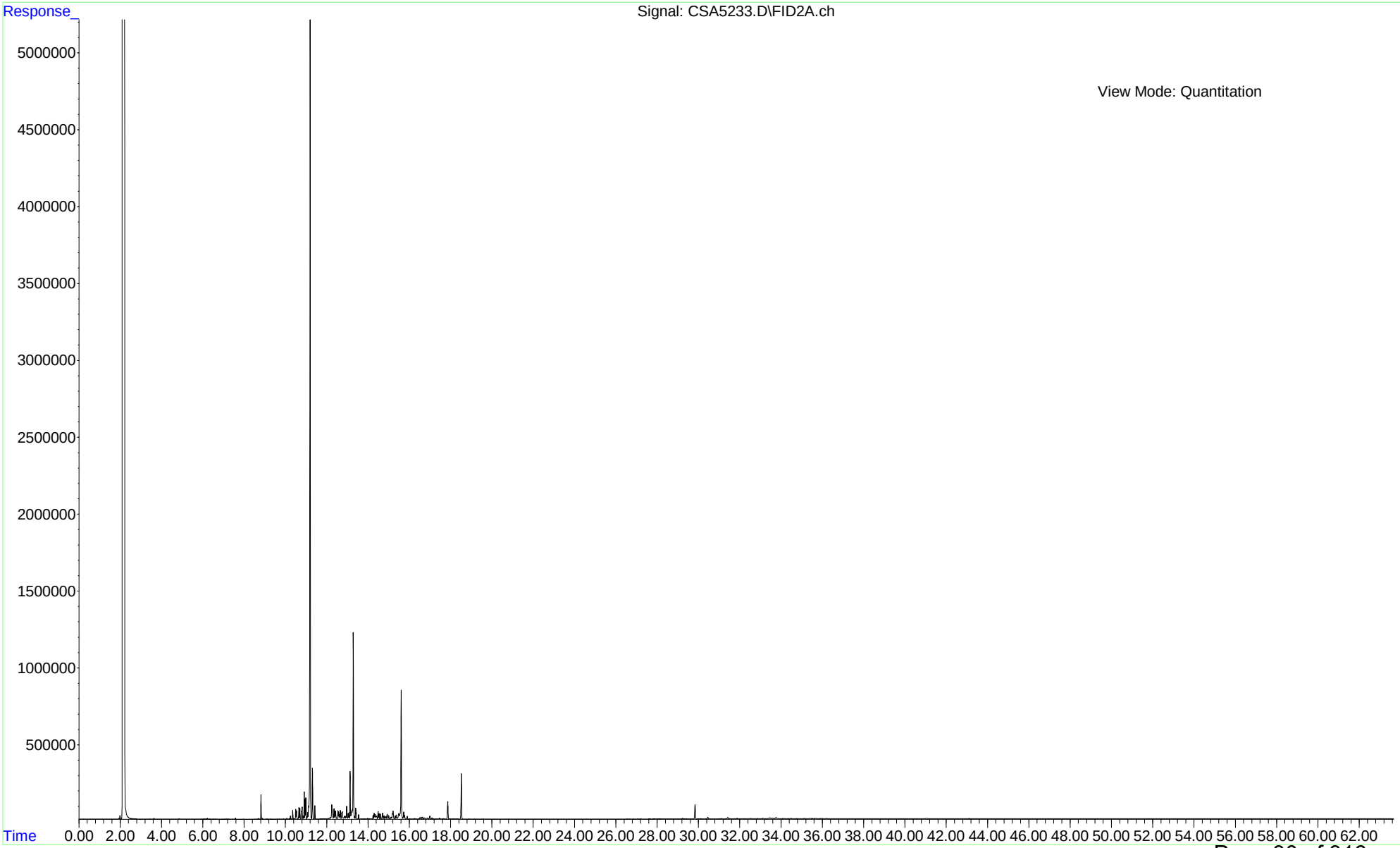

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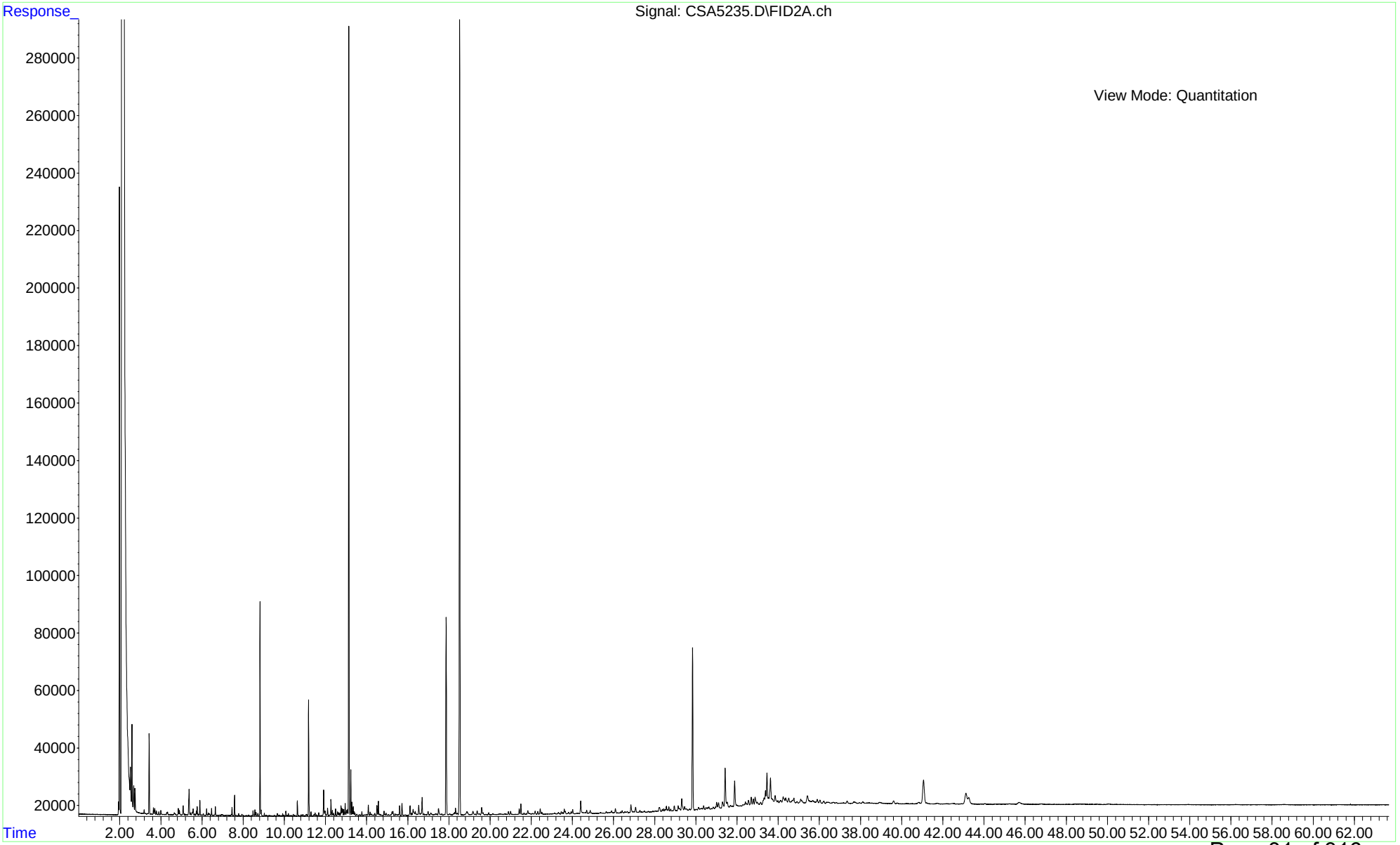
Operator : Chase Brewster
Instrument : GCI
Acquired : 14-Apr-2020, 01:56 using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-3|sed|hc|A
Misc Info :



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...         2-40.SC\CSA5237.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 14-Apr-2020, 03:04     using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-4|sed|hc|A
Misc Info  :
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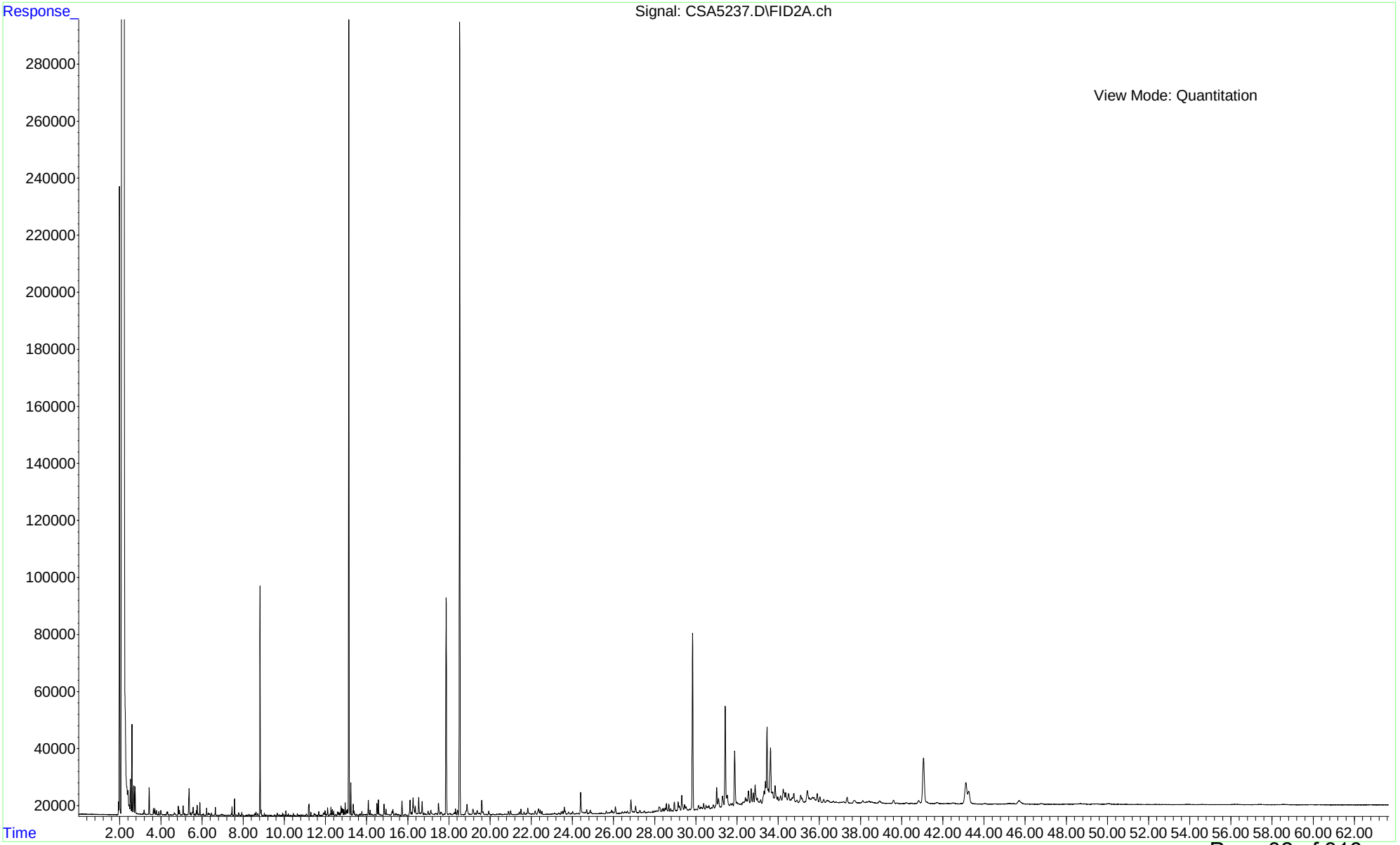

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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 14-Apr-2020, 04:12     using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-5|sed|hc|A
Misc Info  :
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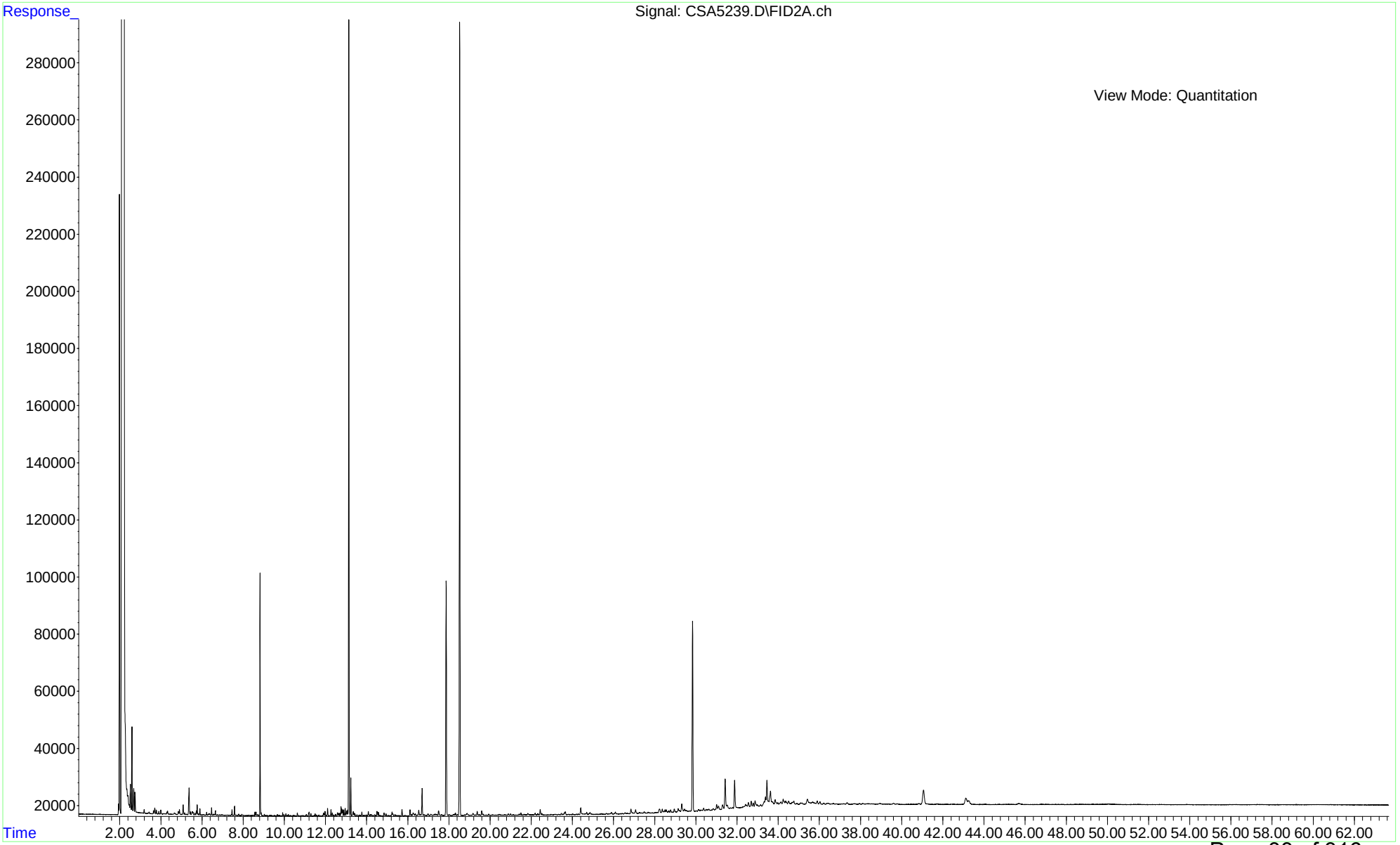

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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 14-Apr-2020, 05:20     using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-6|sed|hc|A
Misc Info  :
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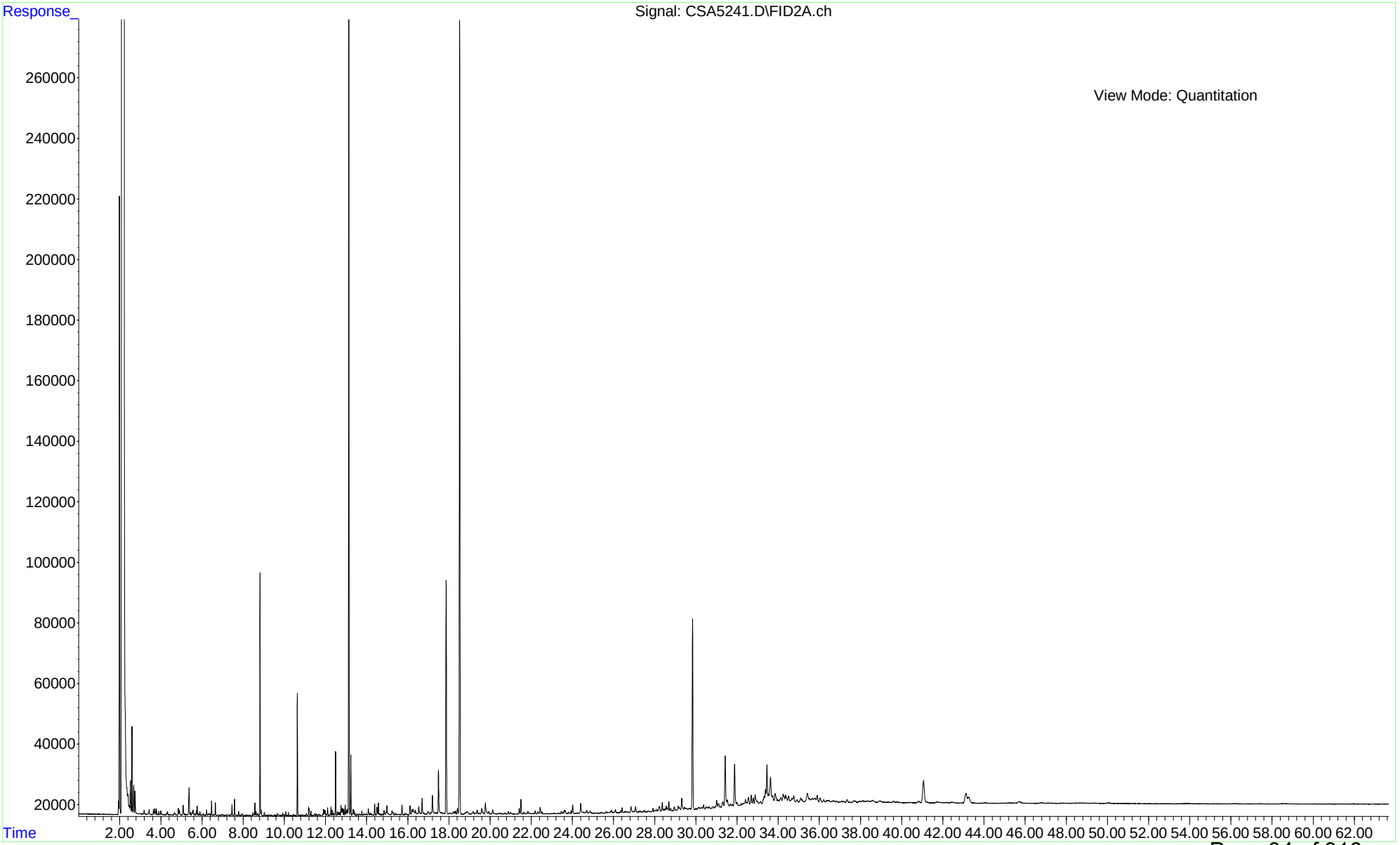

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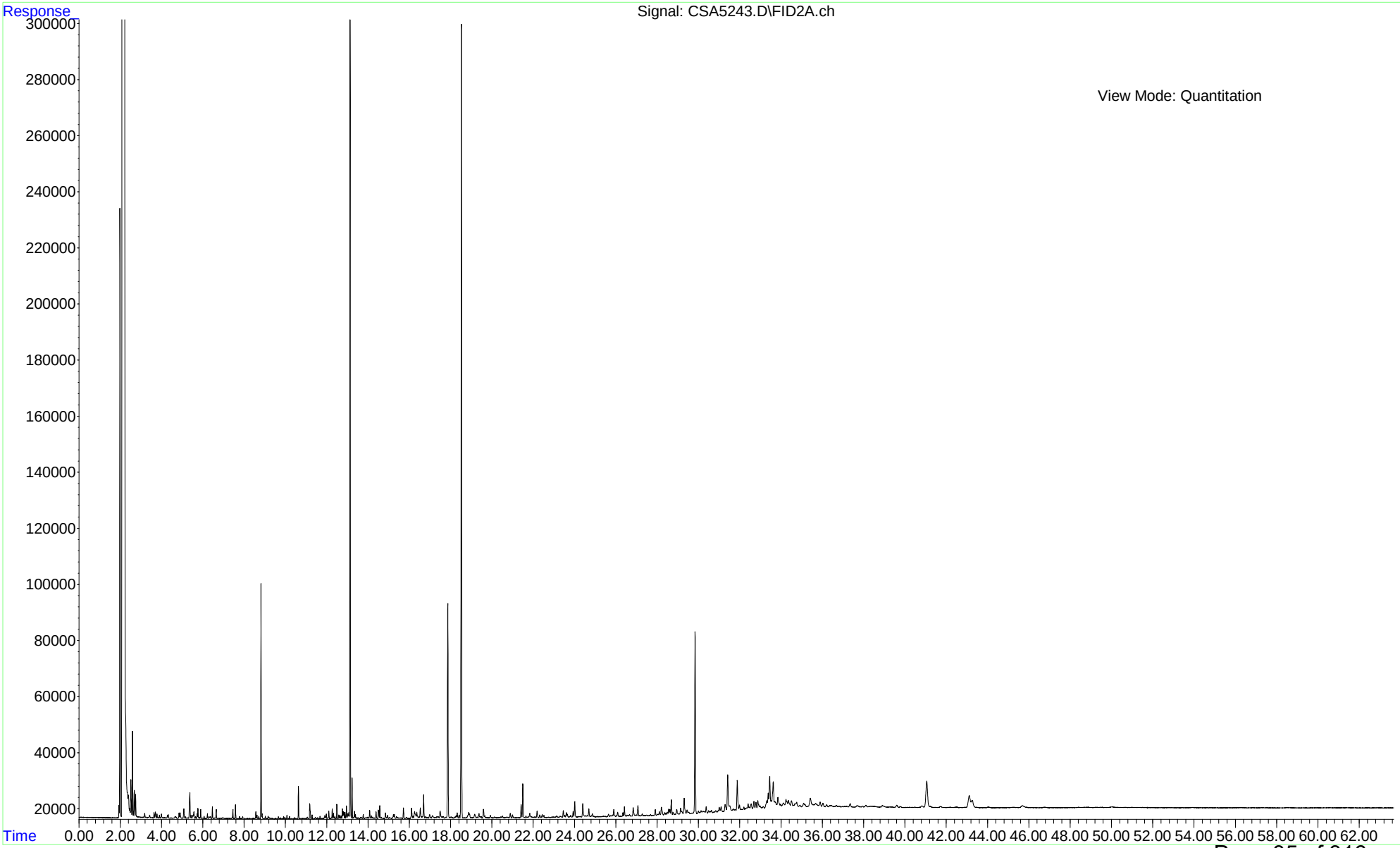
... 2-40.SC\CSA5243.D
Operator : Chase Brewster
Instrument : GCI
Acquired : 14-Apr-2020, 06:28 using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-7|sed|hc|A
Misc Info :



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...         2-40.SC\CSA5245.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 14-Apr-2020, 07:36     using AcqMethod ALIFRONT.M
Sample Name: 3532|03_20|HH-8|sed|hc|A
Misc Info  :
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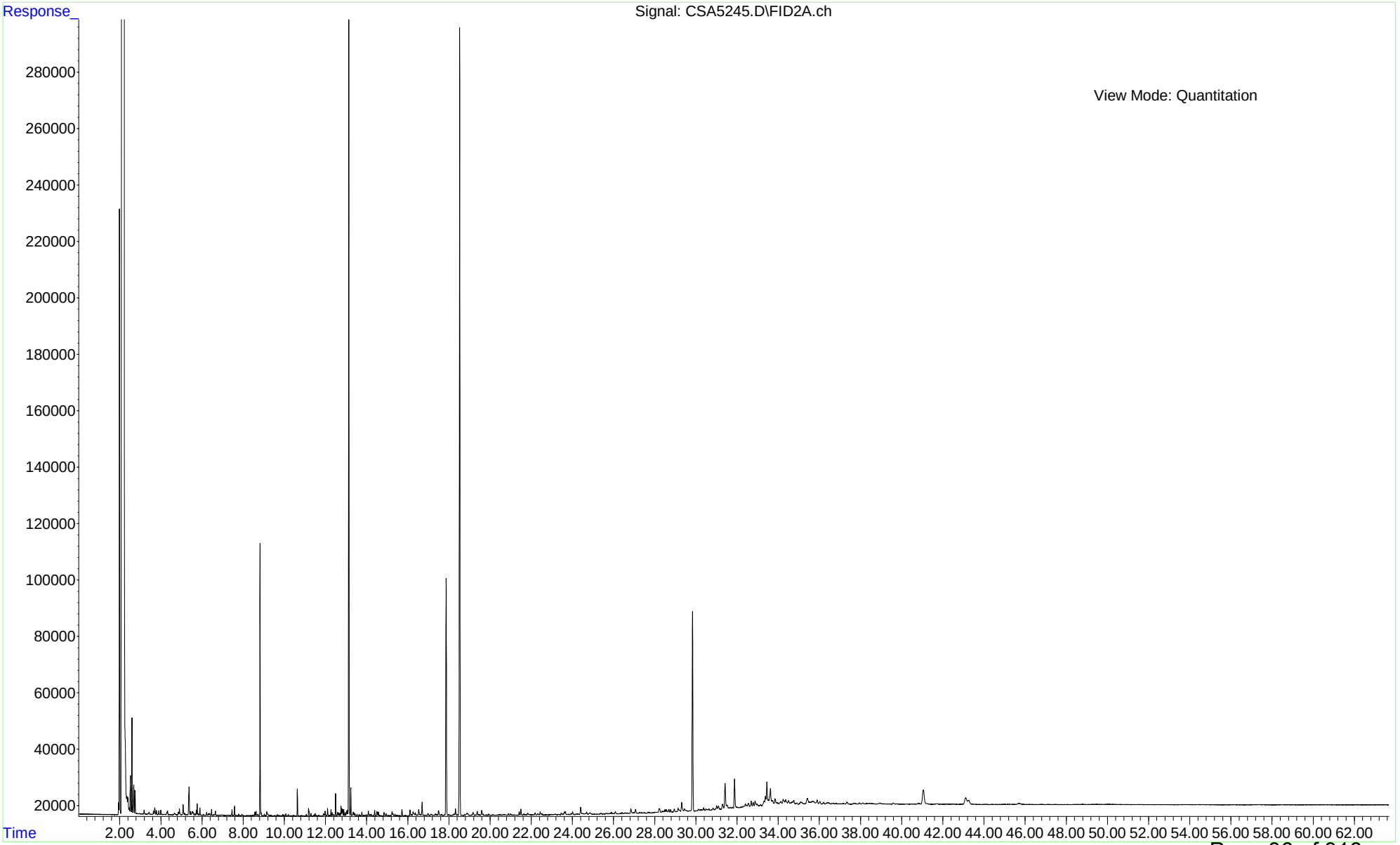


Polycyclic Aromatic Hydrocarbon Concentration

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5231.D	CSA5233.D	CSA5235.D	CSA5237.D
Sample ID	3532|03_20|HH-1|sed|hc|A	3532|03_20|HH-2|sed|hc|A	3532|03_20|HH-3|sed|hc|A	3532|03_20|HH-4|sed|hc|A
Matrix	Sediment	Sediment	Sediment	Sediment
Species	NA	NA	NA	NA
Collection Date	03/12/2020	03/12/2020	03/12/2020	03/12/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020 6:02	14-Apr-2020 18:31	14-Apr-2020 9:27	14-Apr-2020 10:35
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Dry Weight (g)	15.06	15.07	15.02	15.03
Sample Wet Weight (g)	52.53	44.36	53.18	53.72
% Dry	29	34	28	28
% Moisture	71	66	72	72
Dilution	1X	5X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q
cis/trans Decalin	0.8		2.64		3.49		4.08	
C1-Decalins	<0.3	U	2.80		1.67		<0.3	U
C2-Decalins	<0.3	U	12.0		<0.3	U	<0.3	U
C3-Decalins	<0.3	U	34.9		<0.3	U	<0.3	U
C4-Decalins	<0.3	U	36.1		<0.3	U	<0.3	U
Naphthalene	0.756		4.81		0.164	J	0.475	
C1-Naphthalenes	0.633	J	1.81	J	0.774	J	0.647	J
C2-Naphthalenes	<0.7	U	10.3		1.96		1.72	
C3-Naphthalenes	<0.7	U	22.4		4.54		3.72	
C4-Naphthalenes	<0.7	U	<3.4	U	<0.7	U	<0.7	U
Benzothiophene	<0.1	U	<0.5	U	<0.1	U	<0.1	U
C1-Benzothiophenes	<0.2	U	<0.9	U	<0.2	U	<0.2	U
C2-Benzothiophenes	<0.2	U	<0.9	U	<0.2	U	<0.2	U
C3-Benzothiophenes	<0.2	U	<0.9	U	<0.2	U	<0.2	U
C4-Benzothiophenes	<0.2	U	<0.9	U	<0.2	U	<0.2	U
Biphenyl	0.405		<1.5	U	0.717		0.584	
Acenaphthylene	<0	U	<0.2	U	0.051		<0	U
Acenaphthene	0.059	J	5.36		0.080	J	0.081	J
Dibenzofuran	0.378		2.28		0.489		0.446	
Fluorene	0.230		10.9		0.821		0.186	
C1-Fluorenes	0.622		5.95		0.748		0.784	
C2-Fluorenes	<0.4	U	<1.8	U	<0.4	U	<0.4	U
C3-Fluorenes	<0.4	U	<1.8	U	<0.4	U	<0.4	U
Carbazole	0.319		14.6		0.320		0.346	
Anthracene	0.169		<0.6	U	0.162		0.210	
Phenanthrene	1.82		3.27		2.27		1.91	
C1-Phenanthrenes/Anthracenes	2.26		6.40		2.72		2.28	
C2-Phenanthrenes/Anthracenes	7.76		14.5		7.86		6.90	
C3-Phenanthrenes/Anthracenes	2.73		9.70		2.46		2.49	
C4-Phenanthrenes/Anthracenes	1.64		5.30		1.79		1.59	
Dibenzothiophene	0.231		2.84		0.266		0.235	
C1-Dibenzothiophenes	0.522		2.23		0.592		0.483	
C2-Dibenzothiophenes	0.873		3.56		1.10		0.812	
C3-Dibenzothiophenes	1.12		3.97		1.01		0.779	
C4-Dibenzothiophenes	0.560		<1.2	U	<0.2	U	<0.2	U
Fluoranthene	0.982		1.28	J	0.905		1.03	
Pyrene	0.861		1.56		0.740		1.03	
C1-Fluoranthenes/Pyrenes	1.22		2.75		1.22		1.25	
C2-Fluoranthenes/Pyrenes	1.15		2.51		1.43		1.24	
C3-Fluoranthenes/Pyrenes	0.924		2.13	J	1.01		0.852	
C4-Fluoranthenes/Pyrenes	0.603		2.14	J	0.634		0.603	
Naphthobenzothiophene	0.531		1.01		0.599		0.666	
C1-Naphthobenzothiophenes	<0.3	U	1.81		0.650		0.743	
C2-Naphthobenzothiophenes	<0.3	U	2.39		1.11		1.08	
C3-Naphthobenzothiophenes	<0.3	U	<1.3	U	<0.3	U	1.07	
C4-Naphthobenzothiophenes	<0.3	U	<1.3	U	<0.3	U	<0.3	U
Benz(a)anthracene	0.398		0.437	J	0.305		0.508	
Chrysene/Triphenylene	1.27		1.68		1.28		1.31	
C1-Chrysenes	1.52		2.41		1.80		1.68	
C2-Chrysenes	1.84		<1.2	U	2.02		<0.2	U
C3-Chrysenes	<0.2	U	<1.2	U	<0.2	U	<0.2	U
C4-Chrysenes	<0.2	U	<1.2	U	<0.2	U	<0.2	U
Benzo(b)fluoranthene	1.25		1.20		1.27		1.33	
Benzo(k,j)fluoranthene	0.432		0.724		0.376		0.465	
Benzo(a)fluoranthene	0.118		0.608		0.143		<0.1	U
Benzo(e)pyrene	0.792		1.11		0.805		0.945	
Benzo(a)pyrene	0.321		0.744		0.226		0.433	
Perylene	30.4		72.7		27.5		38.9	
Indeno(1,2,3-c,d)pyrene	0.380		0.293		0.062		0.442	
Dibenzo(a,h)anthracene	0.426		0.285	J	0.468		0.360	
C1-Dibenzo(a,h)anthracenes	<0.1	U	<0.6	U	<0.1	U	<0.1	U
C2-Dibenzo(a,h)anthracenes	<0.1	U	<0.6	U	<0.1	U	<0.1	U
C3-Dibenzo(a,h)anthracenes	<0.1	U	<0.6	U	<0.1	U	<0.1	U
Benzo(g,h,i)perylene	0.649		0.144	J	0.548		0.740	
Total PAHs	70.0		319		81.2		87.4	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5231.D	CSA5233.D	CSA5235.D	CSA5237.D
Sample ID	3532|03_20|HH-1|sed|hc|A	3532|03_20|HH-2|sed|hc|A	3532|03_20|HH-3|sed|hc|A	3532|03_20|HH-4|sed|hc|A
Matrix	Sediment	Sediment	Sediment	Sediment
Species	NA	NA	NA	NA
Collection Date	03/12/2020	03/12/2020	03/12/2020	03/12/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020 6:02	14-Apr-2020 18:31	14-Apr-2020 9:27	14-Apr-2020 10:35
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Dry Weight (g)	15.06	15.07	15.02	15.03
Sample Wet Weight (g)	52.53	44.36	53.18	53.72
% Dry	29	34	28	28
% Moisture	71	66	72	72
Dilution	1X	5X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	0.607	J	1.60	J	0.750	J	0.614	J
1-Methylnaphthalene	0.373	J	1.22	J	0.448	J	0.388	J
2,6-Dimethylnaphthalene	0.572		1.89		0.695		0.637	
1,6,7-Trimethylnaphthalene	0.264		2.80		0.221		0.282	
1-Methylfluorene	0.326		3.49		0.409		0.401	
4-Methyldibenzothiophene	0.307		0.973		0.358		0.293	
2/3-Methyldibenzothiophene	0.263		1.47		0.298		0.242	
1-Methyldibenzothiophene	0.118		0.491		0.123		0.102	
3-Methylphenanthrene	0.711		1.88		0.792		0.696	
2-Methylphenanthrene	0.891		2.207		1.08		0.902	
2-Methylanthracene	0.144		0.313	J	0.166		0.181	
4/9-Methylphenanthrene	0.714		2.26		0.898		0.649	
1-Methylphenanthrene	0.573		1.94		0.716		0.633	
3,6-Dimethylphenanthrene	0.301		1.07		0.351		0.303	
Retene	0.147	J	4.65		0.356		0.182	J
2-Methylfluoranthene	0.173	J	0.327	J	0.202	J	0.184	J
Benzo(b)fluorene	0.233		0.279	J	0.099	J	0.098	J
C29-Hopane	1.94		15.50		5.22		3.53	
18a-Oleanane	1.01		<2.9	U	1.29		0.936	
C30-Hopane	5.26		34.9		7.91		8.097	
C20-TAS	0.073	J	0.875	J	0.107	J	0.139	J
C21-TAS	0.212	J	1.14	J	0.182	J	0.313	J
C26(20S)-TAS	1.56		5.02		1.26		2.83	
C26(20R)/C27(20S)-TAS	0.989		6.57		0.967		2.88	
C28(20S)-TAS	0.856		20.2		1.32		1.68	
C27(20R)-TAS	1.53		16.4		0.946		0.949	
C28(20R)-TAS	0.767		14.7		0.771		0.469	J
Surrogate Standards								
Naphthalene-d8	63		84	D	62		64	
Acenaphthene-d10	74		92	D	68		73	
Phenanthrene-d10	87		96	D	75		85	
Chrysene-d12	85		91	D	73		78	
Perylene-d12	51		94	D	37		49	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5239.D	CSA5241.D	CSA5243.D	CSA5245.D
Sample ID	3532|03_20|HH-5|sed|hc|A	3532|03_20|HH-6|sed|hc|A	3532|03_20|HH-7|sed|hc|A	3532|03_20|HH-8|sed|hc|A
Matrix	Sediment	Sediment	Sediment	Sediment
Species	NA	NA	NA	NA
Collection Date	03/11/2020	03/12/2020	03/12/2020	03/11/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020 11:43	14-Apr-2020 12:51	14-Apr-2020 13:59	14-Apr-2020 15:07
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Dry Weight (g)	15.03	15.05	15.04	15.00
Sample Wet Weight (g)	31.41	46.72	52.09	35.00
% Dry	48	32	29	43
% Moisture	52	68	71	57
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q
cis/trans Decalin	0.854		1.79		2.36		1.09	
C1-Decalins	<0.3	U	1.06		<0.3	U	<0.3	U
C2-Decalins	<0.3	U	<0.3	U	<0.3	U	<0.3	U
C3-Decalins	<0.3	U	<0.3	U	<0.3	U	<0.3	U
C4-Decalins	<0.3	U	<0.3	U	<0.3	U	<0.3	U
Naphthalene	0.378		0.375		0.409		0.439	
C1-Naphthalenes	0.338	J	0.751	J	0.707	J	0.377	J
C2-Naphthalenes	0.847		1.85		1.98		0.923	
C3-Naphthalenes	1.10		3.57		3.92		2.29	
C4-Naphthalenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Benzothiophene	<0.1	U	<0.1	U	<0.1	U	<0.1	U
C1-Benzothiophenes	<0.2	U	<0.2	U	<0.2	U	<0.2	U
C2-Benzothiophenes	<0.2	U	<0.2	U	<0.2	U	<0.2	U
C3-Benzothiophenes	<0.2	U	<0.2	U	<0.2	U	<0.2	U
C4-Benzothiophenes	<0.2	U	<0.2	U	<0.2	U	<0.2	U
Biphenyl	0.481		0.598		0.759		0.289	J
Acenaphthylene	0.042		0.060		<0	U	0.041	
Acenaphthene	0.021	J	0.085	J	0.073	J	0.031	J
Dibenzofuran	0.342		0.428		0.416		0.235	
Fluorene	0.309		0.557		0.584		0.284	
C1-Fluorenes	0.382		0.605		0.698		0.338	J
C2-Fluorenes	0.866		<0.4	U	<0.4	U	<0.4	U
C3-Fluorenes	4.43		<0.4	U	<0.4	U	<0.4	U
Carbazole	0.229		0.321		0.314		0.302	
Anthracene	0.077	J	0.119		0.154		0.075	J
Phenanthrene	1.01		1.84		1.82		1.01	
C1-Phenanthrenes/Anthracenes	1.11		1.98		2.30		1.17	
C2-Phenanthrenes/Anthracenes	4.98		6.56		6.91		5.08	
C3-Phenanthrenes/Anthracenes	<0.3	U	1.88		1.88		1.13	
C4-Phenanthrenes/Anthracenes	<0.3	U	1.13		1.54		0.914	
Dibenzothiophene	0.118		0.202		0.223		0.127	
C1-Dibenzothiophenes	0.297		0.408		0.422		0.313	
C2-Dibenzothiophenes	0.549		0.737		0.791		0.614	
C3-Dibenzothiophenes	0.668		0.814		0.735		0.526	
C4-Dibenzothiophenes	0.324		<0.2	U	<0.2	U	<0.2	U
Fluoranthene	0.512		0.861		0.975		0.552	
Pyrene	0.335		0.581		0.743		0.379	
C1-Fluoranthenes/Pyrenes	0.483		0.892		1.09		0.535	
C2-Fluoranthenes/Pyrenes	0.506		1.02		1.13		0.538	
C3-Fluoranthenes/Pyrenes	0.445	J	1.02		1.44		0.370	J
C4-Fluoranthenes/Pyrenes	0.306	J	0.452	J	0.577		0.268	J
Naphthobenzothiophene	0.224		0.443		0.584		0.308	
C1-Naphthobenzothiophenes	<0.3	U	0.569		0.621		0.267	
C2-Naphthobenzothiophenes	<0.3	U	0.928		0.877		0.445	
C3-Naphthobenzothiophenes	<0.3	U	0.699		0.728		0.378	
C4-Naphthobenzothiophenes	<0.3	U	<0.3	U	<0.3	U	<0.3	U
Benz(a)anthracene	0.123	J	0.221		0.326		0.134	J
Chrysene/Triphenylene	0.613		1.04		1.37		0.663	
C1-Chrysenes	0.124	J	1.20		1.50		0.663	
C2-Chrysenes	0.074	J	2.10		2.76		0.731	
C3-Chrysenes	0.101	J	<0.2	U	<0.2	U	<0.2	U
C4-Chrysenes	<0.2	U	<0.2	U	<0.2	U	<0.2	U
Benzo(b)fluoranthene	0.575		1.01		1.24		0.611	
Benzo(k,j)fluoranthene	0.234		0.376		0.417		0.229	
Benzo(a)fluoranthene	0.087	J	0.125		0.178		0.110	
Benzo(e)pyrene	0.356		0.636		0.775		0.419	
Benzo(a)pyrene	0.118		0.217		0.291		0.134	
Perylene	11.7		21.9		28.6		12.0	
Indeno(1,2,3-c,d)pyrene	0.164		0.277		0.329		0.182	
Dibenzo(a,h)anthracene	0.091		0.195		0.298		0.105	
C1-Dibenzo(a,h)anthracenes	<0.1	U	<0.1	U	<0.1	U	<0.1	U
C2-Dibenzo(a,h)anthracenes	<0.1	U	<0.1	U	<0.1	U	<0.1	U
C3-Dibenzo(a,h)anthracenes	<0.1	U	<0.1	U	<0.1	U	<0.1	U
Benzo(g,h,i)perylene	0.255		0.427		0.544		0.269	
Total PAHs	37.2		64.9		76.4		37.9	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5239.D	CSA5241.D	CSA5243.D	CSA5245.D
Sample ID	3532|03_20|HH-5|sed|hc|A	3532|03_20|HH-6|sed|hc|A	3532|03_20|HH-7|sed|hc|A	3532|03_20|HH-8|sed|hc|A
Matrix	Sediment	Sediment	Sediment	Sediment
Species	NA	NA	NA	NA
Collection Date	03/11/2020	03/12/2020	03/12/2020	03/11/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020 11:43	14-Apr-2020 12:51	14-Apr-2020 13:59	14-Apr-2020 15:07
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Dry Weight (g)	15.03	15.05	15.04	15.00
Sample Wet Weight (g)	31.41	46.72	52.09	35.00
% Dry	48	32	29	43
% Moisture	52	68	71	57
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q
Individual Alkyl Isomers and Hopa								
2-Methylnaphthalene	0.319	J	0.726	J	0.656	J	0.345	J
1-Methylnaphthalene	0.205	J	0.437	J	0.440	J	0.240	J
2,6-Dimethylnaphthalene	0.259	J	0.634		0.638		0.293	
1,6,7-Trimethylnaphthalene	0.145		0.321		0.348		0.117	J
1-Methylfluorene	0.163	J	0.317		0.369		0.172	J
4-Methyldibenzothiophene	0.171		0.253		0.261		0.180	
2/3-Methyldibenzothiophene	0.154		0.217		0.228		0.155	
1-Methyldibenzothiophene	0.065	J	0.068	J	0.067	J	0.078	J
3-Methylphenanthrene	0.373		0.635		0.782		0.364	
2-Methylphenanthrene	0.408		0.781		0.915		0.460	
2-Methylanthracene	0.105		0.178		0.141		0.055	J
4/9-Methylphenanthrene	0.320		0.575		0.687		0.375	
1-Methylphenanthrene	0.284		0.483		0.559		0.313	
3,6-Dimethylphenanthrene	0.141		0.242		0.304		0.154	
Retene	<0.2	U	0.121	J	0.242		0.110	J
2-Methylfluoranthene	0.079	J	0.143	J	0.179	J	0.089	J
Benzo(b)fluorene	0.074	J	0.202		0.254		0.114	J
C29-Hopane	1.445		2.78		2.13		1.52	
18a-Oleanane	0.895		1.58		1.48		0.783	
C30-Hopane	3.05		5.14		6.06		3.07	
C20-TAS	0.042	J	0.066	J	0.077	J	0.038	J
C21-TAS	0.103	J	0.211	J	0.089	J	0.122	J
C26(20S)-TAS	0.648		0.945		1.25		0.733	
C26(20R)/C27(20S)-TAS	0.578		0.946		0.941		0.608	
C28(20S)-TAS	0.495	J	0.999		0.981		0.612	
C27(20R)-TAS	0.596		1.03		0.558	J	0.461	J
C28(20R)-TAS	0.688		0.926		0.801		0.703	

Surrogate Standards				
Naphthalene-d8	67	67	68	74
Acenaphthene-d10	78	77	76	83
Phenanthrene-d10	94	87	84	90
Chrysene-d12	89	87	91	88
Perylene-d12	67	60	58	64

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4078A.D
Sample ID	Method Blank
Matrix	Sediment
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	04/08/2020
Extraction Batch	ENV4078
Date Acquired	14-Apr-2020 0:22
Method	SOP1006
Sample Dry Weight (g)	15.00
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	3X MDL	Actual MDL
cis/trans Decalin	<0.1	U	0.396	0.132
C1-Decalins	<0.3	U	0.789	0.263
C2-Decalins	<0.3	U	0.789	0.263
C3-Decalins	<0.3	U	0.789	0.263
C4-Decalins	<0.3	U	0.789	0.263
Naphthalene	<0.3	U	1.03	0.342
C1-Naphthalenes	<1	U	3.09	1.03
C2-Naphthalenes	<0.7	U	2.05	0.684
C3-Naphthalenes	<0.7	U	2.05	0.684
C4-Naphthalenes	<0.7	U	2.05	0.684
Benzothiophene	<0.1	U	0.270	0.090
C1-Benzothiophenes	<0.2	U	0.540	0.180
C2-Benzothiophenes	<0.2	U	0.540	0.180
C3-Benzothiophenes	<0.2	U	0.540	0.180
C4-Benzothiophenes	<0.2	U	0.540	0.180
Biphenyl	<0.3	U	0.882	0.294
Acenaphthylene	<0	U	0.123	0.041
Acenaphthene	<0.1	U	0.309	0.103
Dibenzofuran	<0.2	U	0.612	0.204
Fluorene	<0.2	U	0.549	0.183
C1-Fluorenes	<0.4	U	1.10	0.367
C2-Fluorenes	<0.4	U	1.10	0.367
C3-Fluorenes	<0.4	U	1.10	0.367
Carbazole	<0.1	U	0.450	0.150
Anthracene	<0.1	U	0.345	0.115
Phenanthrene	<0.2	U	0.624	0.208
C1-Phenanthrenes/Anthracenes	<0.1	U	0.231	0.077
C2-Phenanthrenes/Anthracenes	<0.3	U	0.855	0.285
C3-Phenanthrenes/Anthracenes	<0.3	U	0.855	0.285
C4-Phenanthrenes/Anthracenes	<0.3	U	0.855	0.285
Dibenzothiophene	<0.1	U	0.348	0.116
C1-Dibenzothiophenes	<0.1	U	0.192	0.064
C2-Dibenzothiophenes	<0.2	U	0.696	0.232
C3-Dibenzothiophenes	<0.2	U	0.696	0.232
C4-Dibenzothiophenes	<0.2	U	0.696	0.232
Fluoranthene	<0.3	U	0.999	0.333
Pyrene	<0.1	U	0.408	0.136
C1-Fluoranthenes/Pyrenes	<0.5	U	1.41	0.469
C2-Fluoranthenes/Pyrenes	<0.5	U	1.41	0.469
C3-Fluoranthenes/Pyrenes	<0.5	U	1.41	0.469
C4-Fluoranthenes/Pyrenes	<0.5	U	1.41	0.469
Naphthobenzothiophene	<0.1	U	0.384	0.128
C1-Naphthobenzothiophenes	<0.3	U	0.768	0.256
C2-Naphthobenzothiophenes	<0.3	U	0.768	0.256
C3-Naphthobenzothiophenes	<0.3	U	0.768	0.256
C4-Naphthobenzothiophenes	<0.3	U	0.768	0.256
Benz(a)anthracene	<0.2	U	0.576	0.192
Chrysene/Triphenylene	<0.1	U	0.348	0.116
C1-Chrysenes	<0.2	U	0.696	0.232
C2-Chrysenes	<0.2	U	0.696	0.232
C3-Chrysenes	<0.2	U	0.696	0.232
C4-Chrysenes	<0.2	U	0.696	0.232
Benzo(b)fluoranthene	<0.2	U	0.609	0.203
Benzo(k,j)fluoranthene	<0.1	U	0.294	0.098
Benzo(a)fluoranthene	<0.1	U	0.294	0.098
Benzo(e)pyrene	<0.2	U	0.531	0.177
Benzo(a)pyrene	<0.1	U	0.303	0.101
Perylene	<1.3	U	3.80	1.27
Indeno(1,2,3-c,d)pyrene	<0.1	U	0.150	0.050
Dibenzo(a,h)anthracene	<0.1	U	0.192	0.064
C1-Dibenzo(a,h)anthracenes	<0.1	U	0.387	0.129
C2-Dibenzo(a,h)anthracenes	<0.1	U	0.387	0.129
C3-Dibenzo(a,h)anthracenes	<0.1	U	0.387	0.129
Benzo(g,h,i)perylene	<0.1	U	0.264	0.088
Total PAHs	0.0			

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4078A.D
Sample ID	Method Blank
Matrix	Sediment
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	04/08/2020
Extraction Batch	ENV4078
Date Acquired	14-Apr-2020 0:22
Method	SOP1006
Sample Dry Weight (g)	15.00
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	3X MDL	Actual MDL
Individual Alkyl Isomers and Hopanes				
2-Methylnaphthalene	<1.3	U	3.89	1.30
1-Methylnaphthalene	<0.5	U	1.64	0.546
2,6-Dimethylnaphthalene	<0.3	U	0.783	0.261
1,6,7-Trimethylnaphthalene	<0.1	U	0.381	0.127
1-Methylfluorene	<0.2	U	0.573	0.191
4-Methyldibenzothiophene	<0.1	U	0.273	0.091
2/3-Methyldibenzothiophene	<0.1	U	0.273	0.091
1-Methyldibenzothiophene	<0.1	U	0.273	0.091
3-Methylphenanthrene	<0.1	U	0.291	0.097
2-Methylphenanthrene	<0.1	U	0.291	0.097
2-Methylanthracene	<0.1	U	0.291	0.097
4/9-Methylphenanthrene	<0.1	U	0.291	0.097
1-Methylphenanthrene	<0.1	U	0.291	0.097
3,6-Dimethylphenanthrene	<0.1	U	0.330	0.110
Retene	<0.2	U	0.693	0.231
2-Methylfluoranthene	<0.2	U	0.669	0.223
Benzo(b)fluorene	<0.1	U	0.375	0.125
C29-Hopane	<0.6	U	1.73	0.575
18a-Oleanane	<0.6	U	1.73	0.575
C30-Hopane	<0.6	U	1.73	0.575
C20-TAS	<0.6	U	1.73	0.575
C21-TAS	<0.6	U	1.73	0.575
C26(20S)-TAS	<0.6	U	1.73	0.575
C26(20R)/C27(20S)-TAS	<0.6	U	1.73	0.575
C28(20S)-TAS	<0.6	U	1.73	0.575
C27(20R)-TAS	<0.6	U	1.73	0.575
C28(20R)-TAS	<0.6	U	1.73	0.575

Surrogate Standards	
Naphthalene-d8	86
Acenaphthene-d10	88
Phenanthrene-d10	82
Chrysene-d12	87
Perylene-d12	93

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4078B.D
Sample ID	Blank Spike
Matrix	Sediment
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	04/08/2020
Extraction Batch	ENV4078
Date Acquired	14-Apr-2020 1:30
Method	SOP1006
Sample Dry Weight (g)	1.00
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Amount (ng)
cis/trans Decalin	85.8		86		100
C1-Decalins	NA				
C2-Decalins	NA				
C3-Decalins	NA				
C4-Decalins	NA				
Naphthalene	88.2		88		100
C1-Naphthalenes	NA				
C2-Naphthalenes	NA				
C3-Naphthalenes	NA				
C4-Naphthalenes	NA				
Benzothiophene	86.9		87		100
C1-Benzothiophenes	NA				
C2-Benzothiophenes	NA				
C3-Benzothiophenes	NA				
C4-Benzothiophenes	NA				
Biphenyl	127		127		100
Acenaphthylene	92		92		100
Acenaphthene	92.8		93		100
Dibenzofuran	94		94		100
Fluorene	97		97		100
C1-Fluorenes	NA				
C2-Fluorenes	NA				
C3-Fluorenes	NA				
Carbazole	98		98		100
Anthracene	97.5		97		100
Phenanthrene	98.4		98		100
C1-Phenanthrenes/Anthracenes	NA				
C2-Phenanthrenes/Anthracenes	NA				
C3-Phenanthrenes/Anthracenes	NA				
C4-Phenanthrenes/Anthracenes	NA				
Dibenzothiophene	109		109		100
C1-Dibenzothiophenes	NA				
C2-Dibenzothiophenes	NA				
C3-Dibenzothiophenes	NA				
C4-Dibenzothiophenes	NA				
Fluoranthene	103		103		100
Pyrene	101		101		100
C1-Fluoranthenes/Pyrenes	NA				
C2-Fluoranthenes/Pyrenes	NA				
C3-Fluoranthenes/Pyrenes	NA				
C4-Fluoranthenes/Pyrenes	NA				
Naphthobenzothiophene	102		102		100
C1-Naphthobenzothiophenes	NA				
C2-Naphthobenzothiophenes	NA				
C3-Naphthobenzothiophenes	NA				
C4-Naphthobenzothiophenes	NA				
Benz(a)anthracene	102		102		100
Chrysene/Triphenylene	100		100		100
C1-Chrysenes	NA				
C2-Chrysenes	NA				
C3-Chrysenes	NA				
C4-Chrysenes	NA				
Benzo(b)fluoranthene	102		102		100
Benzo(k,j)fluoranthene	98.8		99		100
Benzo(a)fluoranthene	NA				
Benzo(e)pyrene	104		104		100
Benzo(a)pyrene	98		98		100
Perylene	116.2		116		100
Indeno(1,2,3-c,d)pyrene	93.8		94		100
Dibenzo(a,h)anthracene	87.8		88		100
C1-Dibenzo(a,h)anthracenes	NA				
C2-Dibenzo(a,h)anthracenes	NA				
C3-Dibenzo(a,h)anthracenes	NA				
Benzo(g,h,i)perylene	93.2		93		100
Average Recovery (%)			100		

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4078B.D
Sample ID	Blank Spike
Matrix	Sediment
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	04/08/2020
Extraction Batch	ENV4078
Date Acquired	14-Apr-2020 1:30
Method	SOP1006
Sample Dry Weight (g)	1.00
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Amount (ng)
Individual Alkyl Isomers and Hopanes					
2-Methylnaphthalene	89.8		90		100
1-Methylnaphthalene	88.1		88		100
2,6-Dimethylnaphthalene	91.5		92		100
1,6,7-Trimethylnaphthalene	96.5		97		100
1-Methylfluorene	103		103		100
4-Methyldibenzothiophene	115		115		100
2/3-Methyldibenzothiophene	NA				
1-Methyldibenzothiophene	NA				
3-Methylphenanthrene	NA				
2-Methylphenanthrene	NA				
2-Methylanthracene	NA				
4/9-Methylphenanthrene	NA				
1-Methylphenanthrene	106		106		100
3,6-Dimethylphenanthrene	106		106		100
Retene	107		107		100
2-Methylfluoranthene	104		104		100
Benzo(b)fluorene	108		108		100
C29-Hopane	NA				
18a-Oleanane	NA				
C30-Hopane	108		108		100
C20-TAS	NA				
C21-TAS	NA				
C26(20S)-TAS	NA				
C26(20R)/C27(20S)-TAS	NA				
C28(20S)-TAS	NA				
C27(20R)-TAS	NA				
C28(20R)-TAS	NA				

Surrogate Standards	
Naphthalene-d8	80
Acenaphthene-d10	88
Phenanthrene-d10	92
Chrysene-d12	93
Perylene-d12	90

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Matrix Spike Report

Laboratory ID	CSA5239.D	ENV4078C.D	ENV4078D.D
Sample ID	3532|03_20|HH-5|sed|hc|A	MS (3532|03_20|HH-5|sed|hc|A)	MSD (3532|03_20|HH-5|sed|hc|A)
Matrix	Sediment	Sediment	Sediment
Species	NA	NA	NA
Collection Date	03/11/2020	03/11/2020	03/11/2020
Received Date	03/17/2020	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020 11:43	14-Apr-2020 2:38	14-Apr-2020 3:46
Method	SOP1006	SOP1006	SOP1006
Sample Dry Weight (g)	15.03	15.06	15.03
Sample Wet Weight (g)	31.41	31.47	31.41
% Dry	48	48	48
% Moisture	52	52	52
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Q1	Su. Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Q1	RPD (%)	Q	Amount (ng)
cis/trans Decalin	0.854		6.36		83			6.26		81			2		100
C1-Decalins	<0.3	U	NA					NA							
C2-Decalins	<0.3	U	NA					NA							
C3-Decalins	<0.3	U	NA					NA							
C4-Decalins	<0.3	U	NA					NA							
Naphthalene	0.378		5.88		83			5.67		80			4		100
C1-Naphthalenes	0.338	J	NA					NA							
C2-Naphthalenes	0.847		NA					NA							
C3-Naphthalenes	1.10		NA					NA							
C4-Naphthalenes	<0.7	U	NA					NA							
Benzothiophene	<0.1	U	5.48		83			5.35		80			3		100
C1-Benzothiophenes	<0.2	U	NA					NA							
C2-Benzothiophenes	<0.2	U	NA					NA							
C3-Benzothiophenes	<0.2	U	NA					NA							
C4-Benzothiophenes	<0.2	U	NA					NA							
Biphenyl	0.481		8.42		120			8.19		116			3		100
Acenaphthylene	0.042		6.03		90			6.01		90			0		100
Acenaphthene	0.021	J	6.50		98			6.31		94			3		100
Dibenzofuran	0.342		6.45		92			6.32		90			2		100
Fluorene	0.309		6.76		97			6.75		97			0		100
C1-Fluorenes	0.382		NA					NA							
C2-Fluorenes	0.866		NA					NA							
C3-Fluorenes	4.428		NA					NA							
Carbazole	0.229		6.34		92			6.37		92			1		100
Anthracene	0.077	J	6.64		99			6.64		99			0		100
Phenanthrene	1.01		7.47		97			7.34		95			2		100
C1-Phenanthrenes/Anthracenes	1.11		NA					NA							
C2-Phenanthrenes/Anthracenes	4.98		NA					NA							
C3-Phenanthrenes/Anthracenes	<0.3	U	NA					NA							
C4-Phenanthrenes/Anthracenes	<0.3	U	NA					NA							
Dibenzothiophene	0.118		7.29		108			7.16		106			2		100
C1-Dibenzothiophenes	0.297		NA					NA							
C2-Dibenzothiophenes	0.549		NA					NA							
C3-Dibenzothiophenes	0.668		NA					NA							
C4-Dibenzothiophenes	0.324		NA					NA							
Fluoranthene	0.512		7.46		105			7.38		103			1		100
Pyrene	0.335		7.11		102			7.11		102			0		100
C1-Fluoranthenes/Pyrenes	0.483		NA					NA							
C2-Fluoranthenes/Pyrenes	0.506		NA					NA							
C3-Fluoranthenes/Pyrenes	0.445	J	NA					NA							
C4-Fluoranthenes/Pyrenes	0.306	J	NA					NA							
Naphthobenzothiophene	0.224		7.24		106			7.12		104			2		100
C1-Naphthobenzothiophenes	<0.3	U	NA					NA							
C2-Naphthobenzothiophenes	<0.3	U	NA					NA							
C3-Naphthobenzothiophenes	<0.3	U	NA					NA							
C4-Naphthobenzothiophenes	<0.3	U	NA					NA							
Benz(a)anthracene	0.123	J	7.00		103			7.00		103			0		100
Chrysene/Triphenylene	0.613		7.28		100			7.24		100			1		100
C1-Chrysenes	0.124	J	NA					NA							
C2-Chrysenes	0.074	J	NA					NA							
C3-Chrysenes	0.101	J	NA					NA							
C4-Chrysenes	<0.2	U	NA					NA							
Benzo(b)fluoranthene	0.575		7.62		106			7.77		108			2		100
Benzo(k,j)fluoranthene	0.234		6.98		102			7.05		102			1		100
Benzo(a)fluoranthene	0.087	J	NA					NA							
Benzo(e)pyrene	0.356		7.33		105			7.36		105			0		100
Benzo(a)pyrene	0.118		6.52		96			6.49		96			0		100
Perylene	11.7		19.0		109			19.0		110			0		100
Indeno(1,2,3-c,d)pyrene	0.164		6.78		100			6.78		99			0		100
Dibenzo(a,h)anthracene	0.091		6.34		94			6.35		94			0		100
C1-Dibenzo(a,h)anthracenes	<0.1	U	NA					NA							
C2-Dibenzo(a,h)anthracenes	<0.1	U	NA					NA							
C3-Dibenzo(a,h)anthracenes	<0.1	U	NA					NA							
Benzo(g,h,i)perylene	0.255		6.95		101			7.07		102			2		100
Average Recovery (%)					99					99					

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Matrix Spike Report

Laboratory ID	CSA5239.D	ENV4078C.D	ENV4078D.D
Sample ID	3532|03_20|HH-5|sed|hc|A	MS (3532|03_20|HH-5|sed|hc|A)	MSD (3532|03_20|HH-5|sed|hc|A)
Matrix	Sediment	Sediment	Sediment
Species	NA	NA	NA
Collection Date	03/11/2020	03/11/2020	03/11/2020
Received Date	03/17/2020	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078	ENV4078
Date Acquired	14-Apr-2020 11:43	14-Apr-2020 2:38	14-Apr-2020 3:46
Method	SOP1006	SOP1006	SOP1006
Sample Dry Weight (g)	15.03	15.06	15.03
Sample Wet Weight (g)	31.41	31.47	31.41
% Dry	48	48	48
% Moisture	52	52	52
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q Q1	Su. Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q Q1	RPD (%)	Q	Amount (ng)
Individual Alkyl Isomers and Hopanes													
2-Methylnaphthalene	0.319	J	6.00		86		5.93		84		1		100
1-Methylnaphthalene	0.205	J	5.81		84		5.66		82		3		100
2,6-Dimethylnaphthalene	0.259	J	6.20		90		6.21		89		0		100
1,6,7-Trimethylnaphthalene	0.145		6.53		96		6.55		96		0		100
1-Methylfluorene	0.163	J	7.07		104		7.13		105		1		100
4-Methyldibenzothiophene	0.171		7.69		113		7.69		113		0		100
2/3-Methyldibenzothiophene	0.154		NA				NA						
1-Methyldibenzothiophene	0.065	J	NA				NA						
3-Methylphenanthrene	0.373		NA				NA						
2-Methylphenanthrene	0.408		NA				NA						
2-Methylanthracene	0.105		NA				NA						
4/9-Methylphenanthrene	0.320		NA				NA						
1-Methylphenanthrene	0.284		7.29		106		7.30		105		0		100
3,6-Dimethylphenanthrene	0.141		7.33		108		7.37		109		1		100
Retene	<0.2	U	7.27		109		7.24		109		0		100
2-Methylfluoranthene	0.079	J	7.03		105		7.07		105		1		100
Benzo(b)fluorene	0.074	J	7.28		108		7.34		109		1		100
C29-Hopane	1.45		NA				NA						
18a-Oleanane	0.895		NA				NA						
C30-Hopane	3.05		NA				NA						
C20-TAS	0.042	J	NA				NA						
C21-TAS	0.103	J	NA				NA						
C26(20S)-TAS	0.648		NA				NA						
C26(20R)/C27(20S)-TAS	0.578		NA				NA						
C28(20S)-TAS	0.495	J	NA				NA						
C27(20R)-TAS	0.596		NA				NA						
C28(20R)-TAS	0.688		NA				NA						

Surrogate Standards			
Naphthalene-d8	67	76	73
Acenaphthene-d10	78	84	84
Phenanthrene-d10	94	92	91
Chrysene-d12	89	93	92
Perylene-d12	67	76	73

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Laboratory Duplicate Report

Laboratory ID	CSA5233.D	ENV4078E.D
Sample ID	3532|03_20|HH-2|sed|hc|A	Duplicate (3532|03_20|HH-2|sed|hc|A)
Matrix	Sediment	Sediment
Species	NA	NA
Collection Date	03/12/2020	03/12/2020
Received Date	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078
Date Acquired	14-Apr-2020 18:31	14-Apr-2020 17:23
Method	SOP1006	SOP1006
Sample Dry Weight (g)	15.07	15.08
Sample Wet Weight (g)	44.36	44.39
% Dry	34	34
% Moisture	66	66
Dilution	5X	5X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	RPD (%)	Q Q1	3X MDL	MDL
cis/trans Decalin	2.64		2.64		0		1.97	0.655
C1-Decalins	2.80		2.22		23	X	3.93	1.31
C2-Decalins	12.0		11.3		6		3.93	1.31
C3-Decalins	34.9		36.4		4		3.93	1.31
C4-Decalins	36.1		31.4		14		3.93	1.31
Naphthalene	4.81		5.71		17		5.11	1.70
C1-Naphthalenes	1.81	J	1.81	J	0	X	15.4	5.12
C2-Naphthalenes	10.3		11.9		15		10.2	3.40
C3-Naphthalenes	22.4		21.4		5		10.2	3.40
C4-Naphthalenes	<3.4	U	<3.4	U			10.2	3.40
Benzothiophene	<0.5	U	<0.5	U			1.34	0.448
C1-Benzothiophenes	<0.9	U	<0.9	U			2.69	0.896
C2-Benzothiophenes	<0.9	U	<0.9	U			2.69	0.896
C3-Benzothiophenes	<0.9	U	<0.9	U			2.69	0.896
C4-Benzothiophenes	<0.9	U	<0.9	U			2.69	0.896
Biphenyl	<1.5	U	<1.5	U			4.38	1.46
Acenaphthylene	<0.2	U	<0.2	U			0.61	0.203
Acenaphthene	5.36		5.39		1		1.53	0.511
Dibenzofuran	2.28		2.29		0	X	3.05	1.02
Fluorene	10.9		12.1		10		2.74	0.912
C1-Fluorenes	5.95		4.79		22		5.48	1.83
C2-Fluorenes	<1.8	U	<1.8	U			5.48	1.83
C3-Fluorenes	<1.8	U	<1.8	U			5.48	1.83
Carbazole	14.6		14.6		0		2.24	0.745
Anthracene	<0.6	U	<0.6	U			1.72	0.574
Phenanthrene	3.27		3.38		3		3.11	1.04
C1-Phenanthrenes/Anthracenes	6.40		6.44		1		1.15	0.384
C2-Phenanthrenes/Anthracenes	14.5		15.8		8		4.26	1.42
C3-Phenanthrenes/Anthracenes	9.70		9.71		0		4.26	1.42
C4-Phenanthrenes/Anthracenes	5.30		5.65		6		4.26	1.42
Dibenzothiophene	2.84		2.86		1		1.73	0.577
C1-Dibenzothiophenes	2.23		2.14		4		0.95	0.317
C2-Dibenzothiophenes	3.56		3.06		15		3.46	1.15
C3-Dibenzothiophenes	3.97		4.54		13		3.46	1.15
C4-Dibenzothiophenes	<1.2	U	<1.2	U			3.46	1.15
Fluoranthene	1.28	J	1.26	J	2	X	4.97	1.66
Pyrene	1.56		1.55		1	X	2.03	0.677
C1-Fluoranthenes/Pyrenes	2.75		3.21		15	X	7.00	2.33
C2-Fluoranthenes/Pyrenes	2.51		2.70		7	X	7.00	2.33
C3-Fluoranthenes/Pyrenes	2.13	J	2.29	J	7	X	7.00	2.33
C4-Fluoranthenes/Pyrenes	2.14	J	2.38		11	X	7.00	2.33
Naphthobenzothiophene	1.01		1.26		23	X	1.91	0.636
C1-Naphthobenzothiophenes	1.81		1.91		5	X	3.82	1.27
C2-Naphthobenzothiophenes	2.39		2.76		15	X	3.82	1.27
C3-Naphthobenzothiophenes	<1.3	U	<1.3	U			3.82	1.27
C4-Naphthobenzothiophenes	<1.3	U	<1.3	U			3.82	1.27
Benz(a)anthracene	0.437	J	0.420	J	4	X	2.87	0.957
Chrysene/Triphenylene	1.68		1.69		1	X	1.73	0.576
C1-Chrysenes	2.41		2.53		5	X	3.46	1.15
C2-Chrysenes	<1.2	U	<1.2	U			3.46	1.15
C3-Chrysenes	<1.2	U	<1.2	U			3.46	1.15
C4-Chrysenes	<1.2	U	<1.2	U			3.46	1.15
Benzo(b)fluoranthene	1.20		1.20		0	X	3.03	1.01
Benzo(k,j)fluoranthene	0.724		0.678		7	X	1.46	0.488
Benzo(a)fluoranthene	0.608		0.536		13	X	1.46	0.488
Benzo(e)pyrene	1.11		1.17		5	X	2.64	0.880
Benzo(a)pyrene	0.744		0.639		15	X	1.51	0.504
Perylene	72.7		72.6		0		18.9	6.30
Indeno(1,2,3-c,d)pyrene	0.293		0.437		39	X	0.750	0.250
Dibenzo(a,h)anthracene	0.285	J	0.293	J	3	X	0.960	0.320
C1-Dibenzo(a,h)anthracenes	<0.6	U	<0.6	U			1.92	0.640
C2-Dibenzo(a,h)anthracenes	<0.6	U	<0.6	U			1.92	0.640
C3-Dibenzo(a,h)anthracenes	<0.6	U	<0.6	U			1.92	0.640
Benzo(g,h,i)perylene	0.144	J	0.332	J	79	X	1.31	0.437
Total PAHs	319		319		0			

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Laboratory Duplicate Report

Laboratory ID	CSA5233.D	ENV4078E.D
Sample ID	3532|03_20|HH-2|sed|hc|A	Duplicate (3532|03_20|HH-2|sed|hc|A)
Matrix	Sediment	Sediment
Species	NA	NA
Collection Date	03/12/2020	03/12/2020
Received Date	03/17/2020	03/17/2020
Extraction Date	04/08/2020	04/08/2020
Extraction Batch	ENV4078	ENV4078
Date Acquired	14-Apr-2020 18:31	14-Apr-2020 17:23
Method	SOP1006	SOP1006
Sample Dry Weight (g)	15.07	15.08
Sample Wet Weight (g)	44.36	44.39
% Dry	34	34
% Moisture	66	66
Dilution	5X	5X

Target Compounds	Su. Corrected Conc. (ng/dry g)	Q	Su. Corrected Conc. (ng/dry g)	Q	RPD (%)	Q Q1	3X MDL	MDL
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	1.60	J	1.64	J	2	X	19.3	6.45
1-Methylnaphthalene	1.22	J	1.17	J	4	X	8.16	2.72
2,6-Dimethylnaphthalene	1.89		2.09		10	X	3.89	1.30
1,6,7-Trimethylnaphthalene	2.80		2.75		2		1.90	0.634
1-Methylfluorene	3.49		3.56		2		2.86	0.952
4-Methyldibenzothiophene	0.973		1.00		3	X	1.37	0.455
2/3-Methyldibenzothiophene	1.47		1.40		5		1.37	0.455
1-Methyldibenzothiophene	0.491		0.414	J	17	X	1.37	0.455
3-Methylphenanthrene	1.88		1.86		1		1.45	0.483
2-Methylphenanthrene	2.21		2.26		2		1.45	0.483
2-Methylanthracene	0.313	J	0.327	J	4	X	1.45	0.483
4/9-Methylphenanthrene	2.26		2.27		1		1.45	0.483
1-Methylphenanthrene	1.94		1.93		0		1.45	0.483
3,6-Dimethylphenanthrene	1.07		1.21		12	X	1.64	0.546
Retene	4.65		4.66		0		3.45	1.15
2-Methylfluoranthene	0.327	J	0.27	J	19	X	3.32	1.11
Benzo(b)fluorene	0.279	J	0.32	J	12	X	1.86	0.621
C29-Hopane	15.50		14.99		3		8.59	2.86
18a-Oleanane	<2.9	U	<2.9	U			8.59	2.86
C30-Hopane	34.9		37.2		6		8.59	2.86
C20-TAS	0.875	J	0.787	J	11	X	8.59	2.86
C21-TAS	1.14	J	0.996	J	14	X	8.59	2.86
C26(20S)-TAS	5.02		4.60		9	X	8.59	2.86
C26(20R)/C27(20S)-TAS	6.57		6.94		5	X	8.59	2.86
C28(20S)-TAS	20.2		16.0		23		8.59	2.86
C27(20R)-TAS	16.4		16.3		1		8.59	2.86
C28(20R)-TAS	14.7		15.2		3		8.59	2.86
Surrogate Standards								
Naphthalene-d8	84	D	84	D				
Acenaphthene-d10	92	D	92	D				
Phenanthrene-d10	96	D	96	D				
Chrysene-d12	91	D	91	D				
Perylene-d12	94	D	94	D				

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70381K.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4078
Date Acquired	13-Apr-2020 23:14
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	Q1	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
cis/trans Decalin	832						
C1-Decalins	1041						
C2-Decalins	995						
C3-Decalins	731						
C4-Decalins	531						
Naphthalene	858			0	855±46	647	1081
C1-Naphthalenes	1699						
C2-Naphthalenes	2147						
C3-Naphthalenes	1578						
C4-Naphthalenes	762						
Benzothiophene	14.6						
C1-Benzothiophenes	36.2						
C2-Benzothiophenes	42.3						
C3-Benzothiophenes	41.8						
C4-Benzothiophenes	25.9						
Biphenyl	193						
Acenaphthylene	7.87	J					
Acenaphthene	11.2						
Dibenzofuran	28.5						
Fluorene	141						
C1-Fluorenes	354						
C2-Fluorenes	423						
C3-Fluorenes	245						
Carbazole	8.85	J					
Anthracene	3.92	J		14	3.42±0.59	2.26	4.81
Phenanthrene	287			11	258±27	185	342
C1-Phenanthrenes/Anthracenes	705						
C2-Phenanthrenes/Anthracenes	792						
C3-Phenanthrenes/Anthracenes	521						
C4-Phenanthrenes/Anthracenes	266						
Dibenzothiophene	56.9			9	51.8±2.1	39.8	64.7
C1-Dibenzothiophenes	165						
C2-Dibenzothiophenes	215						
C3-Dibenzothiophenes	140						
C4-Dibenzothiophenes	69.0						
Fluoranthene	4.07	J		7	4.36±0.4	3.17	5.71
Pyrene	15.4			4	14.81±0.39	11.5	18.2
C1-Fluoranthenes/Pyrenes	84.7						
C2-Fluoranthenes/Pyrenes	120						
C3-Fluoranthenes/Pyrenes	148						
C4-Fluoranthenes/Pyrenes	74						
Naphthobenzothiophene	27.1						
C1-Naphthobenzothiophenes	71.8						
C2-Naphthobenzothiophenes	104						
C3-Naphthobenzothiophenes	64.0						
C4-Naphthobenzothiophenes	29.4						
Benz(a)anthracene	6.28	J		11	7.03±0.85	4.94	9.46
Chrysene/Triphenylene	58.7			36	41±11.9	23.3	63.5
C1-Chrysenes	132						
C2-Chrysenes	164						
C3-Chrysenes	112						
C4-Chrysenes	72.7						
Benzo(b)fluoranthene	5.50	J		2	5.62±0.34	4.22	7.15
Benzo(k,j)fluoranthene	1.13	J					
Benzo(a)fluoranthene	<10	U					
Benzo(e)pyrene	12.5			15	10.78±0.6	8.14	13.7
Benzo(a)pyrene	1.54	J					
Perylene	0.688	J					
Indeno(1,2,3-c,d)pyrene	0.688	J					
Dibenzo(a,h)anthracene	0.699	J		20	0.574±0.091	0.386	0.798
C1-Dibenzo(a,h)anthracenes	<10	U					
C2-Dibenzo(a,h)anthracenes	<10	U					
C3-Dibenzo(a,h)anthracenes	<10	U					
Benzo(g,h,i)perylene	1.97	J		7	2.11±0.26	1.48	2.84
Total PAHs	17282						

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70381K.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4078
Date Acquired	13-Apr-2020 23:14
Method	SOP1006
Sample Weight (mg)	4.10

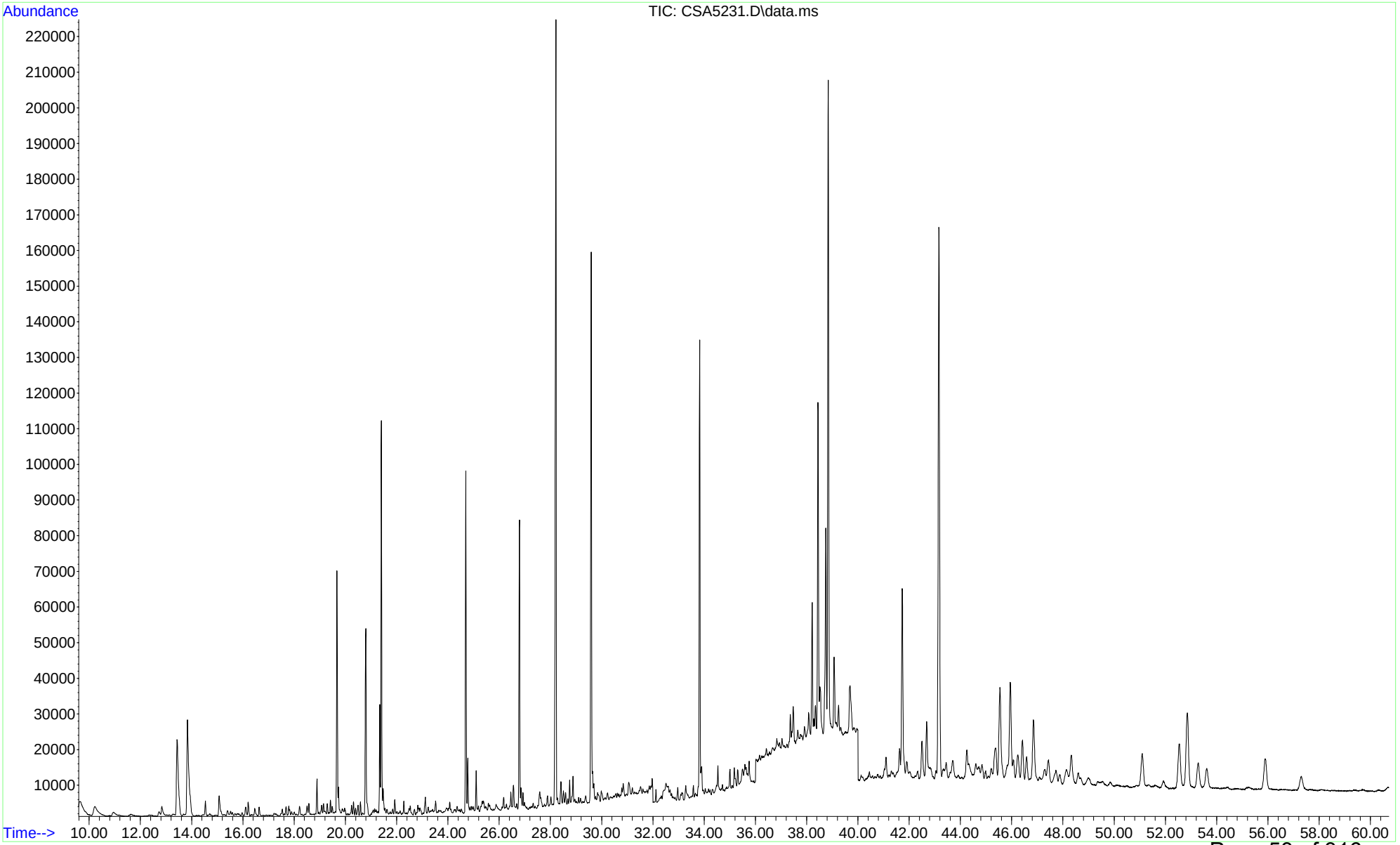
Target Compounds	Su. Corrected Conc. (ng/mg)	Q	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
Individual Alkyl Isomers and Hopanes						
2-Methylnaphthalene	1569		4	1630±50	1264	2016
1-Methylnaphthalene	1065		7	1140±20	896	1392
2,6-Dimethylnaphthalene	1016					
1,6,7-Trimethylnaphthalene	298					
1-Methylfluorene	266					
4-Methyldibenzothiophene	121					
2/3-Methyldibenzothiophene	59.2					
1-Methyldibenzothiophene	37.1					
3-Methylphenanthrene	212		3	206±32	139	286
2-Methylphenanthrene	231		1	230±14	173	293
2-Methylanthracene	16.8					
4/9-Methylphenanthrene	293		23	232±19	170	301
1-Methylphenanthrene	194		14	169±10	127	215
3,6-Dimethylphenanthrene	74.4					
Retene	25.7					
2-Methylfluoranthene	4.05	J				
Benzo(b)fluorene	10.4					
C29-Hopane	22.8					
18a-Oleanane	<10	U				
C30-Hopane	53.7					
C20-TAS	43.0					
C21-TAS	37.7					
C26(20S)-TAS	24.3					
C26(20R)/C27(20S)-TAS	70.9					
C28(20S)-TAS	57.9					
C27(20R)-TAS	49.0					
C28(20R)-TAS	40.9					

Surrogate Standards	
Naphthalene-d8	83
Acenaphthene-d10	97
Phenanthrene-d10	91
Chrysene-d12	98
Perylene-d12	98

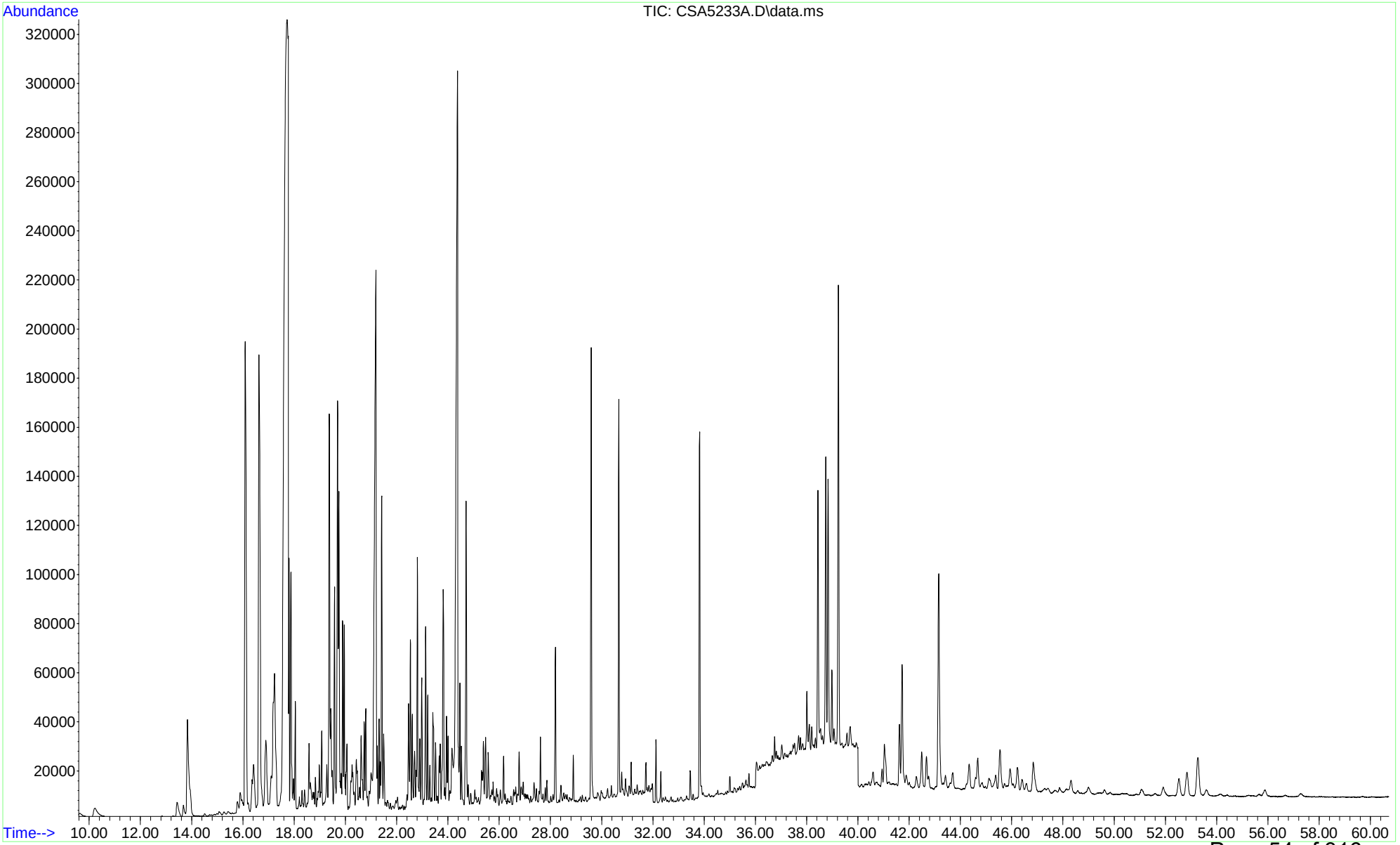
Peak Resolution (m/z 192)	93%
4/9-Methylphenanthrene from	137
1-Methylyphenanthrene	147

Polycyclic Aromatic Hydrocarbon Total Ion Chromatograms

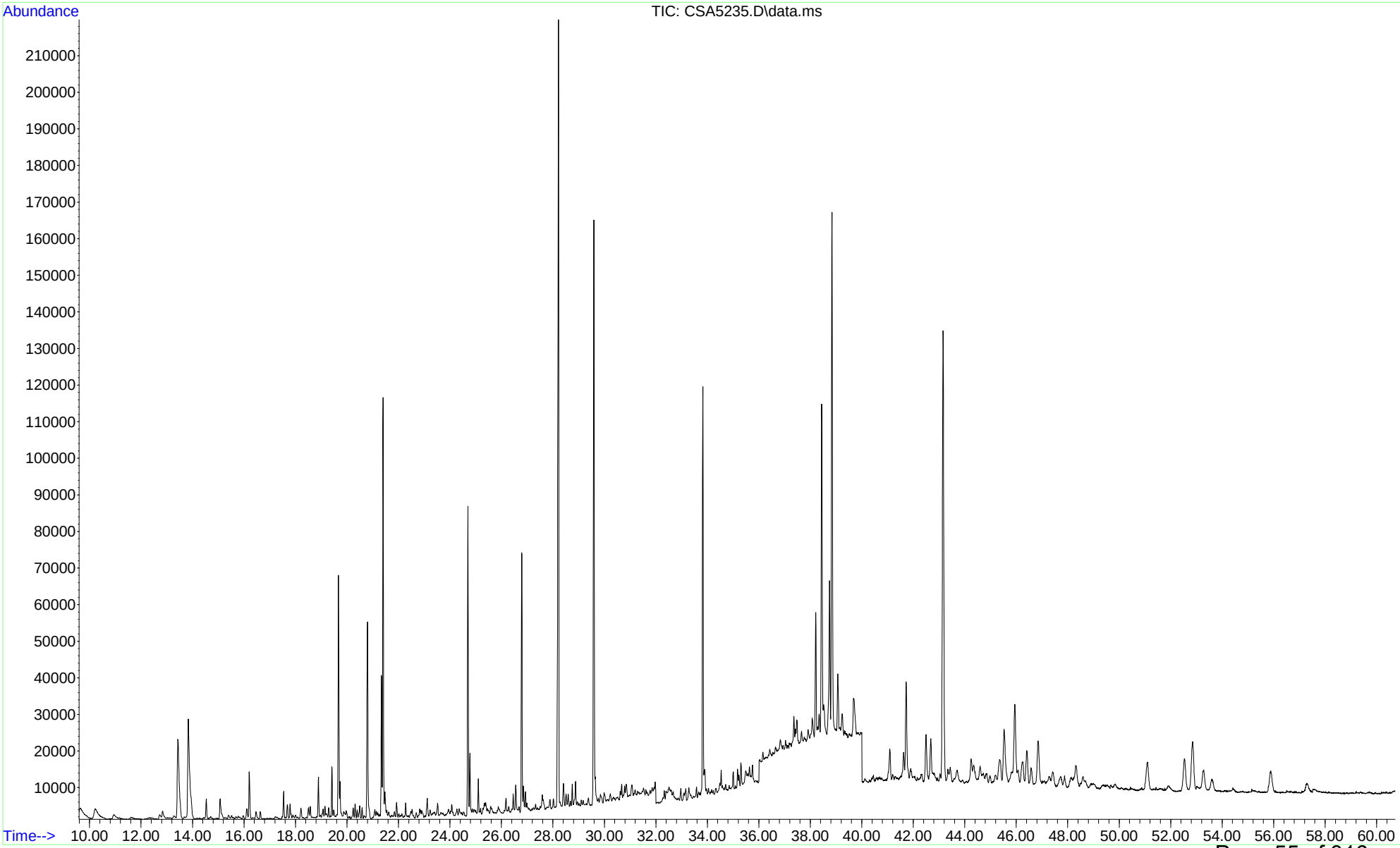
File :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
... ata\CSA5231.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 14 Apr 2020 6:02 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sed|hc|A
Misc Info :



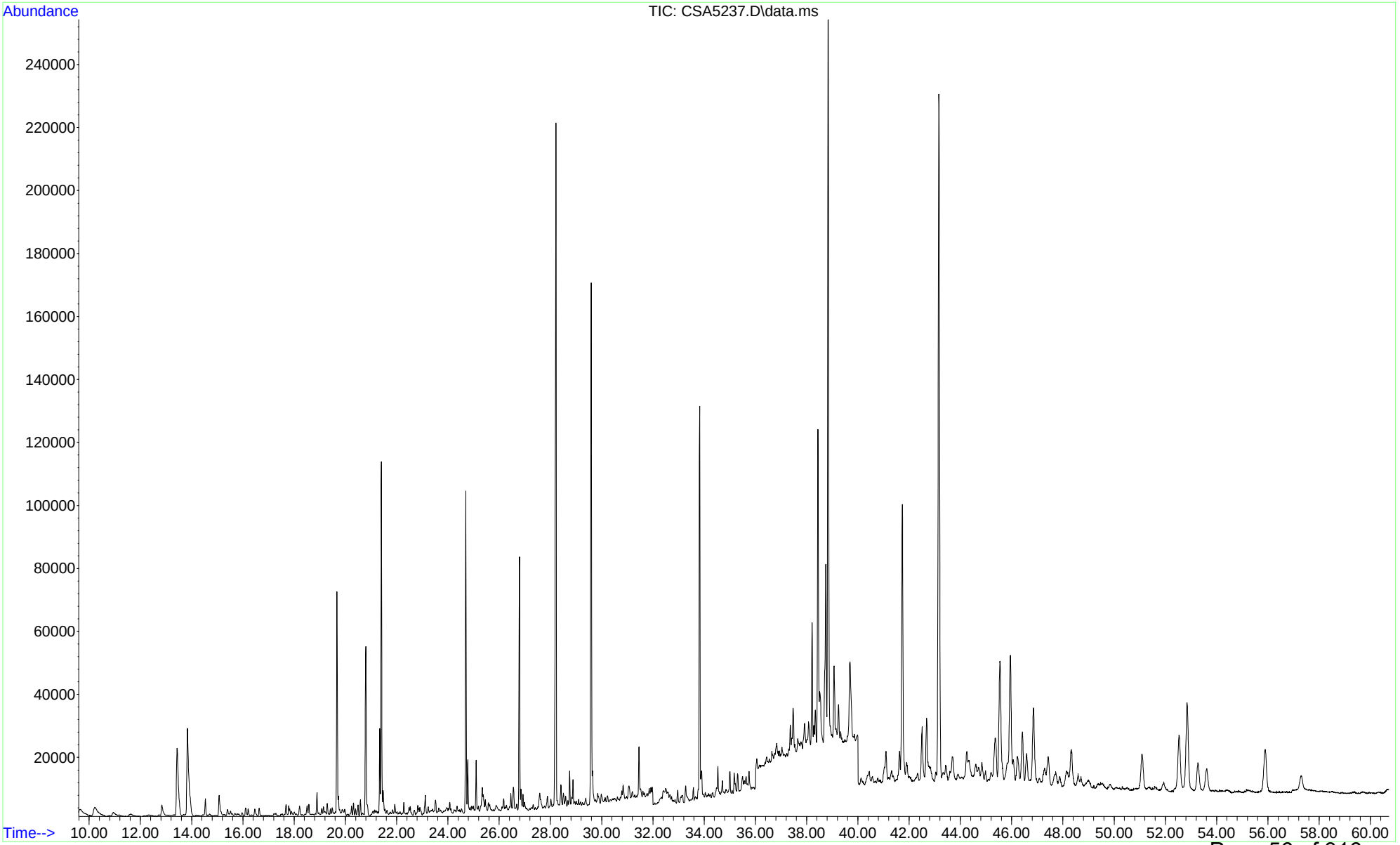
File :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
... ata\CSA5233A.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 14 Apr 2020 18:31 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sed|hc|A
Misc Info : 5x Dilutions



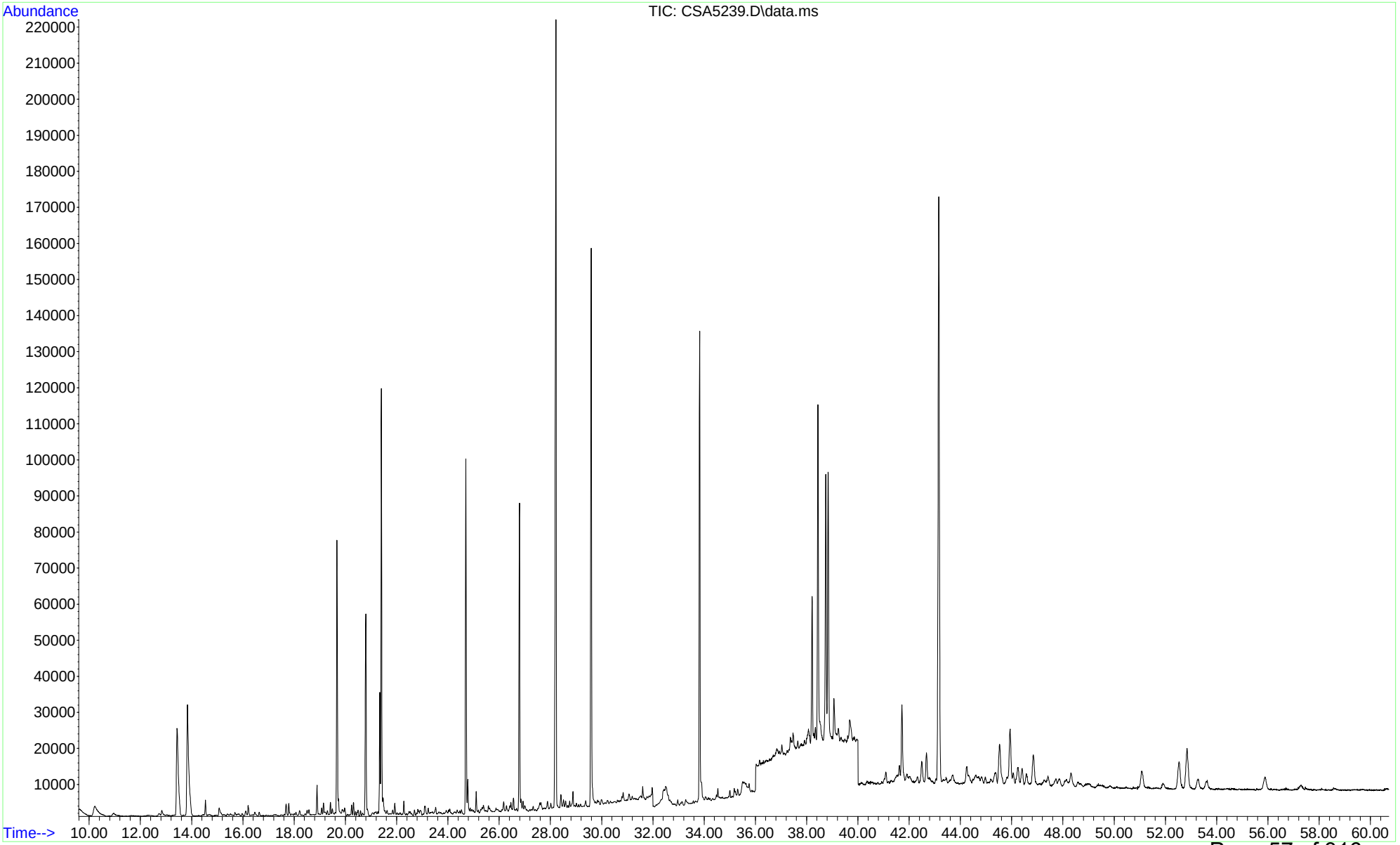
```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
...         ata\CSA5235.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 14 Apr 2020   9:27     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sed|hc|A
Misc Info  :
```



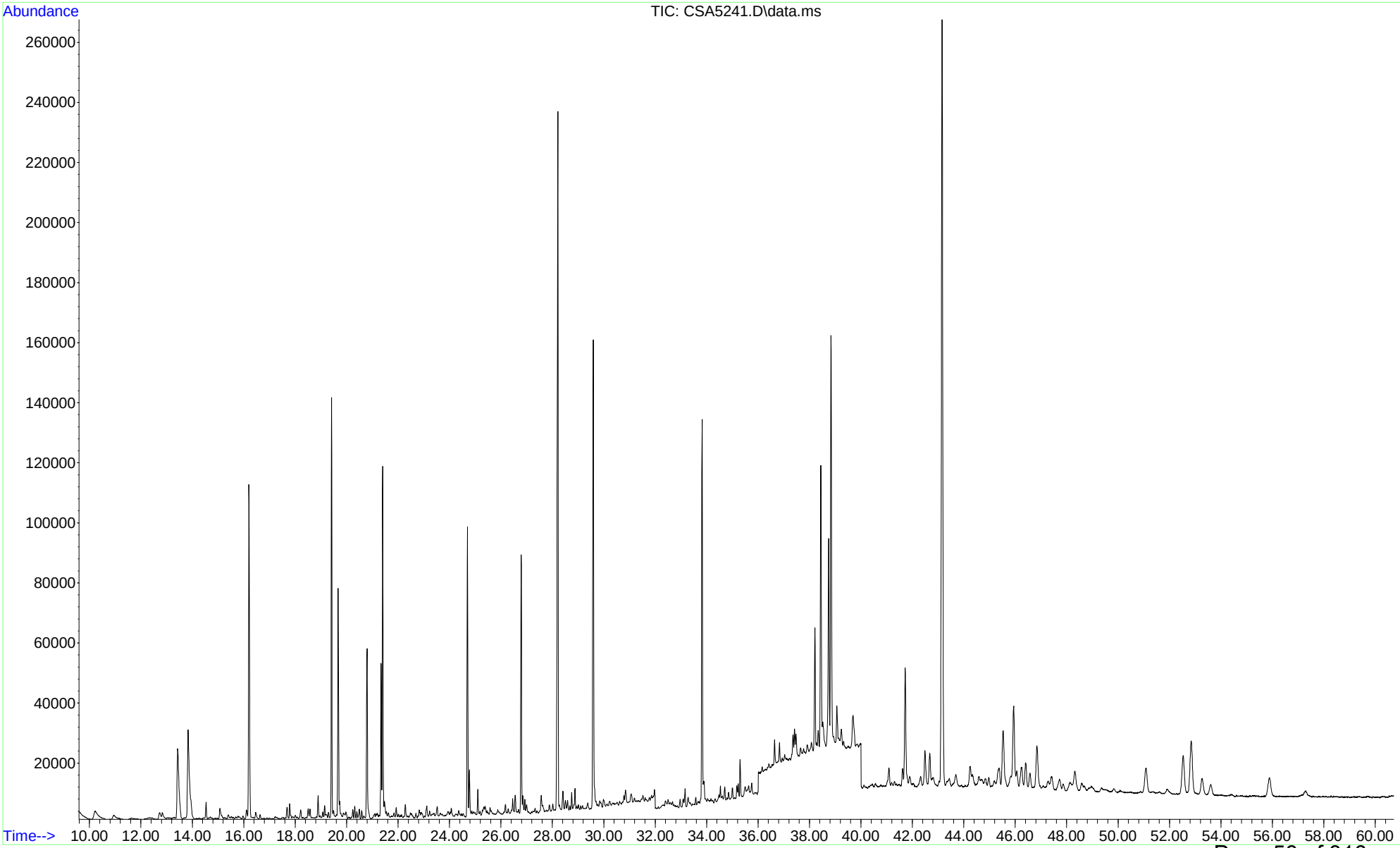
```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
...         ata\CSA5237.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 14 Apr 2020  10:35     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sed|hc|A
Misc Info  :
```



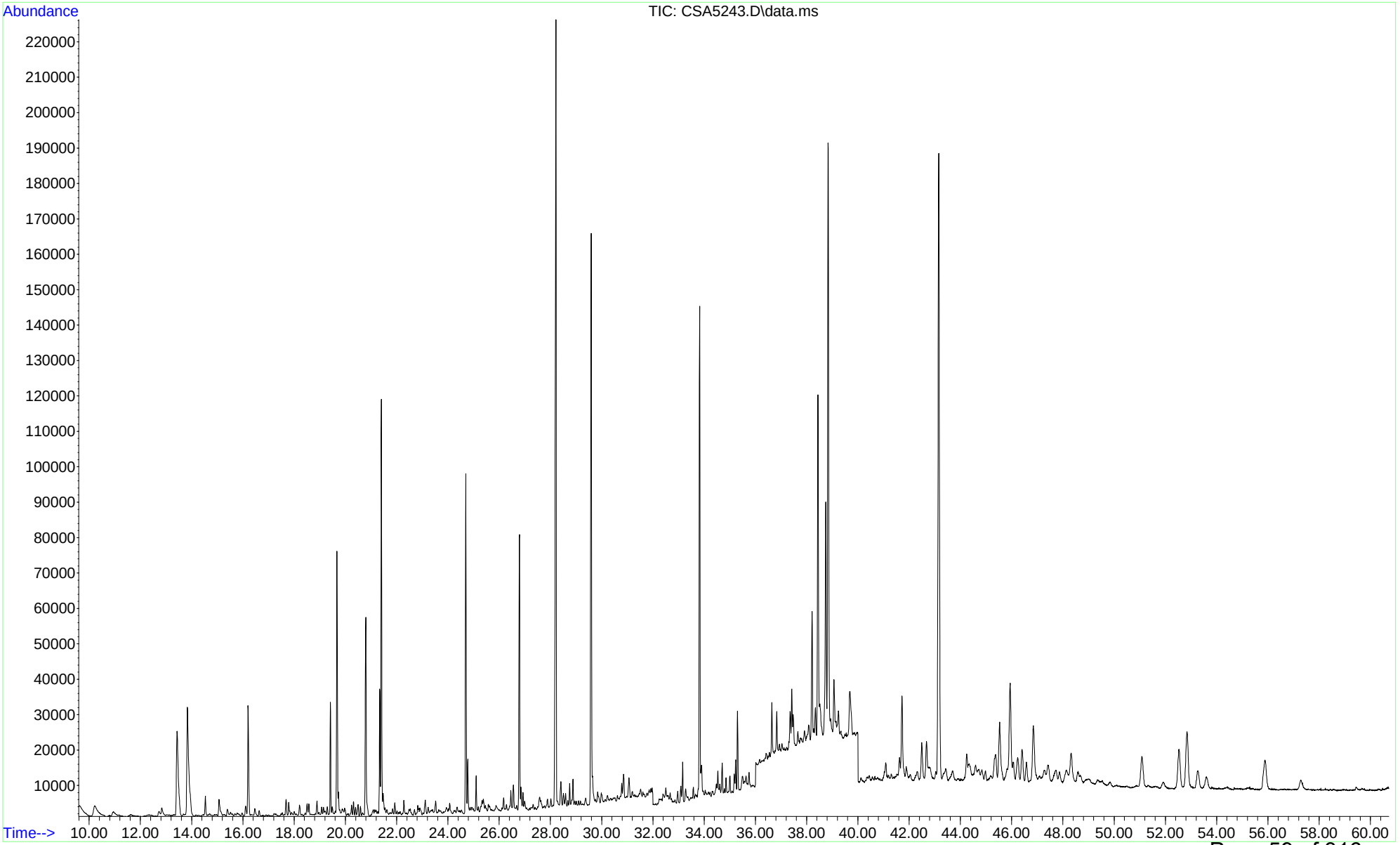
File :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
... ata\CSA5239.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 14 Apr 2020 11:43 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sed|hc|A
Misc Info :



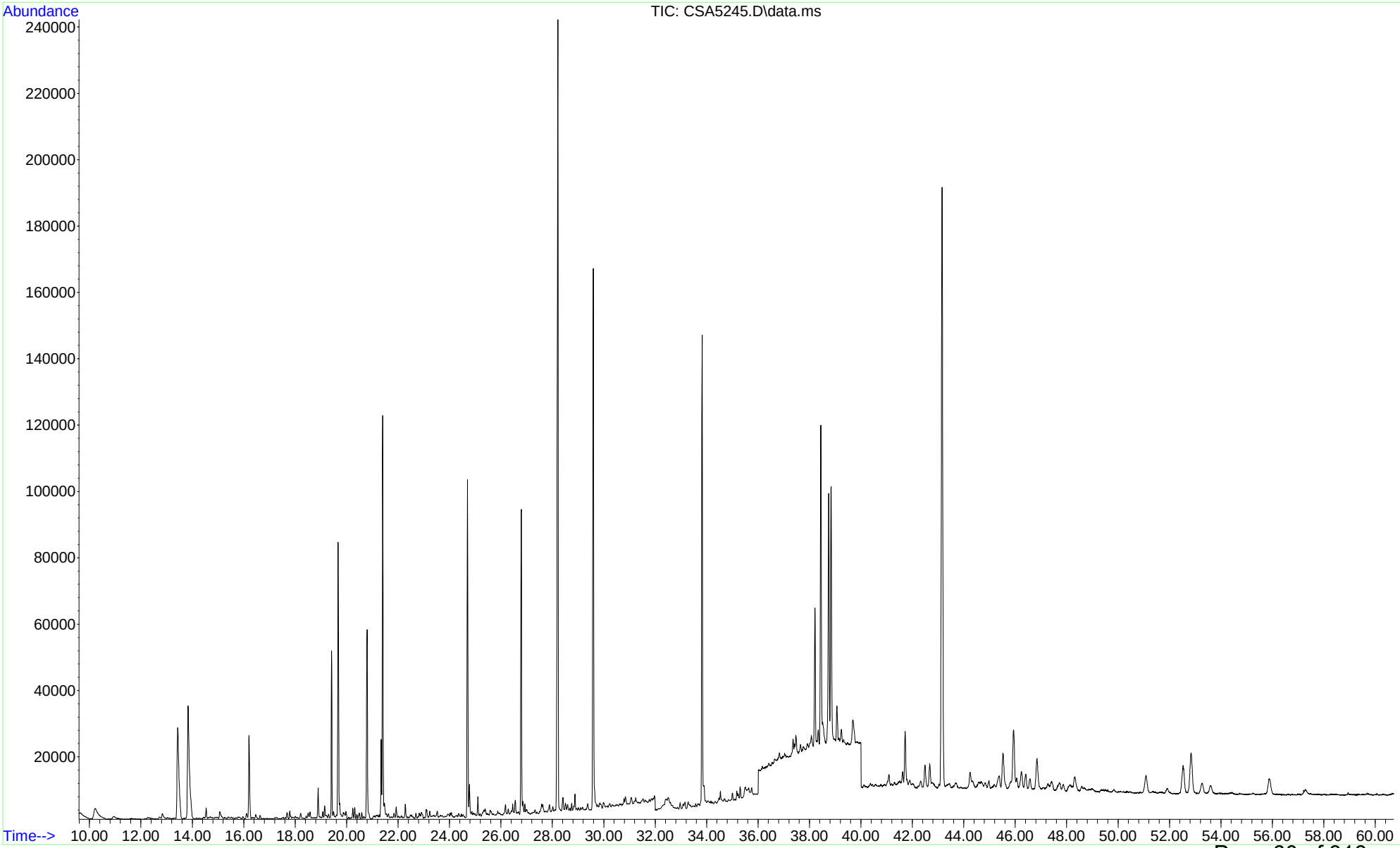
File :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
... ata\CSA5241.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 14 Apr 2020 12:51 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sed|hc|A
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
...         ata\CSA5243.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 14 Apr 2020  13:59     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sed|hc|A
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4078\ENV4078-MS70381PAH Raw D
...         ata\CSA5245.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 14 Apr 2020  15:07     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sed|hc|A
Misc Info  :
```



Water Samples

Total Petroleum Hydrocarbons/ Aliphatic Hydrocarbons/ Concentrations

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5190.D	CSA5191.D	CSA5192.D
Sample ID	3532|03_20|HH-8|sw_s|hc|01	3532|03_20|HH-8|sw_s|hc|02	3532|03_20|HH-8|sw_m|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073	ENV4073
Date Acquired	23-Mar-2020, 22:07	23-Mar-2020, 23:15	24-Mar-2020, 00:23
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.04	1.03	1.00
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	0.121	
n-C25	<0.066	U	0.080		0.114	
n-C26	<0.07	U	0.156		0.216	
n-C27	<0.069	U	0.263		0.377	
n-C28	<0.077	U	0.359		0.523	
n-C29	<0.087	U	0.526		0.718	
n-C30	<0.081	U	0.528		0.685	
n-C31	<0.126	U	0.472		0.611	
n-C32	<0.083	U	0.299		0.375	
n-C33	<0.282	U	0.159	J	0.155	J
n-C34	<0.106	U	0.065	J	0.061	J
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes			2.9		4.0	
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	63	60	74
n-eicosane-d42	85	87	93
n-triacontane-d62	86	90	96

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5193.D	CSA5194.D	CSA5195.D
Sample ID	3532|03_20|HH-8|sw_m|hc|02	3532|03_20|HH-8|sw_b|hc|01	3532|03_20|HH-8|sw_b|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073	ENV4073
Date Acquired	24-Mar-2020, 01:31	24-Mar-2020, 03:46	24-Mar-2020, 04:54
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.03	1.02	1.04
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	0.129		<0.07	U	<0.07	U
n-C27	0.191		0.127		<0.069	U
n-C28	0.227		0.245		0.134	
n-C29	0.349		0.284		0.228	
n-C30	0.295		0.214		0.148	
n-C31	0.274		0.174		0.132	
n-C32	0.182		0.137		0.120	
n-C33	0.116	J	<0.282	U	0.055	J
n-C34	0.044	J	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes	1.8		1.2		0.8	
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	66	74	62
n-eicosane-d42	91	89	82
n-triacontane-d62	94	92	85

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5196.D	CSA5197.D	CSA5198.D
Sample ID	3532|03_20|HH-4|sw_s|hc|01	3532|03_20|HH-4|sw_s|hc|02	3532|03_20|HH-4|sw_m|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073	ENV4073
Date Acquired	24-Mar-2020, 06:02	24-Mar-2020, 07:10	24-Mar-2020, 08:18
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.02	1.03	1.03
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.07	U
n-C27	<0.069	U	0.114		<0.069	U
n-C28	0.138		0.152		<0.077	U
n-C29	0.263		0.262		<0.087	U
n-C30	0.194		0.183		<0.081	U
n-C31	0.191		0.169		<0.126	U
n-C32	0.140		0.135		<0.083	U
n-C33	0.059	J	<0.282	U	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes	1.0		1.0			
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	60	61	55
n-eicosane-d42	80	81	87
n-triacontane-d62	83	84	89

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5199.D	CSA5200.D	CSA5201.D
Sample ID	3532|03_20|HH-4|sw_m|hc|02	3532|03_20|HH-4|sw_b|hc|01	3532|03_20|HH-4|sw_b|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073	ENV4073
Date Acquired	24-Mar-2020, 09:26	24-Mar-2020, 10:34	24-Mar-2020, 11:42
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.02	1.03	1.02
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.07	U
n-C27	<0.069	U	0.161		<0.069	U
n-C28	<0.077	U	0.195		<0.077	U
n-C29	<0.087	U	0.326		<0.087	U
n-C30	<0.081	U	0.270		<0.081	U
n-C31	<0.126	U	0.225		<0.126	U
n-C32	<0.083	U	0.168		<0.083	U
n-C33	<0.282	U	0.094	J	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes			1.4			
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	67	46	57
n-eicosane-d42	81	71	86
n-triacontane-d62	83	75	89

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5202.D	CSA5203.D	CSA5204.D
Sample ID	3532|03_20|HH-6|sw_s|hc|01	3532|03_20|HH-6|sw_s|hc|02	3532|03_20|HH-6|sw_m|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073	ENV4073
Date Acquired	24-Mar-2020, 12:50	24-Mar-2020, 15:06	24-Mar-2020, 16:14
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.03	1.04	1.03
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	0.128		<0.07	U	<0.07	U
n-C27	0.187		<0.069	U	<0.069	U
n-C28	0.216		<0.077	U	<0.077	U
n-C29	0.336		<0.087	U	<0.087	U
n-C30	0.257		<0.081	U	<0.081	U
n-C31	0.247		<0.126	U	<0.126	U
n-C32	0.166		<0.083	U	<0.083	U
n-C33	<0.282	U	<0.282	U	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes	1.5					
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	51	55	54
n-eicosane-d42	85	75	81
n-triacontane-d62	87	78	84

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5205.D	CSA5206.D	CSA5207.D
Sample ID	3532|03_20|HH-6|sw_m|hc|02	3532|03_20|HH-6|sw_b|hc|01	3532|03_20|HH-6|sw_b|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073	ENV4073
Date Acquired	24-Mar-2020, 17:22	24-Mar-2020, 18:29	24-Mar-2020, 19:37
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.02	1.02	1.03
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	0.073	
n-C26	<0.07	U	0.114		0.124	
n-C27	<0.069	U	0.163		0.172	
n-C28	<0.077	U	0.217		0.210	
n-C29	<0.087	U	0.350		0.312	
n-C30	<0.081	U	0.352		0.240	
n-C31	<0.126	U	0.274		0.249	
n-C32	<0.083	U	0.184		0.170	
n-C33	<0.282	U	0.123	J	0.150	J
n-C34	<0.106	U	<0.106	U	0.082	J
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes			1.8		1.8	
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	52	49	47
n-eicosane-d42	82	79	82
n-triacontane-d62	86	83	85

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5208.D	CSA5209.D	CSA5210.D
Sample ID	3532|03_20|HH-1|sw_s|hc|01	3532|03_20|HH-1|sw_s|hc|02	3532|03_20|HH-1|sw_m|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/18/20	03/18/20	03/19/20
Extraction Batch	ENV4073	ENV4073	ENV4074
Date Acquired	24-Mar-2020, 20:45	24-Mar-2020, 21:53	25-Mar-2020, 21:38
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.04	1.00	0.98
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.294	U
n-C10	<0.252	U	<0.252	U	<0.257	U
n-C11	<0.251	U	<0.251	U	<0.256	U
n-C12	<0.266	U	<0.266	U	<0.272	U
n-C13	<0.258	U	<0.258	U	<0.264	U
i-C15	<0.256	U	<0.256	U	<0.262	U
n-C14	<0.277	U	<0.277	U	<0.282	U
i-C16	<0.234	U	<0.234	U	<0.239	U
n-C15	<0.256	U	<0.256	U	<0.262	U
n-C16	<0.234	U	<0.234	U	<0.239	U
i-C18	<0.1	U	<0.1	U	<0.102	U
n-C17	<0.174	U	<0.174	U	<0.177	U
Pristane	<0.19	U	<0.19	U	<0.194	U
n-C18	<0.1	U	<0.1	U	<0.102	U
Phytane	<0.201	U	<0.201	U	<0.205	U
n-C19	<0.073	U	<0.073	U	<0.075	U
n-C20	<0.077	U	<0.077	U	<0.079	U
n-C21	<0.081	U	<0.081	U	<0.082	U
n-C22	<0.15	U	<0.15	U	<0.153	U
n-C23	<0.117	U	<0.117	U	<0.119	U
n-C24	<0.069	U	<0.069	U	<0.07	U
n-C25	<0.066	U	<0.066	U	<0.067	U
n-C26	<0.07	U	<0.07	U	<0.072	U
n-C27	<0.069	U	<0.069	U	<0.07	U
n-C28	<0.077	U	<0.077	U	<0.079	U
n-C29	<0.087	U	<0.087	U	<0.089	U
n-C30	<0.081	U	<0.081	U	<0.083	U
n-C31	<0.126	U	<0.126	U	<0.128	U
n-C32	<0.083	U	<0.083	U	<0.084	U
n-C33	<0.282	U	<0.282	U	<0.288	U
n-C34	<0.106	U	<0.106	U	<0.108	U
n-C35	<0.112	U	<0.112	U	<0.114	U
n-C36	<0.113	U	<0.113	U	<0.115	U
n-C37	<0.148	U	<0.148	U	<0.151	U
n-C38	<0.127	U	<0.127	U	<0.13	U
n-C39	<0.16	U	<0.16	U	<0.164	U
n-C40	<0.144	U	<0.144	U	<0.147	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13	U	<13.265	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13.265	U
Unresolved Complex Mixture	<13	U	<13	U	<13.265	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	52	59	72
n-eicosane-d42	87	85	92
n-triacontane-d62	89	88	95

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5211.D	CSA5212.D	CSA5213.D
Sample ID	3532|03_20|HH-1|sw_m|hc|02	3532|03_20|HH-1|sw_b|hc|01	3532|03_20|HH-1|sw_b|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/19/20	03/19/20	03/19/20
Extraction Batch	ENV4074	ENV4074	ENV4074
Date Acquired	25-Mar-2020, 22:47	25-Mar-2020, 23:55	26-Mar-2020, 01:04
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.03	0.97	1.01
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.297	U	<0.288	U
n-C10	<0.252	U	<0.259	U	<0.252	U
n-C11	<0.251	U	<0.259	U	<0.251	U
n-C12	<0.266	U	<0.275	U	<0.266	U
n-C13	<0.258	U	<0.266	U	<0.258	U
i-C15	<0.256	U	<0.264	U	<0.256	U
n-C14	<0.277	U	<0.285	U	<0.277	U
i-C16	<0.234	U	<0.241	U	<0.234	U
n-C15	<0.256	U	<0.264	U	<0.256	U
n-C16	<0.234	U	<0.241	U	<0.234	U
i-C18	<0.1	U	<0.103	U	<0.1	U
n-C17	<0.174	U	<0.179	U	<0.174	U
Pristane	<0.19	U	<0.196	U	<0.19	U
n-C18	<0.1	U	<0.103	U	<0.1	U
Phytane	<0.201	U	<0.207	U	<0.201	U
n-C19	<0.073	U	<0.076	U	<0.073	U
n-C20	<0.077	U	<0.08	U	<0.077	U
n-C21	<0.081	U	<0.083	U	<0.081	U
n-C22	<0.15	U	<0.154	U	<0.15	U
n-C23	<0.117	U	<0.121	U	<0.117	U
n-C24	<0.069	U	<0.071	U	<0.069	U
n-C25	<0.066	U	<0.068	U	<0.066	U
n-C26	<0.07	U	<0.072	U	<0.07	U
n-C27	<0.069	U	<0.071	U	<0.069	U
n-C28	<0.077	U	<0.079	U	<0.077	U
n-C29	<0.087	U	<0.09	U	<0.087	U
n-C30	<0.081	U	<0.083	U	<0.081	U
n-C31	<0.126	U	<0.13	U	<0.126	U
n-C32	<0.083	U	<0.085	U	<0.083	U
n-C33	<0.282	U	<0.291	U	<0.282	U
n-C34	<0.106	U	<0.11	U	<0.106	U
n-C35	<0.112	U	<0.115	U	<0.112	U
n-C36	<0.113	U	<0.117	U	<0.113	U
n-C37	<0.148	U	<0.153	U	<0.148	U
n-C38	<0.127	U	<0.131	U	<0.127	U
n-C39	<0.16	U	<0.165	U	<0.16	U
n-C40	<0.144	U	<0.148	U	<0.144	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13.402	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13.402	U	<13	U
Unresolved Complex Mixture	<13	U	<13.402	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	57	64	60
n-eicosane-d42	79	84	78
n-triacontane-d62	81	88	81

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5214.D	CSA5215.D	CSA5216.D
Sample ID	3532|03_20|HH-2|sw_s|hc|01	3532|03_20|HH-2|sw_s|hc|02	3532|03_20|HH-2|sw_m|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/19/20	03/19/20	03/19/20
Extraction Batch	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020, 03:20	26-Mar-2020, 04:29	26-Mar-2020, 05:37
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.00	1.01	0.99
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.291	U
n-C10	<0.252	U	<0.252	U	<0.254	U
n-C11	<0.251	U	<0.251	U	<0.253	U
n-C12	<0.266	U	<0.266	U	<0.269	U
n-C13	<0.258	U	<0.258	U	<0.261	U
i-C15	<0.256	U	<0.256	U	<0.259	U
n-C14	<0.277	U	<0.277	U	<0.279	U
i-C16	<0.234	U	<0.234	U	<0.237	U
n-C15	<0.256	U	<0.256	U	<0.259	U
n-C16	<0.234	U	<0.234	U	<0.237	U
i-C18	<0.1	U	<0.1	U	<0.101	U
n-C17	<0.174	U	<0.174	U	<0.175	U
Pristane	<0.19	U	<0.19	U	<0.192	U
n-C18	<0.1	U	<0.1	U	<0.101	U
Phytane	<0.201	U	<0.201	U	<0.203	U
n-C19	<0.073	U	<0.073	U	<0.074	U
n-C20	<0.077	U	<0.077	U	<0.078	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.151	U
n-C23	<0.117	U	<0.117	U	<0.118	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.071	U
n-C27	<0.069	U	<0.069	U	<0.069	U
n-C28	<0.077	U	<0.077	U	<0.078	U
n-C29	<0.087	U	<0.087	U	<0.088	U
n-C30	<0.081	U	<0.081	U	<0.082	U
n-C31	<0.126	U	<0.126	U	<0.127	U
n-C32	<0.083	U	<0.083	U	<0.084	U
n-C33	<0.282	U	<0.282	U	<0.285	U
n-C34	<0.106	U	<0.106	U	<0.107	U
n-C35	<0.112	U	<0.112	U	<0.113	U
n-C36	<0.113	U	<0.113	U	<0.114	U
n-C37	<0.148	U	<0.148	U	<0.149	U
n-C38	<0.127	U	<0.127	U	<0.128	U
n-C39	<0.16	U	<0.16	U	<0.162	U
n-C40	<0.144	U	<0.144	U	<0.145	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13	U	<13.131	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13.131	U
Unresolved Complex Mixture	<13	U	<13	U	<13.131	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	69	60	57
n-eicosane-d42	91	87	81
n-triacontane-d62	93	88	84

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5217.D	CSA5218.D	CSA5219.D
Sample ID	3532|03_20|HH-2|sw_m|hc|02	3532|03_20|HH-2|sw_b|hc|01	3532|03_20|HH-2|sw_b|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/19/20	03/19/20	03/19/20
Extraction Batch	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020, 06:45	26-Mar-2020, 07:54	26-Mar-2020, 09:02
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.00	1.04	1.01
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.07	U
n-C27	<0.069	U	<0.069	U	<0.069	U
n-C28	<0.077	U	<0.077	U	<0.077	U
n-C29	<0.087	U	<0.087	U	<0.087	U
n-C30	<0.081	U	<0.081	U	<0.081	U
n-C31	<0.126	U	<0.126	U	<0.126	U
n-C32	<0.083	U	<0.083	U	<0.083	U
n-C33	<0.282	U	<0.282	U	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	58	63	55
n-eicosane-d42	76	92	79
n-triacontane-d62	79	95	81

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5220.D	CSA5221.D	CSA5222.D
Sample ID	3532|03_20|HH-3|sw_s|hc|01	3532|03_20|HH-3|sw_s|hc|02	3532|03_20|HH-3|sw_m|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/19/20	03/19/20	03/19/20
Extraction Batch	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020, 10:11	26-Mar-2020, 11:19	26-Mar-2020, 12:28
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.00	0.97	0.98
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.297	U	<0.294	U
n-C10	<0.252	U	<0.259	U	<0.257	U
n-C11	<0.251	U	<0.259	U	<0.256	U
n-C12	<0.266	U	<0.275	U	<0.272	U
n-C13	<0.258	U	<0.266	U	<0.264	U
i-C15	<0.256	U	<0.264	U	<0.262	U
n-C14	<0.277	U	<0.285	U	<0.282	U
i-C16	<0.234	U	<0.241	U	<0.239	U
n-C15	<0.256	U	<0.264	U	<0.262	U
n-C16	<0.234	U	<0.241	U	<0.239	U
i-C18	<0.1	U	<0.103	U	<0.102	U
n-C17	<0.174	U	<0.179	U	<0.177	U
Pristane	<0.19	U	<0.196	U	<0.194	U
n-C18	<0.1	U	<0.103	U	<0.102	U
Phytane	<0.201	U	<0.207	U	<0.205	U
n-C19	<0.073	U	<0.076	U	<0.075	U
n-C20	<0.077	U	<0.08	U	<0.079	U
n-C21	<0.081	U	<0.083	U	<0.082	U
n-C22	<0.15	U	<0.154	U	<0.153	U
n-C23	<0.117	U	<0.121	U	<0.119	U
n-C24	<0.069	U	<0.071	U	<0.07	U
n-C25	<0.066	U	<0.068	U	<0.067	U
n-C26	<0.07	U	<0.072	U	<0.072	U
n-C27	<0.069	U	<0.071	U	<0.07	U
n-C28	<0.077	U	<0.079	U	<0.079	U
n-C29	<0.087	U	<0.09	U	<0.089	U
n-C30	<0.081	U	<0.083	U	<0.083	U
n-C31	<0.126	U	<0.13	U	<0.128	U
n-C32	<0.083	U	<0.085	U	<0.084	U
n-C33	<0.282	U	<0.291	U	<0.288	U
n-C34	<0.106	U	<0.11	U	<0.108	U
n-C35	<0.112	U	<0.115	U	<0.114	U
n-C36	<0.113	U	<0.117	U	<0.115	U
n-C37	<0.148	U	<0.153	U	<0.151	U
n-C38	<0.127	U	<0.131	U	<0.13	U
n-C39	<0.16	U	<0.165	U	<0.164	U
n-C40	<0.144	U	<0.148	U	<0.147	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13.402	U	<13.265	U
Total Resolved Hydrocarbons	<13	U	<13.402	U	<13.265	U
Unresolved Complex Mixture	<13	U	<13.402	U	<13.265	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	56	56	48
n-eicosane-d42	85	85	66
n-triacontane-d62	87	87	68

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5223.D	CSA5224.D	CSA5225.D
Sample ID	3532|03_20|HH-3|sw_m|hc|02	3532|03_20|HH-3|sw_b|hc|01	3532|03_20|HH-3|sw_b|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20
Extraction Date	03/19/20	03/19/20	03/19/20
Extraction Batch	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020, 14:45	26-Mar-2020, 15:53	26-Mar-2020, 17:01
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	0.99	0.95	0.93
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.291	U	<0.303	U	<0.31	U
n-C10	<0.254	U	<0.265	U	<0.27	U
n-C11	<0.253	U	<0.264	U	<0.27	U
n-C12	<0.269	U	<0.28	U	<0.286	U
n-C13	<0.261	U	<0.272	U	<0.278	U
i-C15	<0.259	U	<0.27	U	<0.276	U
n-C14	<0.279	U	<0.291	U	<0.297	U
i-C16	<0.237	U	<0.246	U	<0.252	U
n-C15	<0.259	U	<0.27	U	<0.276	U
n-C16	<0.237	U	<0.246	U	<0.252	U
i-C18	<0.101	U	<0.106	U	<0.108	U
n-C17	<0.175	U	<0.183	U	<0.187	U
Pristane	<0.192	U	<0.2	U	<0.204	U
n-C18	<0.101	U	<0.106	U	<0.108	U
Phytane	<0.203	U	<0.211	U	<0.216	U
n-C19	<0.074	U	<0.077	U	<0.079	U
n-C20	<0.078	U	<0.081	U	<0.083	U
n-C21	<0.081	U	<0.085	U	<0.087	U
n-C22	<0.151	U	<0.158	U	<0.161	U
n-C23	<0.118	U	<0.123	U	<0.126	U
n-C24	<0.069	U	<0.072	U	<0.074	U
n-C25	<0.066	U	<0.069	U	<0.07	U
n-C26	<0.071	U	<0.074	U	<0.076	U
n-C27	<0.069	U	<0.072	U	<0.074	U
n-C28	<0.078	U	<0.081	U	<0.083	U
n-C29	<0.088	U	<0.092	U	<0.094	U
n-C30	<0.082	U	<0.085	U	<0.087	U
n-C31	<0.127	U	<0.133	U	<0.135	U
n-C32	<0.084	U	<0.087	U	<0.089	U
n-C33	<0.285	U	<0.297	U	<0.303	U
n-C34	<0.107	U	<0.112	U	<0.114	U
n-C35	<0.113	U	<0.118	U	<0.12	U
n-C36	<0.114	U	<0.119	U	<0.122	U
n-C37	<0.149	U	<0.156	U	<0.159	U
n-C38	<0.128	U	<0.134	U	<0.137	U
n-C39	<0.162	U	<0.169	U	<0.172	U
n-C40	<0.145	U	<0.151	U	<0.154	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13.131	U	<13.684	U	<13.978	U
Total Resolved Hydrocarbons	<13.131	U	<13.684	U	<13.978	U
Unresolved Complex Mixture	<13.131	U	<13.684	U	<13.978	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	64	68	64
n-eicosane-d42	80	84	89
n-triacontane-d62	82	87	91

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5226.D	CSA5227.D	CSA5228.D	CSA5229.D
Sample ID	3532|03_20|EB|diw|hc|01	3532|03_20|FB|diw|hc|01	3532|03_20|DI|diw|hc|01	3532|03_20|CH2Cl2|hc|01
Matrix	Water	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/17/20	03/17/20	03/17/20
Extraction Date	03/19/20	03/19/20	03/19/20	03/20/20
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4075
Date Acquired	26-Mar-2020, 18:10	26-Mar-2020, 19:18	26-Mar-2020, 20:27	25-Mar-2020, 21:38
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.04	0.97	1.04	0.06
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)
n-C9	<0.288	U	<0.297	U	<0.288	U	<4.804
n-C10	<0.252	U	<0.259	U	<0.252	U	<4.192
n-C11	<0.251	U	<0.259	U	<0.251	U	<4.179
n-C12	<0.266	U	<0.275	U	<0.266	U	<4.438
n-C13	<0.258	U	<0.266	U	<0.258	U	<4.306
i-C15	<0.256	U	<0.264	U	<0.256	U	<4.274
n-C14	<0.277	U	<0.285	U	<0.277	U	<4.61
i-C16	<0.234	U	<0.241	U	<0.234	U	<3.903
n-C15	<0.256	U	<0.264	U	<0.256	U	<4.274
n-C16	<0.234	U	<0.241	U	<0.234	U	<3.903
i-C18	<0.1	U	<0.103	U	<0.1	U	<1.673
n-C17	<0.174	U	<0.179	U	<0.174	U	<2.895
Pristane	<0.19	U	<0.196	U	<0.19	U	<3.164
n-C18	<0.1	U	<0.103	U	<0.1	U	<1.673
Phytane	<0.201	U	<0.207	U	<0.201	U	<3.343
n-C19	<0.073	U	<0.076	U	<0.073	U	<1.224
n-C20	<0.077	U	<0.08	U	<0.077	U	<1.287
n-C21	<0.081	U	<0.083	U	<0.081	U	<1.344
n-C22	<0.15	U	<0.154	U	<0.15	U	<2.495
n-C23	<0.117	U	<0.121	U	<0.117	U	<1.95
n-C24	<0.069	U	<0.071	U	<0.069	U	<1.144
n-C25	<0.066	U	<0.068	U	<0.066	U	<1.092
n-C26	<0.07	U	<0.072	U	<0.07	U	<1.171
n-C27	<0.069	U	<0.071	U	<0.069	U	<1.143
n-C28	<0.077	U	<0.079	U	<0.077	U	<1.284
n-C29	<0.087	U	<0.09	U	<0.087	U	<1.454
n-C30	<0.081	U	<0.083	U	<0.081	U	<1.348
n-C31	<0.126	U	<0.13	U	<0.126	U	<2.099
n-C32	<0.083	U	<0.085	U	<0.083	U	<1.379
n-C33	<0.282	U	<0.291	U	<0.282	U	<4.698
n-C34	<0.106	U	<0.11	U	<0.106	U	<1.771
n-C35	<0.112	U	<0.115	U	<0.112	U	<1.861
n-C36	<0.113	U	<0.117	U	<0.113	U	<1.886
n-C37	<0.148	U	<0.153	U	<0.148	U	<2.466
n-C38	<0.127	U	<0.131	U	<0.127	U	<2.12
n-C39	<0.16	U	<0.165	U	<0.16	U	<2.674
n-C40	<0.144	U	<0.148	U	<0.144	U	<2.394
Total Alkanes							
Total Petroleum Hydrocarbons	<13	U	<13.402	U	<13	U	<216.667
Total Resolved Hydrocarbons	<13	U	<13.402	U	<13	U	<216.667
Unresolved Complex Mixture	<13	U	<13.402	U	<13	U	<216.667
EOM (µg/L)	NA		NA		NA		NA

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	66	57	59	88
n-eicosane-d42	85	83	85	95
n-triacontane-d62	87	85	88	97

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5230.D	CSA5247.D	CSA5248.D
Sample ID	3532|03_20|DI|hc|01	3532|03_20|HH-5|sw_s|hc|01	3532|03_20|HH-5|sw_s|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/17/20	03/18/20	03/18/20
Extraction Date	03/20/20	03/20/20	03/20/20
Extraction Batch	ENV4075	ENV4075	ENV4075
Date Acquired	25-Mar-2020, 22:47	25-Mar-2020, 23:55	26-Mar-2020, 01:04
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	0.04	1.04	1.05
Dilution	1X	1X	1X

Target Compounds	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	U	<7.206	U	<0.288	U	<0.288	U
n-C10	U	<6.288	U	<0.252	U	<0.252	U
n-C11	U	<6.269	U	<0.251	U	<0.251	U
n-C12	U	<6.658	U	<0.266	U	<0.266	U
n-C13	U	<6.46	U	<0.258	U	<0.258	U
i-C15	U	<6.412	U	<0.256	U	<0.256	U
n-C14	U	<6.914	U	<0.277	U	<0.277	U
i-C16	U	<5.854	U	<0.234	U	<0.234	U
n-C15	U	<6.412	U	<0.256	U	<0.256	U
n-C16	U	<5.854	U	<0.234	U	<0.234	U
i-C18	U	<2.509	U	<0.1	U	<0.1	U
n-C17	U	<4.342	U	<0.174	U	<0.174	U
Pristane	U	<4.746	U	<0.19	U	<0.19	U
n-C18	U	<2.509	U	<0.1	U	<0.1	U
Phytane	U	<5.015	U	<0.201	U	<0.201	U
n-C19	U	<1.836	U	<0.073	U	<0.073	U
n-C20	U	<1.93	U	<0.077	U	<0.077	U
n-C21	U	<2.017	U	<0.081	U	<0.081	U
n-C22	U	<3.743	U	<0.15	U	<0.15	U
n-C23	U	<2.925	U	<0.117	U	<0.117	U
n-C24	U	<1.716	U	<0.069	U	<0.069	U
n-C25	U	<1.638	U	<0.066	U	<0.066	U
n-C26	U	<1.757	U	<0.07	U	<0.07	U
n-C27	U	<1.714	U	<0.069	U	<0.069	U
n-C28	U	<1.926	U	<0.077	U	<0.077	U
n-C29	U	<2.181	U	<0.087	U	<0.087	U
n-C30	U	<2.022	U	<0.081	U	<0.081	U
n-C31	U	<3.148	U	<0.126	U	<0.126	U
n-C32	U	<2.069	U	<0.083	U	<0.083	U
n-C33	U	<7.047	U	<0.282	U	<0.282	U
n-C34	U	<2.657	U	<0.106	U	<0.106	U
n-C35	U	<2.791	U	<0.112	U	<0.112	U
n-C36	U	<2.829	U	<0.113	U	<0.113	U
n-C37	U	<3.699	U	<0.148	U	<0.148	U
n-C38	U	<3.179	U	<0.127	U	<0.127	U
n-C39	U	<4.01	U	<0.16	U	<0.16	U
n-C40	U	<3.591	U	<0.144	U	<0.144	U
Total Alkanes							
Total Petroleum Hydrocarbons	U	<325	U	<13	U	<13	U
Total Resolved Hydrocarbons	U	<325	U	<13	U	<13	U
Unresolved Complex Mixture	U	<325	U	<13	U	<13	U
EOM (µg/L)		NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	88	63	68
n-eicosane-d42	95	84	92
n-triacontane-d62	95	86	93

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5249.D	CSA5250.D	CSA5251.D
Sample ID	3532|03_20|HH-5|sw_m|hc|01	3532|03_20|HH-5|sw_m|hc|02	3532|03_20|HH-5|sw_b|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/18/20	03/18/20	03/18/20
Extraction Date	03/20/20	03/20/20	03/20/20
Extraction Batch	ENV4075	ENV4075	ENV4075
Date Acquired	26-Mar-2020, 03:20	26-Mar-2020, 04:29	26-Mar-2020, 05:37
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.04	1.04	1.04
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.07	U
n-C27	<0.069	U	<0.069	U	<0.069	U
n-C28	<0.077	U	<0.077	U	<0.077	U
n-C29	<0.087	U	<0.087	U	<0.087	U
n-C30	<0.081	U	<0.081	U	<0.081	U
n-C31	<0.126	U	<0.126	U	<0.126	U
n-C32	<0.083	U	<0.083	U	<0.083	U
n-C33	<0.282	U	<0.282	U	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	67	67	51
n-eicosane-d42	89	88	83
n-triacontane-d62	90	89	84

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5252.D	CSA5253.D	CSA5254.D
Sample ID	3532|03_20|HH-5|sw_b|hc|02	3532|03_20|HH-7|sw_s|hc|01	3532|03_20|HH-7|sw_s|hc|02
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/18/20	03/18/20	03/18/20
Extraction Date	03/20/20	03/20/20	03/20/20
Extraction Batch	ENV4075	ENV4075	ENV4075
Date Acquired	26-Mar-2020, 06:45	26-Mar-2020, 07:54	26-Mar-2020, 09:02
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.04	1.02	1.02
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.07	U
n-C27	<0.069	U	<0.069	U	<0.069	U
n-C28	<0.077	U	<0.077	U	<0.077	U
n-C29	<0.087	U	<0.087	U	<0.087	U
n-C30	<0.081	U	<0.081	U	<0.081	U
n-C31	<0.126	U	<0.126	U	<0.126	U
n-C32	<0.083	U	<0.083	U	<0.083	U
n-C33	<0.282	U	<0.282	U	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	59	68	56
n-eicosane-d42	86	90	92
n-triacontane-d62	87	91	92

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5255.D	CSA5256.D	CSA5257.D
Sample ID	3532|03_20|HH-7|sw_m|hc|01	3532|03_20|HH-7|sw_m|hc|02	3532|03_20|HH-7|sw_b|hc|01
Matrix	Water	Water	Water
Collection Date	03/13/20	03/13/20	03/13/20
Received Date	03/18/20	03/18/20	03/18/20
Extraction Date	03/20/20	03/20/20	03/20/20
Extraction Batch	ENV4075	ENV4075	ENV4075
Date Acquired	26-Mar-2020, 10:11	26-Mar-2020, 11:19	26-Mar-2020, 12:28
Method	B&B SOP1016	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.05	1.05	1.05
Dilution	1X	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U	<0.288	U	<0.288	U
n-C10	<0.252	U	<0.252	U	<0.252	U
n-C11	<0.251	U	<0.251	U	<0.251	U
n-C12	<0.266	U	<0.266	U	<0.266	U
n-C13	<0.258	U	<0.258	U	<0.258	U
i-C15	<0.256	U	<0.256	U	<0.256	U
n-C14	<0.277	U	<0.277	U	<0.277	U
i-C16	<0.234	U	<0.234	U	<0.234	U
n-C15	<0.256	U	<0.256	U	<0.256	U
n-C16	<0.234	U	<0.234	U	<0.234	U
i-C18	<0.1	U	<0.1	U	<0.1	U
n-C17	<0.174	U	<0.174	U	<0.174	U
Pristane	<0.19	U	<0.19	U	<0.19	U
n-C18	<0.1	U	<0.1	U	<0.1	U
Phytane	<0.201	U	<0.201	U	<0.201	U
n-C19	<0.073	U	<0.073	U	<0.073	U
n-C20	<0.077	U	<0.077	U	<0.077	U
n-C21	<0.081	U	<0.081	U	<0.081	U
n-C22	<0.15	U	<0.15	U	<0.15	U
n-C23	<0.117	U	<0.117	U	<0.117	U
n-C24	<0.069	U	<0.069	U	<0.069	U
n-C25	<0.066	U	<0.066	U	<0.066	U
n-C26	<0.07	U	<0.07	U	<0.07	U
n-C27	<0.069	U	<0.069	U	<0.069	U
n-C28	<0.077	U	<0.077	U	<0.077	U
n-C29	<0.087	U	<0.087	U	<0.087	U
n-C30	<0.081	U	<0.081	U	<0.081	U
n-C31	<0.126	U	<0.126	U	<0.126	U
n-C32	<0.083	U	<0.083	U	<0.083	U
n-C33	<0.282	U	<0.282	U	<0.282	U
n-C34	<0.106	U	<0.106	U	<0.106	U
n-C35	<0.112	U	<0.112	U	<0.112	U
n-C36	<0.113	U	<0.113	U	<0.113	U
n-C37	<0.148	U	<0.148	U	<0.148	U
n-C38	<0.127	U	<0.127	U	<0.127	U
n-C39	<0.16	U	<0.16	U	<0.16	U
n-C40	<0.144	U	<0.144	U	<0.144	U
Total Alkanes						
Total Petroleum Hydrocarbons	<13	U	<13	U	<13	U
Total Resolved Hydrocarbons	<13	U	<13	U	<13	U
Unresolved Complex Mixture	<13	U	<13	U	<13	U
EOM (µg/L)	NA		NA		NA	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	64	63	56
n-eicosane-d42	79	90	86
n-triacontane-d62	81	91	87

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5258.D
Sample ID	3532|03_20|HH-7|sw_b|hc|02
Matrix	Water
Collection Date	03/13/20
Received Date	03/18/20
Extraction Date	03/20/20
Extraction Batch	ENV4075
Date Acquired	26-Mar-2020, 14:45
Method	B&B SOP1016
Sample Volume (L)	1.05
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q
n-C9	<0.288	U
n-C10	<0.252	U
n-C11	<0.251	U
n-C12	<0.266	U
n-C13	<0.258	U
i-C15	<0.256	U
n-C14	<0.277	U
i-C16	<0.234	U
n-C15	<0.256	U
n-C16	<0.234	U
i-C18	<0.1	U
n-C17	<0.174	U
Pristane	<0.19	U
n-C18	<0.1	U
Phytane	<0.201	U
n-C19	<0.073	U
n-C20	<0.077	U
n-C21	<0.081	U
n-C22	<0.15	U
n-C23	<0.117	U
n-C24	<0.069	U
n-C25	<0.066	U
n-C26	<0.07	U
n-C27	<0.069	U
n-C28	<0.077	U
n-C29	<0.087	U
n-C30	<0.081	U
n-C31	<0.126	U
n-C32	<0.083	U
n-C33	<0.282	U
n-C34	<0.106	U
n-C35	<0.112	U
n-C36	<0.113	U
n-C37	<0.148	U
n-C38	<0.127	U
n-C39	<0.16	U
n-C40	<0.144	U
Total Alkanes		
Total Petroleum Hydrocarbons	<13	U
Total Resolved Hydrocarbons	<13	U
Unresolved Complex Mixture	<13	U
EOM (µg/L)	NA	

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	65
n-eicosane-d42	90
n-triacontane-d62	91

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4073A.D
Sample ID	Method Blank
Matrix	Water
Collection Date	NA
Received Date	NA
Extraction Date	03/18/20
Extraction Batch	ENV4073
Date Acquired	23-Mar-2020, 18:43
Method	B&B SOP1016
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Q	3X MDL Conc. (µg/L)	Actual MDL Conc. (µg/L)
n-C9	<0.288	U		0.865	0.288
n-C10	<0.252	U		0.755	0.252
n-C11	<0.251	U		0.752	0.251
n-C12	<0.266	U		0.799	0.266
n-C13	<0.258	U		0.775	0.258
i-C15	<0.256	U		0.769	0.256
n-C14	<0.277	U		0.830	0.277
i-C16	<0.234	U		0.702	0.234
n-C15	<0.256	U		0.769	0.256
n-C16	<0.234	U		0.702	0.234
i-C18	<0.1	U		0.301	0.100
n-C17	<0.174	U		0.521	0.174
Pristane	<0.19	U		0.570	0.190
n-C18	<0.1	U		0.301	0.100
Phytane	<0.201	U		0.602	0.201
n-C19	<0.073	U		0.220	0.073
n-C20	<0.077	U		0.232	0.077
n-C21	<0.081	U		0.242	0.081
n-C22	<0.15	U		0.449	0.150
n-C23	<0.117	U		0.351	0.117
n-C24	<0.069	U		0.206	0.069
n-C25	<0.066	U		0.197	0.066
n-C26	<0.07	U		0.211	0.070
n-C27	<0.069	U		0.206	0.069
n-C28	<0.077	U		0.231	0.077
n-C29	<0.087	U		0.262	0.087
n-C30	<0.081	U		0.243	0.081
n-C31	<0.126	U		0.378	0.126
n-C32	<0.083	U		0.248	0.083
n-C33	<0.282	U		0.846	0.282
n-C34	<0.106	U		0.319	0.106
n-C35	<0.112	U		0.335	0.112
n-C36	<0.113	U		0.339	0.113
n-C37	<0.148	U		0.444	0.148
n-C38	<0.127	U		0.382	0.127
n-C39	<0.16	U		0.481	0.160
n-C40	<0.144	U		0.431	0.144
Total Alkanes					
Total Petroleum Hydrocarbons	<13	U		39.00	13.00
Total Resolved Hydrocarbons	<13	U		39.00	13.00
Unresolved Complex Mixture	<13	U		39.00	13.00
EOM (µg/L)	NA			300	100

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	67
n-eicosane-d42	91
n-triacontane-d62	94

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4074A.D
Sample ID	Method Blank
Matrix	Water
Collection Date	NA
Received Date	NA
Extraction Date	03/19/20
Extraction Batch	ENV4074
Date Acquired	25-Mar-2020, 18:13
Method	B&B SOP1016
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Q	3X MDL Conc. (µg/L)	Actual MDL Conc. (µg/L)
n-C9	<0.288	U		0.865	0.288
n-C10	<0.252	U		0.755	0.252
n-C11	<0.251	U		0.752	0.251
n-C12	<0.266	U		0.799	0.266
n-C13	<0.258	U		0.775	0.258
i-C15	<0.256	U		0.769	0.256
n-C14	<0.277	U		0.830	0.277
i-C16	<0.234	U		0.702	0.234
n-C15	<0.256	U		0.769	0.256
n-C16	<0.234	U		0.702	0.234
i-C18	<0.1	U		0.301	0.100
n-C17	<0.174	U		0.521	0.174
Pristane	<0.19	U		0.570	0.190
n-C18	<0.1	U		0.301	0.100
Phytane	<0.201	U		0.602	0.201
n-C19	<0.073	U		0.220	0.073
n-C20	<0.077	U		0.232	0.077
n-C21	<0.081	U		0.242	0.081
n-C22	<0.15	U		0.449	0.150
n-C23	<0.117	U		0.351	0.117
n-C24	<0.069	U		0.206	0.069
n-C25	<0.066	U		0.197	0.066
n-C26	<0.07	U		0.211	0.070
n-C27	<0.069	U		0.206	0.069
n-C28	<0.077	U		0.231	0.077
n-C29	<0.087	U		0.262	0.087
n-C30	<0.081	U		0.243	0.081
n-C31	<0.126	U		0.378	0.126
n-C32	<0.083	U		0.248	0.083
n-C33	<0.282	U		0.846	0.282
n-C34	<0.106	U		0.319	0.106
n-C35	<0.112	U		0.335	0.112
n-C36	<0.113	U		0.339	0.113
n-C37	<0.148	U		0.444	0.148
n-C38	<0.127	U		0.382	0.127
n-C39	<0.16	U		0.481	0.160
n-C40	<0.144	U		0.431	0.144
Total Alkanes					
Total Petroleum Hydrocarbons	<13	U		39.00	13.00
Total Resolved Hydrocarbons	<13	U		39.00	13.00
Unresolved Complex Mixture	<13	U		39.00	13.00
EOM (µg/L)	NA			300	100

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	78
n-eicosane-d42	91
n-triacontane-d62	93

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4075A.D
Sample ID	Method Blank
Matrix	Water
Collection Date	NA
Received Date	NA
Extraction Date	03/20/20
Extraction Batch	ENV4075
Date Acquired	25-Mar-2020, 18:13
Method	B&B SOP1016
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Q	Q	3X MDL Conc. (µg/L)	Actual MDL Conc. (µg/L)
n-C9	<0.288	U		0.865	0.288
n-C10	<0.252	U		0.755	0.252
n-C11	<0.251	U		0.752	0.251
n-C12	<0.266	U		0.799	0.266
n-C13	<0.258	U		0.775	0.258
i-C15	<0.256	U		0.769	0.256
n-C14	<0.277	U		0.830	0.277
i-C16	<0.234	U		0.702	0.234
n-C15	<0.256	U		0.769	0.256
n-C16	<0.234	U		0.702	0.234
i-C18	<0.1	U		0.301	0.100
n-C17	<0.174	U		0.521	0.174
Pristane	<0.19	U		0.570	0.190
n-C18	<0.1	U		0.301	0.100
Phytane	<0.201	U		0.602	0.201
n-C19	<0.073	U		0.220	0.073
n-C20	<0.077	U		0.232	0.077
n-C21	<0.081	U		0.242	0.081
n-C22	<0.15	U		0.449	0.150
n-C23	<0.117	U		0.351	0.117
n-C24	<0.069	U		0.206	0.069
n-C25	<0.066	U		0.197	0.066
n-C26	<0.07	U		0.211	0.070
n-C27	<0.069	U		0.206	0.069
n-C28	<0.077	U		0.231	0.077
n-C29	<0.087	U		0.262	0.087
n-C30	<0.081	U		0.243	0.081
n-C31	<0.126	U		0.378	0.126
n-C32	<0.083	U		0.248	0.083
n-C33	<0.282	U		0.846	0.282
n-C34	<0.106	U		0.319	0.106
n-C35	<0.112	U		0.335	0.112
n-C36	<0.113	U		0.339	0.113
n-C37	<0.148	U		0.444	0.148
n-C38	<0.127	U		0.382	0.127
n-C39	<0.16	U		0.481	0.160
n-C40	<0.144	U		0.431	0.144
Total Alkanes					
Total Petroleum Hydrocarbons	<13	U		39.00	13.00
Total Resolved Hydrocarbons	<13	U		39.00	13.00
Unresolved Complex Mixture	<13	U		39.00	13.00
EOM (µg/L)	NA			300	100

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	75
n-eicosane-d42	94
n-triacontane-d62	96

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4073B.D	ENV4073C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/18/20	03/18/20
Extraction Batch	ENV4073	ENV4073
Date Acquired	23-Mar-2020, 19:51	23-Mar-2020, 20:59
Method	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Recovery (%)	Q	Su. Corrected Conc. (µg/L)	Recovery (%)	Q	RPD (%)	Q	Spike Amount (µg)
n-C9	7.72	77		7.63	76		1		10.0
n-C10	7.53	75		7.78	77		3		10.1
n-C11	8.02	80		8.35	83		4		10.0
n-C12	8.25	84		8.45	86		2		9.9
n-C13	8.68	87		8.74	87		1		10.0
n-C14	9.13	92		9.04	92		1		9.9
n-C15	9.53	94		9.41	93		1		10.1
n-C16	9.94	99		9.81	98		1		10.0
n-C17	10.3	102		10.2	101		1		10.1
Pristane	10.1	101		10.0	101		1		9.96
n-C18	10.1	102		10.0	101		1		9.9
Phytane	9.83	100		9.86	100		0		9.9
n-C19	10.1	101		10.1	101		0		10.0
n-C20	10.2	102		10.2	102		0		10.0
n-C21	10.3	102		10.4	103		0		10.1
n-C22	10.3	104		10.3	104		0		9.91
n-C23	10.3	103		10.3	103		0		10.03
n-C24	11.4	114		11.4	114		0		10.03
n-C25	10.4	104		10.4	103		1		10.1
n-C26	10.1	101		10.1	101		0		10.0
n-C27	10.5	104		10.4	103		1		10.1
n-C28	10.8	108		10.7	107		1		10.0
n-C29	10.8	107		10.7	106		1		10.05
n-C30	10.8	108		10.7	107		1		10.0
n-C31	11.0	110		11.0	109		1		10.1
n-C32	10.4	105		10.4	105		0		9.92
n-C33	10.7	106		10.7	107		1		10.1
n-C34	10.8	107		10.9	108		1		10.1
n-C35	10.6	106		10.6	107		0		10.0
n-C36	11.1	110		11.2	112		1		10.1
n-C37	10.5	104		10.5	105		1		10.1
n-C38	10.9	108		11.0	109		0		10.1
n-C39	10.1	100		10.1	101		0		10.0
n-C40	11.0	111		11.0	111		0		10.0
Average %Recovery		101			101				

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	70	63
n-eicosane-d42	88	91
n-triacontane-d62	91	94

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4074B.D	ENV4074C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/19/20	03/19/20
Extraction Batch	ENV4074	ENV4074
Date Acquired	25-Mar-2020, 19:21	25-Mar-2020, 20:30
Method	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Recovery (%)	Q	Su. Corrected Conc. (µg/L)	Recovery (%)	Q	RPD (%)	Q	Spike Amount (µg)
n-C9	9.34	93		9.46	95		1		10.0
n-C10	8.13	81		8.14	81		0		10.1
n-C11	8.70	87		8.64	86		1		10.0
n-C12	8.77	89		8.74	89		0		9.9
n-C13	9.03	90		8.95	89		1		10.0
n-C14	9.42	95		9.26	94		2		9.9
n-C15	9.59	95		9.61	95		0		10.1
n-C16	9.92	99		9.82	98		1		10.0
n-C17	10.1	100		10.2	101		1		10.1
Pristane	10.0	100		10.0	100		0		9.96
n-C18	10.2	102		10.1	101		1		9.9
Phytane	9.79	99		9.81	100		0		9.9
n-C19	10.1	100		10.1	101		0		10.0
n-C20	10.2	101		10.3	103		1		10.0
n-C21	10.2	102		10.3	102		1		10.1
n-C22	10.2	103		10.3	104		0		9.91
n-C23	10.2	102		10.2	102		0		10.03
n-C24	11.2	112		11.3	113		0		10.03
n-C25	10.3	102		10.3	103		0		10.1
n-C26	9.94	99		10.0	99		0		10.0
n-C27	10.2	101		10.3	103		1		10.1
n-C28	10.8	108		10.9	109		1		10.0
n-C29	10.4	104		10.5	104		1		10.05
n-C30	10.5	105		10.6	105		0		10.0
n-C31	10.7	106		10.7	107		0		10.1
n-C32	10.0	101		10.1	102		1		9.92
n-C33	10.4	103		10.5	104		0		10.1
n-C34	10.6	105		10.7	106		1		10.1
n-C35	10.4	104		10.4	105		1		10.0
n-C36	10.9	109		11.0	110		1		10.1
n-C37	10.4	103		10.4	103		0		10.1
n-C38	10.7	107		10.8	107		0		10.1
n-C39	9.93	99		9.92	99		0		10.0
n-C40	10.9	110		10.8	109		1		10.0
Average %Recovery		101			101				

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	67	68
n-eicosane-d42	88	89
n-triacontane-d62	89	91

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4075B.D	ENV4075C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/20/20	03/20/20
Extraction Batch	ENV4075	ENV4075
Date Acquired	25-Mar-2020, 19:21	25-Mar-2020, 20:30
Method	B&B SOP1016	B&B SOP1016
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (µg/L)	Recovery (%)	Q	Su. Corrected Conc. (µg/L)	Recovery (%)	Q	RPD (%)	Q	Spike Amount (µg)
n-C9	10.1	101		9.75	97		4		10.0
n-C10	7.86	78		7.33	73		7		10.1
n-C11	8.21	82		7.76	77		6		10.0
n-C12	8.41	85		7.93	80		6		9.9
n-C13	8.75	87		8.34	83		5		10.0
n-C14	9.39	95		9.03	91		4		9.9
n-C15	9.75	97		9.56	95		2		10.1
n-C16	10.2	101		10.0	99		2		10.0
n-C17	10.3	102		10.2	102		1		10.1
Pristane	10.1	101		10.0	100		1		9.96
n-C18	10.1	101		9.94	100		1		9.9
Phytane	9.6	98		9.55	97		1		9.9
n-C19	10.0	100		9.90	99		1		10.0
n-C20	10.2	102		10.0	100		1		10.0
n-C21	10.2	102		10.1	100		1		10.1
n-C22	10.3	104		10.1	102		2		9.91
n-C23	10.2	102		10.0	100		2		10.03
n-C24	11.1	111		10.9	108		2		10.03
n-C25	10.4	103		10.1	100		3		10.1
n-C26	9.94	99		9.75	97		2		10.0
n-C27	10.2	102		10.0	99		2		10.1
n-C28	10.7	107		10.5	105		2		10.0
n-C29	10.4	104		10.2	102		2		10.05
n-C30	10.5	104		10.2	102		2		10.0
n-C31	10.7	106		10.5	104		2		10.1
n-C32	10.1	102		9.83	99		3		9.92
n-C33	10.4	103		10.1	100		3		10.1
n-C34	10.7	106		10.5	104		2		10.1
n-C35	10.4	104		10.2	102		2		10.0
n-C36	10.9	108		10.7	106		2		10.1
n-C37	10.1	100		10.0	99		1		10.1
n-C38	10.6	105		10.5	104		1		10.1
n-C39	9.74	97		9.69	97		1		10.0
n-C40	10.8	108		10.6	106		1		10.0
Average %Recovery		100			98				

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)
n-dodecane-d26	64	69
n-eicosane-d42	82	94
n-triacontane-d62	83	95

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	FID60115G.D
Sample ID	ALI-SRM2779-20-06-1
Matrix	Reference Oil
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	NA
Date Acquired	24-Mar-2020, 23:01
Method	B&B SOP1016
Sample Weight (mg)	20.0
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/mg)	Q	Q	Dev. (%)	B&B Average	- 3 σ Conc. (µg/mg)	+ 3 σ Conc. (µg/mg)
n-C9	12.3			4	11.8	9.72	13.9
n-C10	11.6			7	10.8	8.96	12.7
n-C11	10.6			9	9.72	8.17	11.3
n-C12	8.88			6	8.35	6.96	9.74
n-C13	9.01			19	7.56	5.75	9.38
i-C15	1.32			15	1.56	1.08	2.05
n-C14	6.43			4	6.70	5.60	7.80
i-C16	2.34			7	2.50	2.01	2.99
n-C15	6.26			1	6.29	5.29	7.30
n-C16	5.53			5	5.29	4.35	6.23
i-C18	1.43			9	1.57	1.22	1.93
n-C17	4.54			2	4.47	3.70	5.23
Pristane	2.52			4	2.42	1.99	2.84
n-C18	3.58			1	3.61	3.14	4.08
Phytane	1.37			10	1.53	1.24	1.82
n-C19	2.71			17	3.28	2.66	3.90
n-C20	3.00			7	2.81	2.37	3.25
n-C21	2.41			3	2.33	1.95	2.72
n-C22	2.10			3	2.04	1.70	2.39
n-C23	1.81			1	1.83	1.53	2.13
n-C24	1.86			13	1.64	1.35	1.92
n-C25	1.31			4	1.37	1.17	1.57
n-C26	1.12			2	1.15	0.967	1.33
n-C27	0.89			3	0.918	0.772	1.06
n-C28	0.831			7	0.780	0.635	0.925
n-C29	0.775			3	0.753	0.643	0.863
n-C30	0.630			4	0.658	0.547	0.769
n-C31	0.538			2	0.547	0.457	0.638
n-C32	0.496			2	0.486	0.407	0.565
n-C33	0.486			4	0.467	0.375	0.559
n-C34	0.458			9	0.422	0.350	0.493
n-C35	0.359			5	0.342	0.278	0.407
n-C36	0.204	J		1	0.201	0.156	0.246
n-C37	0.203	J		2	0.207	0.158	0.256
n-C38	0.178	J		5	0.169	0.129	0.208
n-C39	0.147	J		8	0.160	0.124	0.196
n-C40	0.143	J		7	0.154	0.118	0.190
Total Petroleum Hydrocarbons	544			5	574	452	695

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	99
n-eicosane-d42	100
n-triacontane-d62	99

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	FID60117G.D
Sample ID	ALI-SRM2779-20-06-1
Matrix	Reference Oil
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	NA
Date Acquired	26-Mar-2020, 21:35
Method	B&B SOP1016
Sample Weight (mg)	20.0
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/mg)	Q	Q	Dev. (%)	B&B Average	- 3 σ Conc. (µg/mg)	+ 3 σ Conc. (µg/mg)
n-C9	10.9			8	11.8	9.72	13.9
n-C10	10.3			5	10.8	8.96	12.7
n-C11	9.42			3	9.72	8.17	11.3
n-C12	7.85			6	8.35	6.96	9.74
n-C13	8.22			9	7.56	5.75	9.38
i-C15	1.12			28	1.56	1.08	2.05
n-C14	6.20			7	6.70	5.60	7.80
i-C16	2.10			16	2.50	2.01	2.99
n-C15	5.65			10	6.29	5.29	7.30
n-C16	4.81			9	5.29	4.35	6.23
i-C18	1.35			14	1.57	1.22	1.93
n-C17	4.58			2	4.47	3.70	5.23
Pristane	2.42			0	2.42	1.99	2.84
n-C18	3.88			7	3.61	3.14	4.08
Phytane	1.35			12	1.53	1.24	1.82
n-C19	3.03			8	3.28	2.66	3.90
n-C20	2.98			6	2.81	2.37	3.25
n-C21	2.37			1	2.33	1.95	2.72
n-C22	2.12			4	2.04	1.70	2.39
n-C23	1.84			0	1.83	1.53	2.13
n-C24	1.83			12	1.64	1.35	1.92
n-C25	1.57			14	1.37	1.17	1.57
n-C26	1.11			3	1.15	0.967	1.33
n-C27	0.874			5	0.918	0.772	1.06
n-C28	0.807			3	0.780	0.635	0.925
n-C29	0.754			0	0.753	0.643	0.863
n-C30	0.598			9	0.658	0.547	0.769
n-C31	0.522			5	0.547	0.457	0.638
n-C32	0.480			1	0.486	0.407	0.565
n-C33	0.497			6	0.467	0.375	0.559
n-C34	0.418			1	0.422	0.350	0.493
n-C35	0.339	J		1	0.342	0.278	0.407
n-C36	0.202	J		0	0.201	0.156	0.246
n-C37	0.202	J		2	0.207	0.158	0.256
n-C38	0.174	J		3	0.169	0.129	0.208
n-C39	0.154	J		4	0.160	0.124	0.196
n-C40	0.162	J		5	0.154	0.118	0.190
Total Petroleum Hydrocarbons	635			11	574	452	695

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	99
n-eicosane-d42	100
n-triacontane-d62	100

CSA - 3532 Guyana
Aliphatic Hydrocarbon and Total Petroleum Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	FID60118G.D
Sample ID	ALI-SRM2779-20-06-1
Matrix	Reference Oil
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	NA
Date Acquired	26-Mar-2020, 15:53
Method	B&B SOP1016
Sample Weight (mg)	20.0
Dilution	1X

Target Compounds	Su. Corrected Conc. (µg/mg)	Q	Q	Dev. (%)	B&B Average	- 3 σ Conc. (µg/mg)	+ 3 σ Conc. (µg/mg)
n-C9	10.7			9	11.8	9.72	13.9
n-C10	10.1			7	10.8	8.96	12.7
n-C11	9.23			5	9.72	8.17	11.3
n-C12	7.73			7	8.35	6.96	9.74
n-C13	8.14			8	7.56	5.75	9.38
i-C15	1.29			18	1.56	1.08	2.05
n-C14	6.18			8	6.70	5.60	7.80
i-C16	2.10			16	2.50	2.01	2.99
n-C15	5.66			10	6.29	5.29	7.30
n-C16	4.82			9	5.29	4.35	6.23
i-C18	1.35			14	1.57	1.22	1.93
n-C17	4.71			5	4.47	3.70	5.23
Pristane	2.49			3	2.42	1.99	2.84
n-C18	3.46			4	3.61	3.14	4.08
Phytane	1.36			11	1.53	1.24	1.82
n-C19	3.42			4	3.28	2.66	3.90
n-C20	3.01			7	2.81	2.37	3.25
n-C21	2.41			3	2.33	1.95	2.72
n-C22	2.13			4	2.04	1.70	2.39
n-C23	1.81			1	1.83	1.53	2.13
n-C24	1.78			9	1.64	1.35	1.92
n-C25	1.42			3	1.37	1.17	1.57
n-C26	1.10			5	1.15	0.967	1.33
n-C27	0.863			6	0.918	0.772	1.06
n-C28	0.798			2	0.780	0.635	0.925
n-C29	0.743			1	0.753	0.643	0.863
n-C30	0.590			10	0.658	0.547	0.769
n-C31	0.514			6	0.547	0.457	0.638
n-C32	0.475			2	0.486	0.407	0.565
n-C33	0.492			5	0.467	0.375	0.559
n-C34	0.449			6	0.422	0.350	0.493
n-C35	0.309	J		10	0.342	0.278	0.407
n-C36	0.207	J		3	0.201	0.156	0.246
n-C37	0.189	J		9	0.207	0.158	0.256
n-C38	0.179	J		6	0.169	0.129	0.208
n-C39	0.156	J		2	0.160	0.124	0.196
n-C40	0.175	J		13	0.154	0.118	0.190
Total Petroleum Hydrocarbons	620			8	574	452	695

Surrogate (Su)	Su Recovery (%)
n-dodecane-d26	97
n-eicosane-d42	100
n-triacontane-d62	97

Total Petroleum Hydrocarbons Chromatograms

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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 23-Mar-2020, 22:07     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-8|sw_s|hc|01
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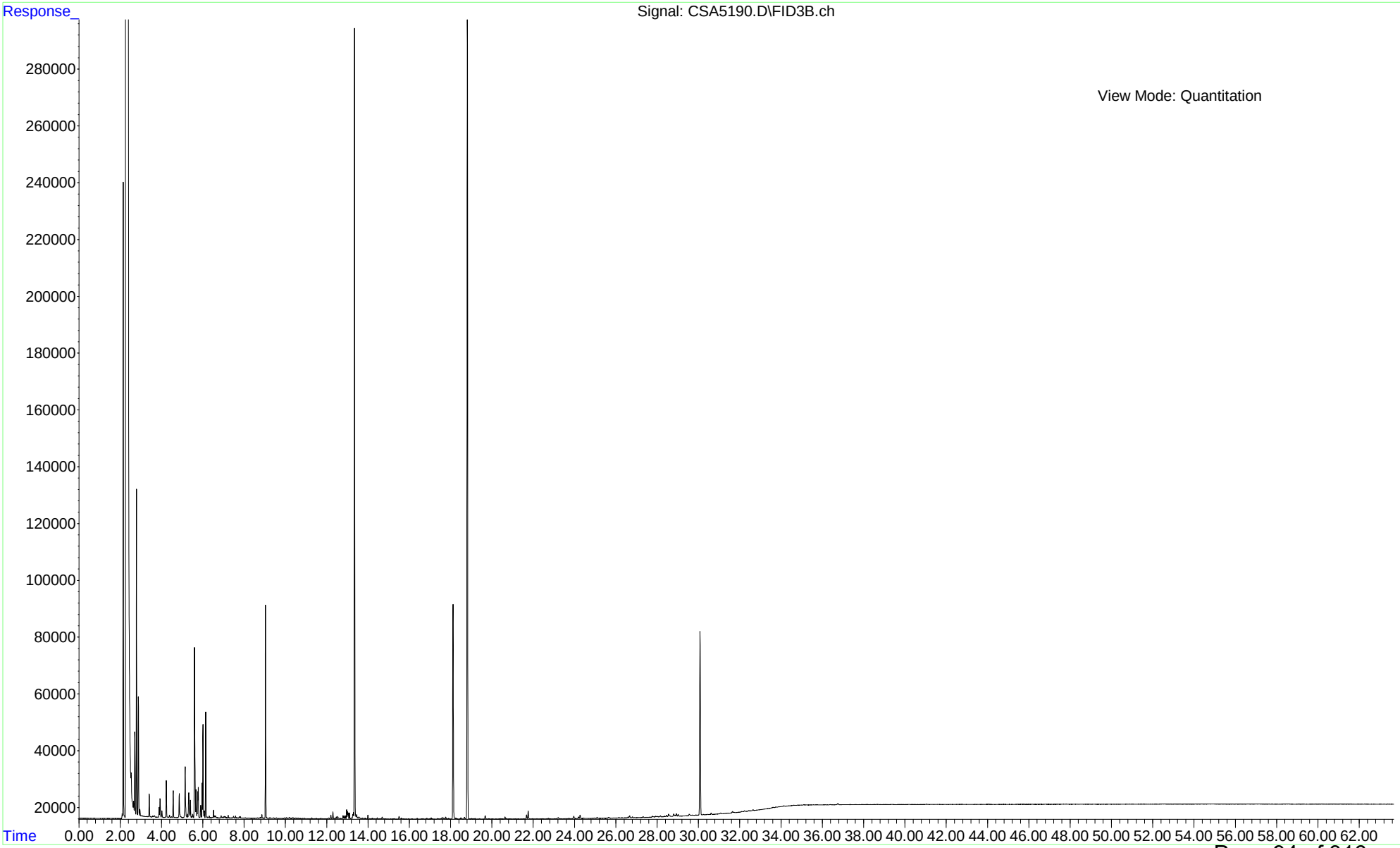

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Operator   : Chase Brewster
Instrument :   GCI
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Sample Name: 3532|03_20|HH-8|sw_s|hc|02
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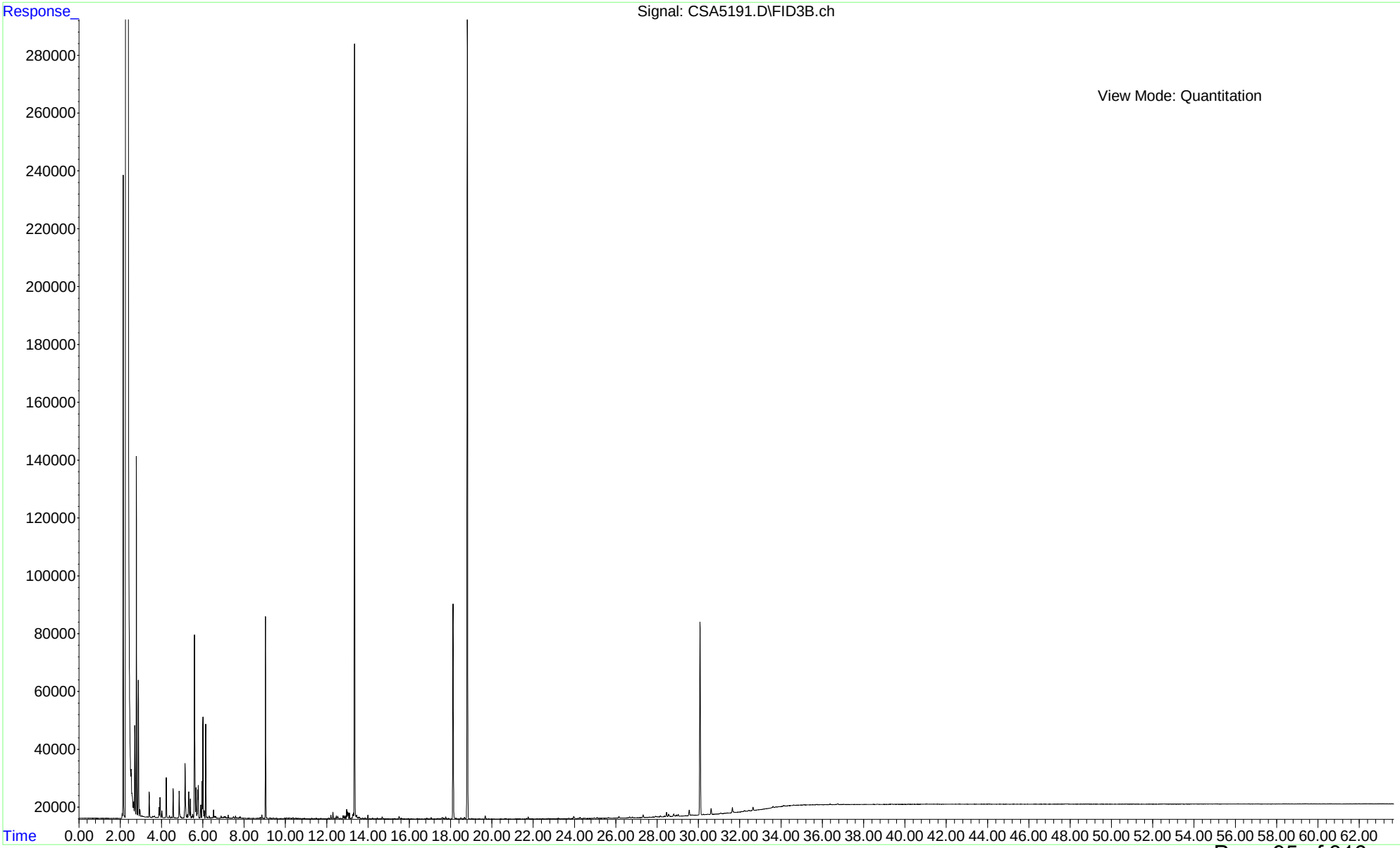

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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 00:23     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-8|sw_m|hc|01
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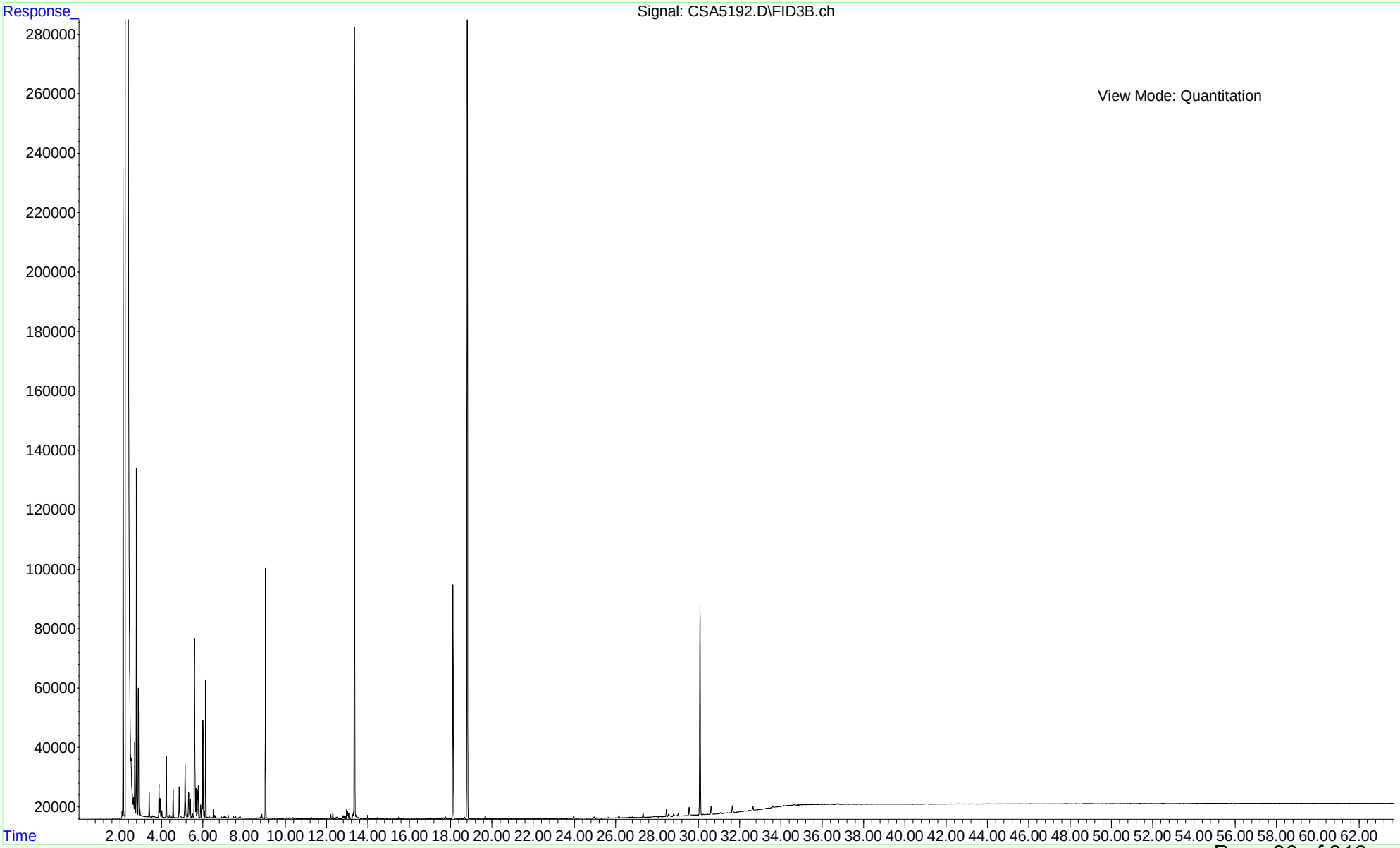

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Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 01:31     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-8|sw_m|hc|02
Misc Info  :
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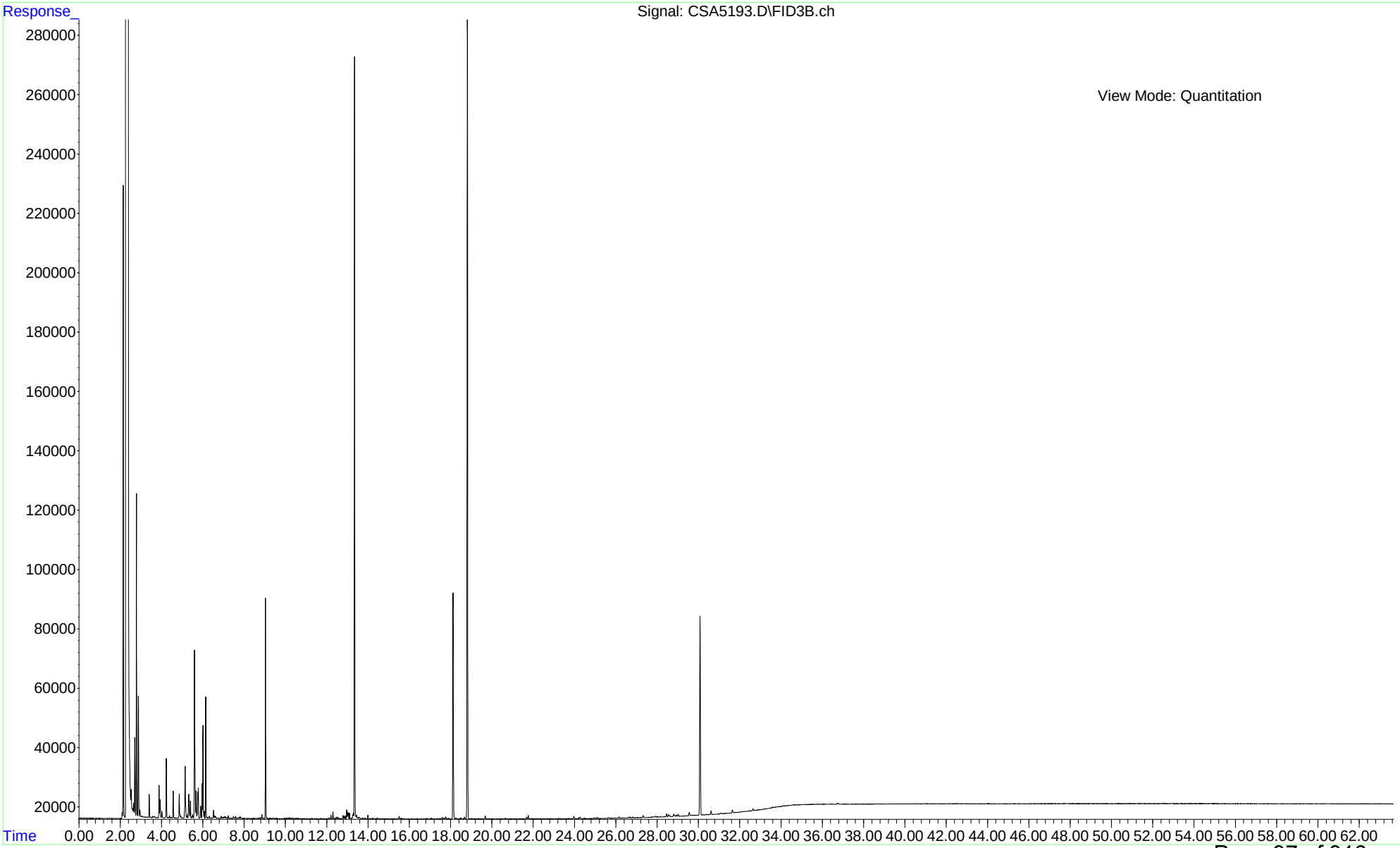

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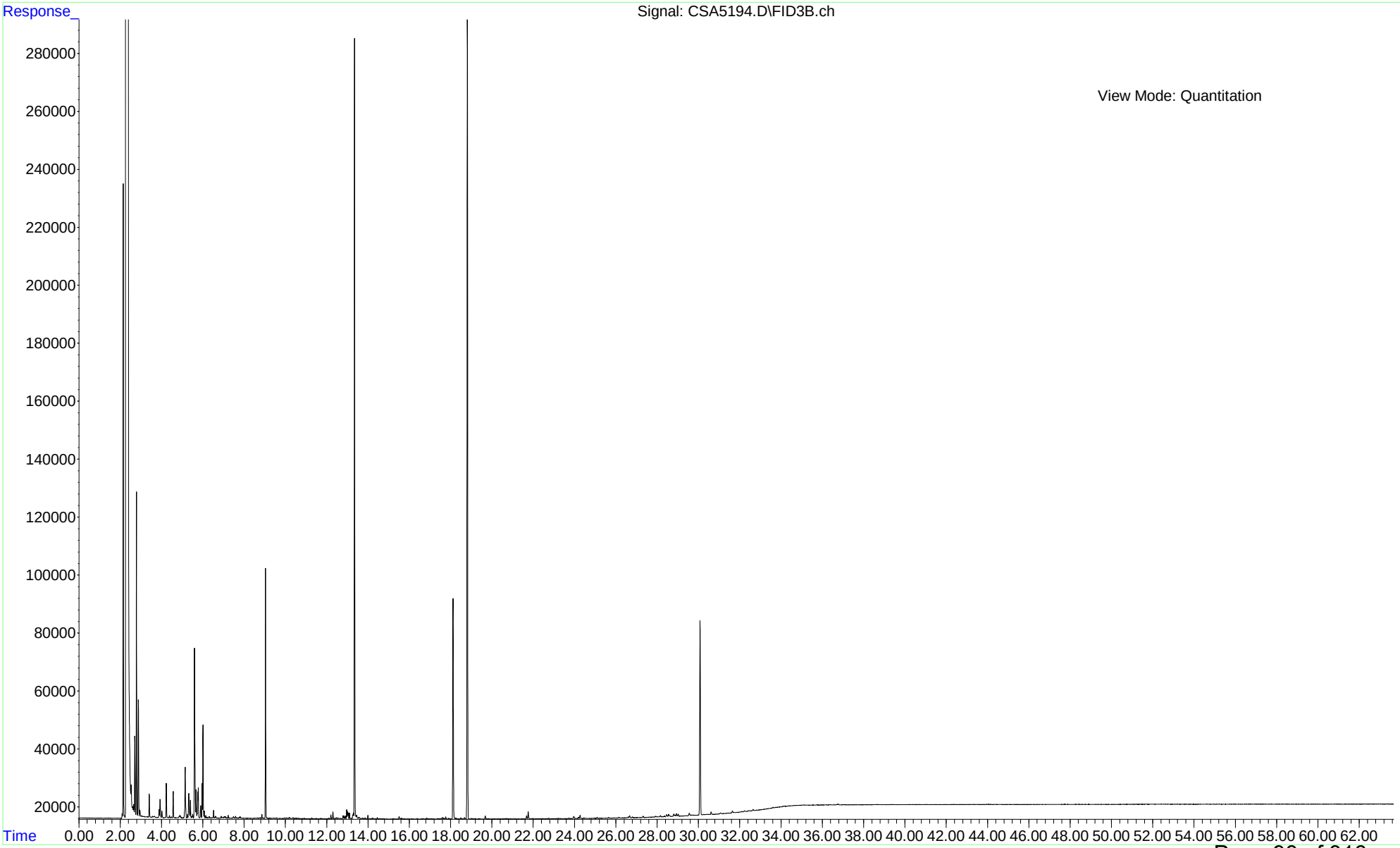
...         6-00.SC\CSA5194.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 03:46     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-8|sw_b|hc|01
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5195.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 04:54     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-8|sw_b|hc|02
Misc Info  :
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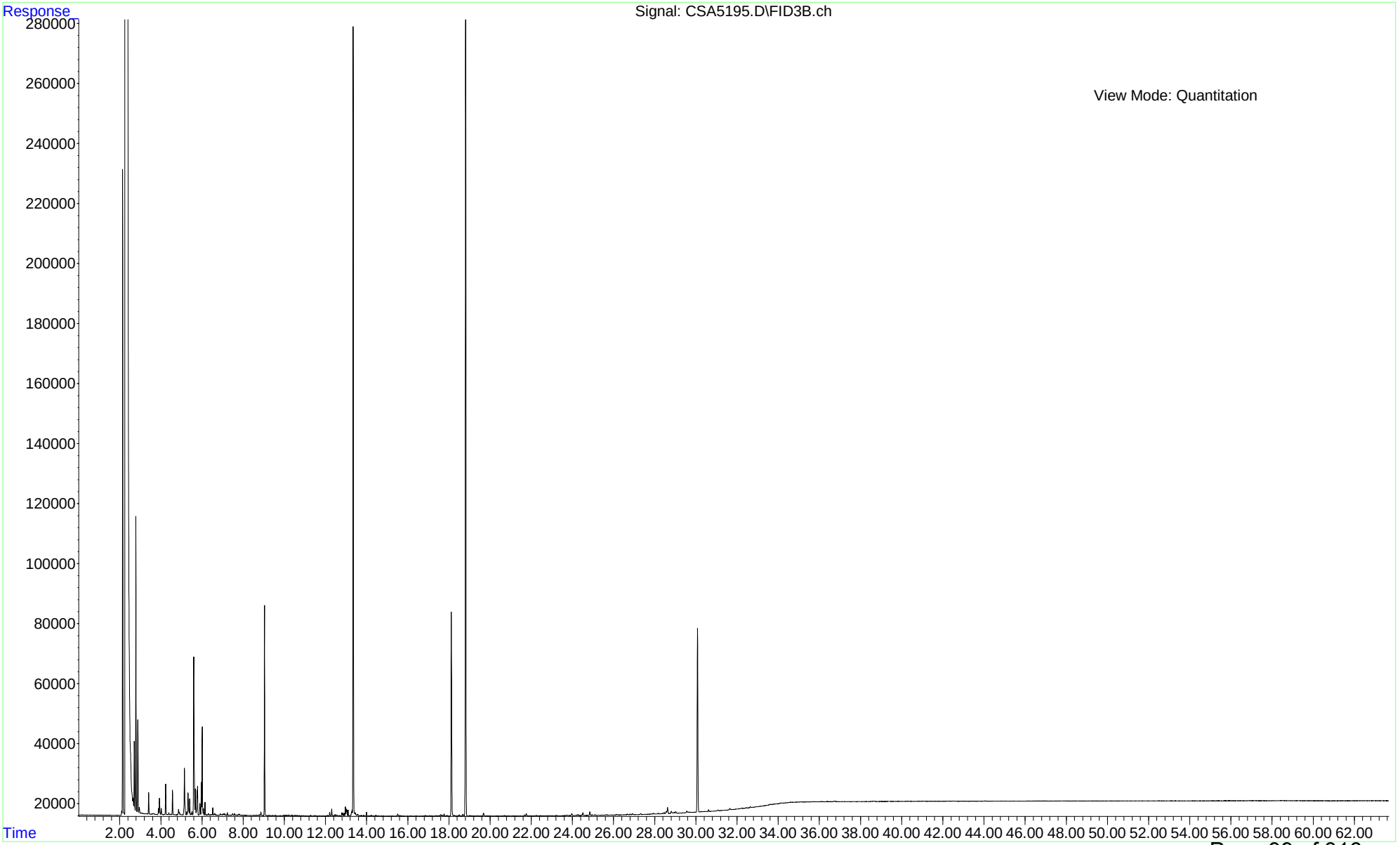
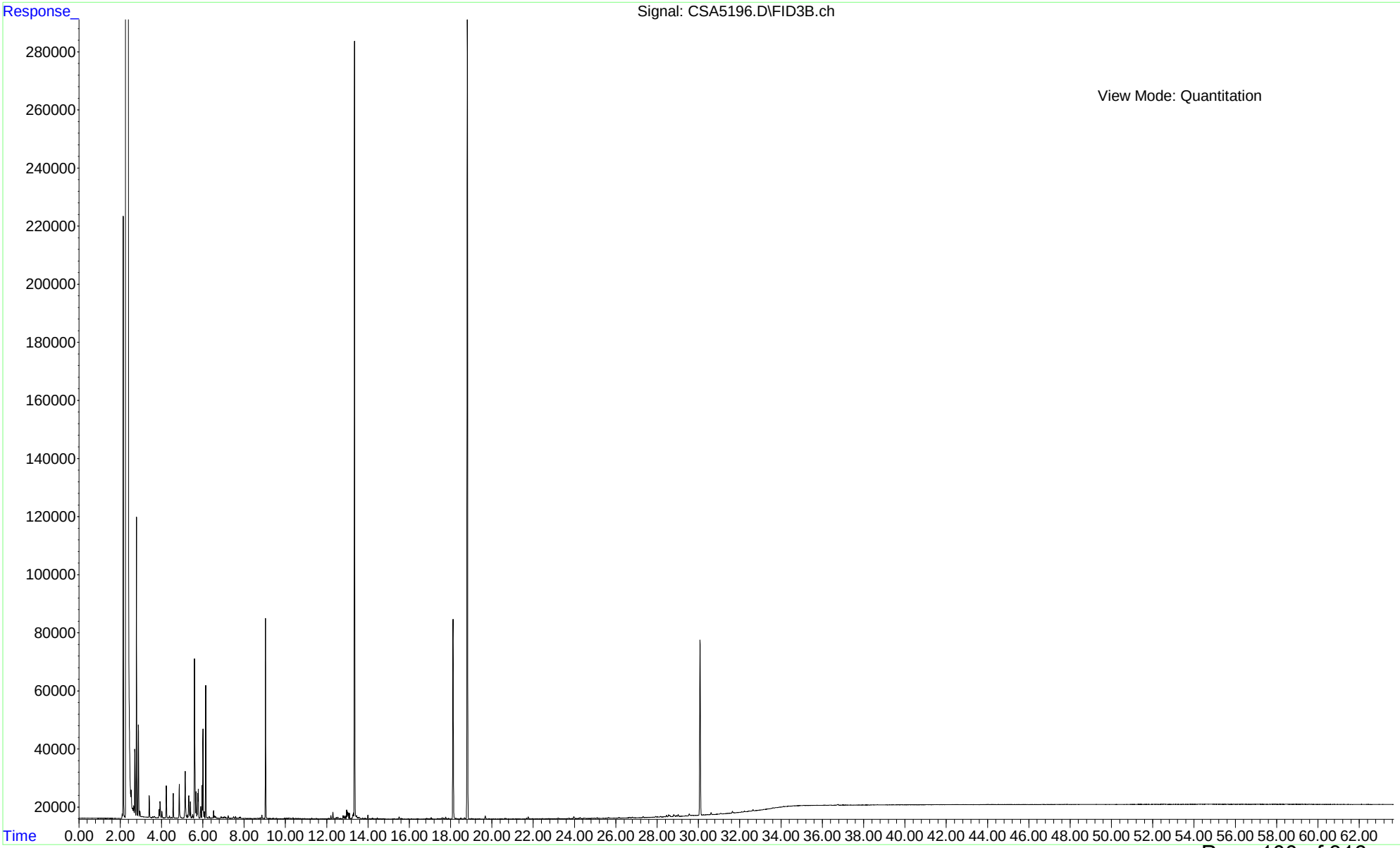


File :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
... 6-00.SC\CSA5196.D
Operator : Chase Brewster
Instrument : GCI
Acquired : 24-Mar-2020, 06:02 using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-4|sw_s|hc|01
Misc Info :



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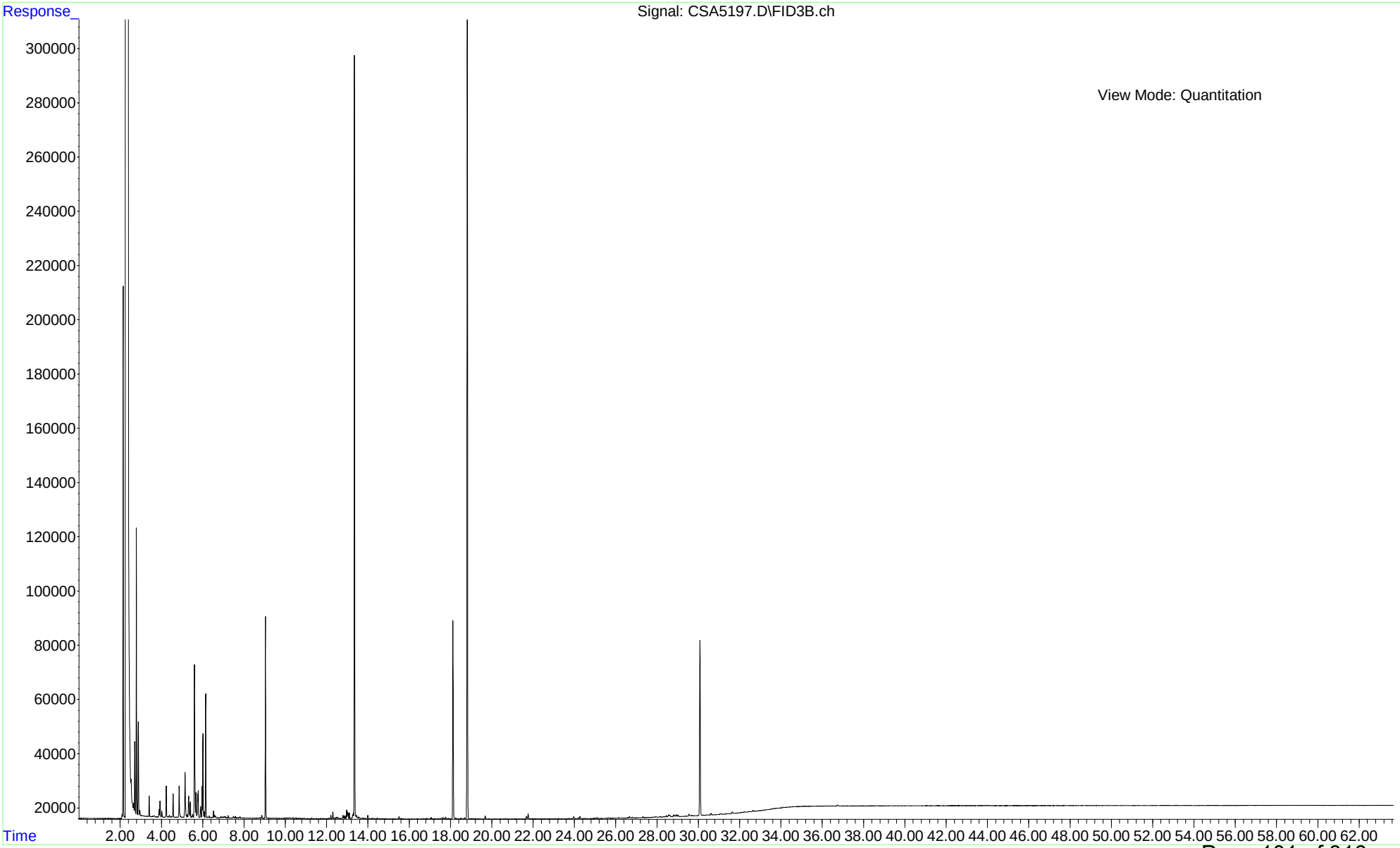
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5197.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 07:10     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-4|sw_s|hc|02
Misc Info  :
```



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File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5198.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 08:18     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-4|sw_m|hc|01
Misc Info  :
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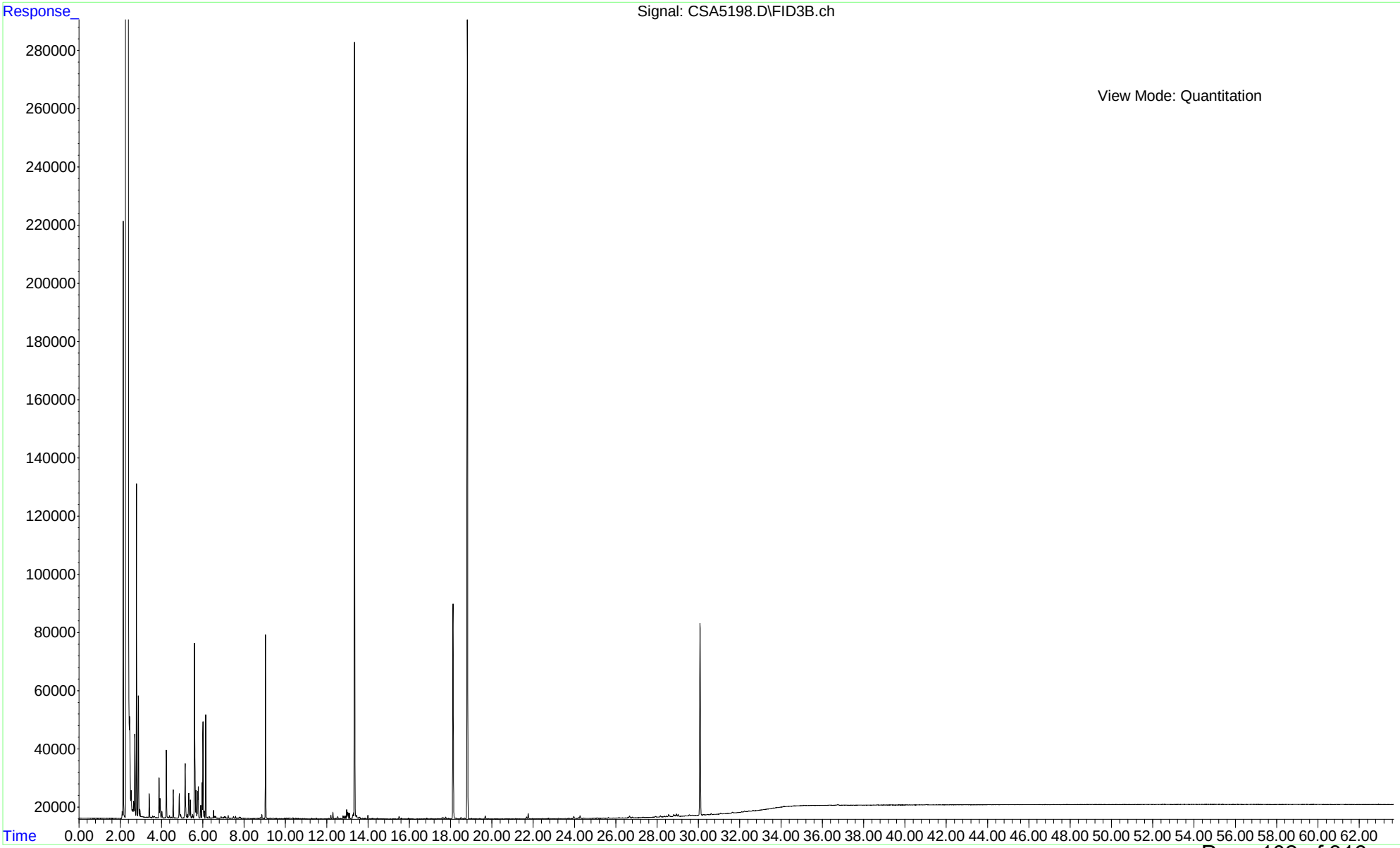
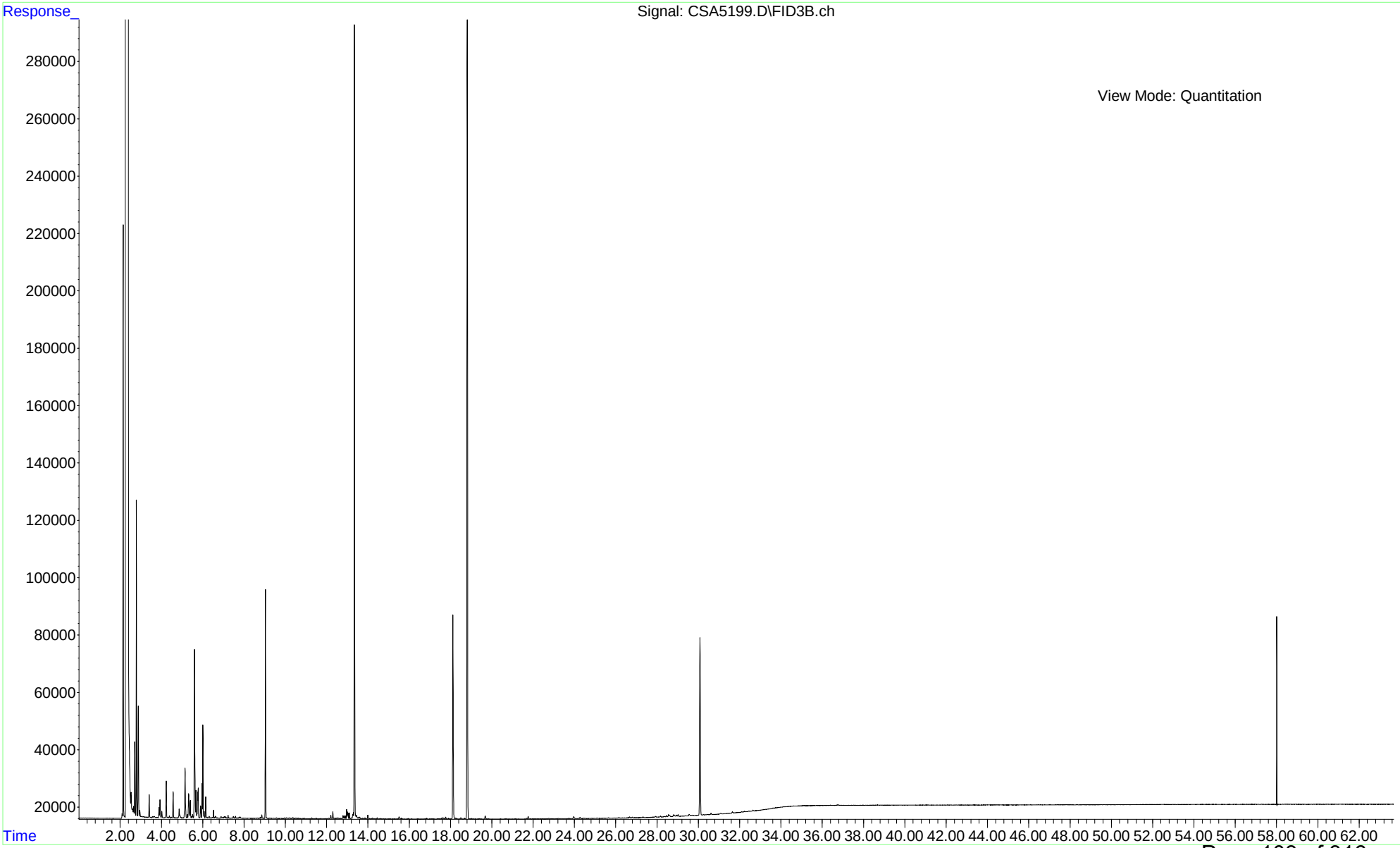
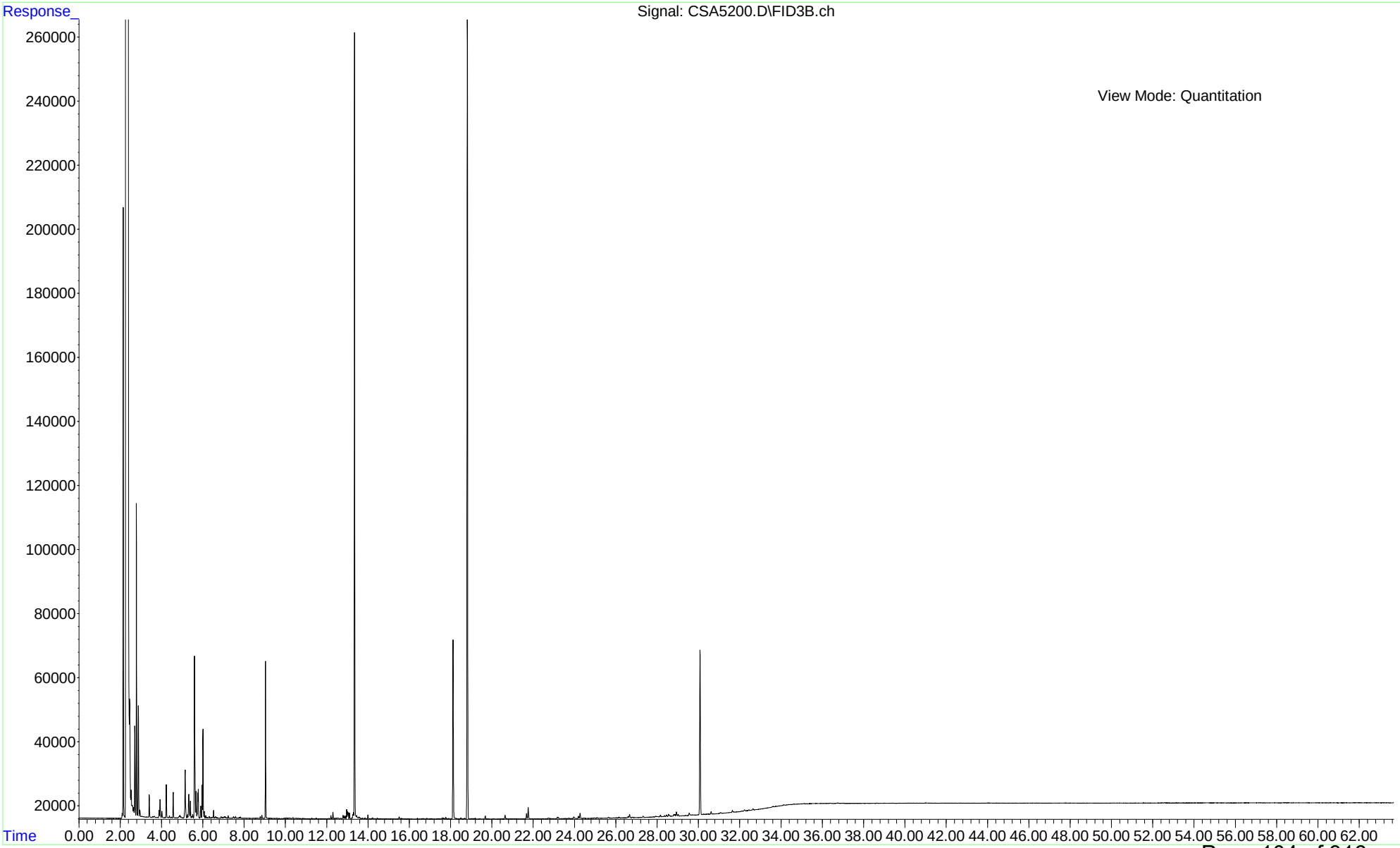


```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5199.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 09:26     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-4|sw_m|hc|02
Misc Info  :
```



File :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
... 6-00.SC\CSA5200.D
Operator : Chase Brewster
Instrument : GCI
Acquired : 24-Mar-2020, 10:34 using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-4|sw_b|hc|01
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5201.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 11:42     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-4|sw_b|hc|02
Misc Info  :
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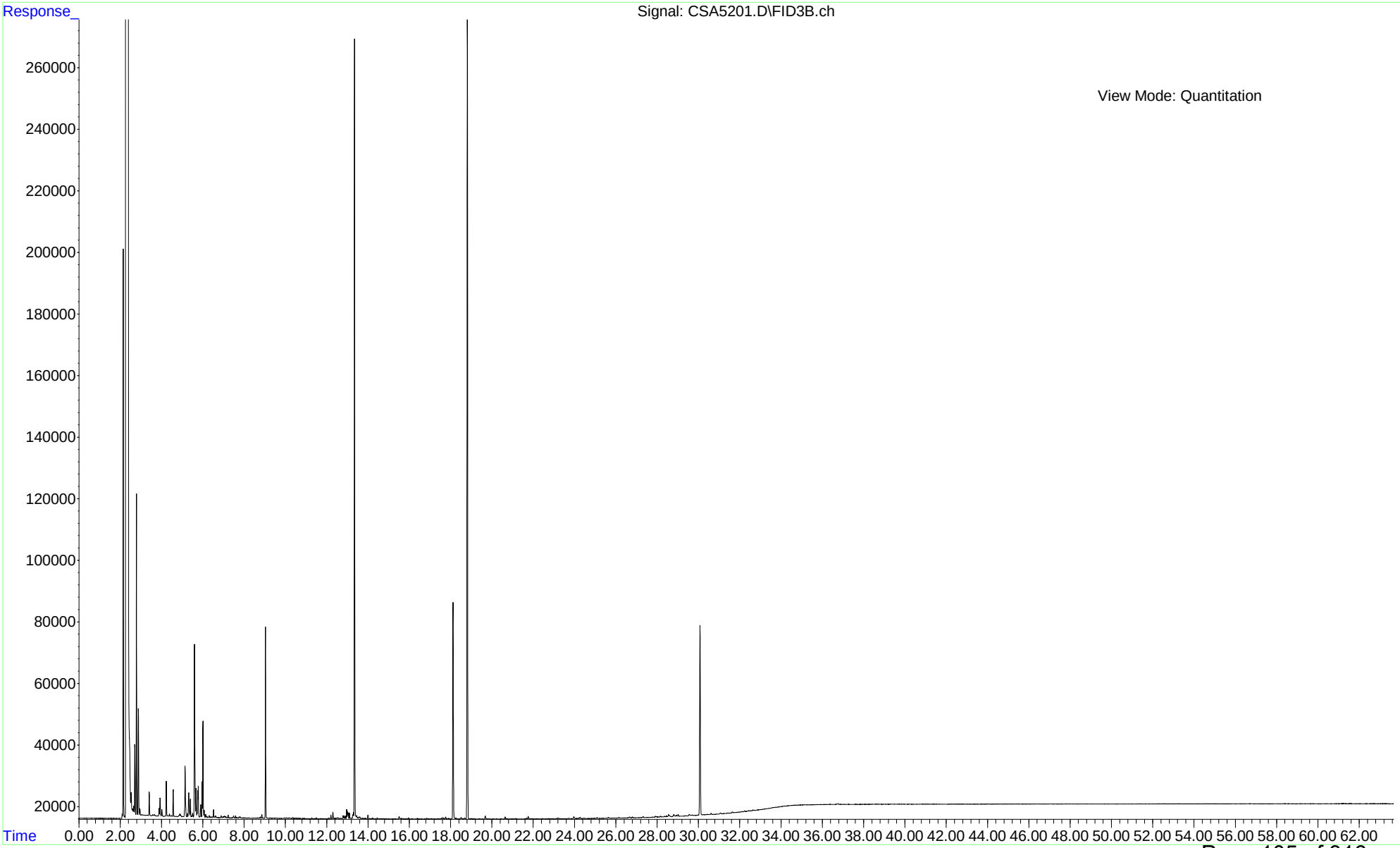

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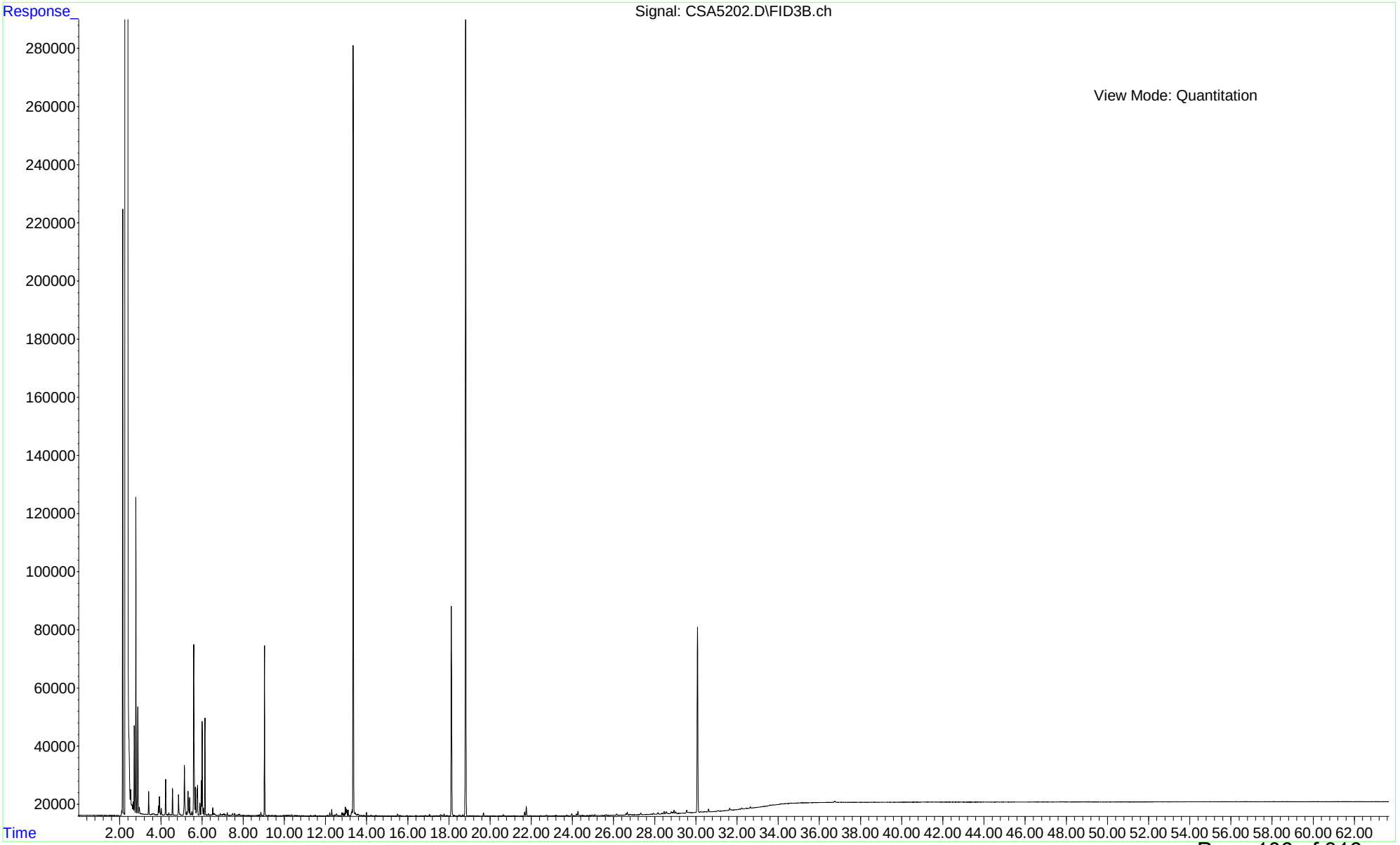
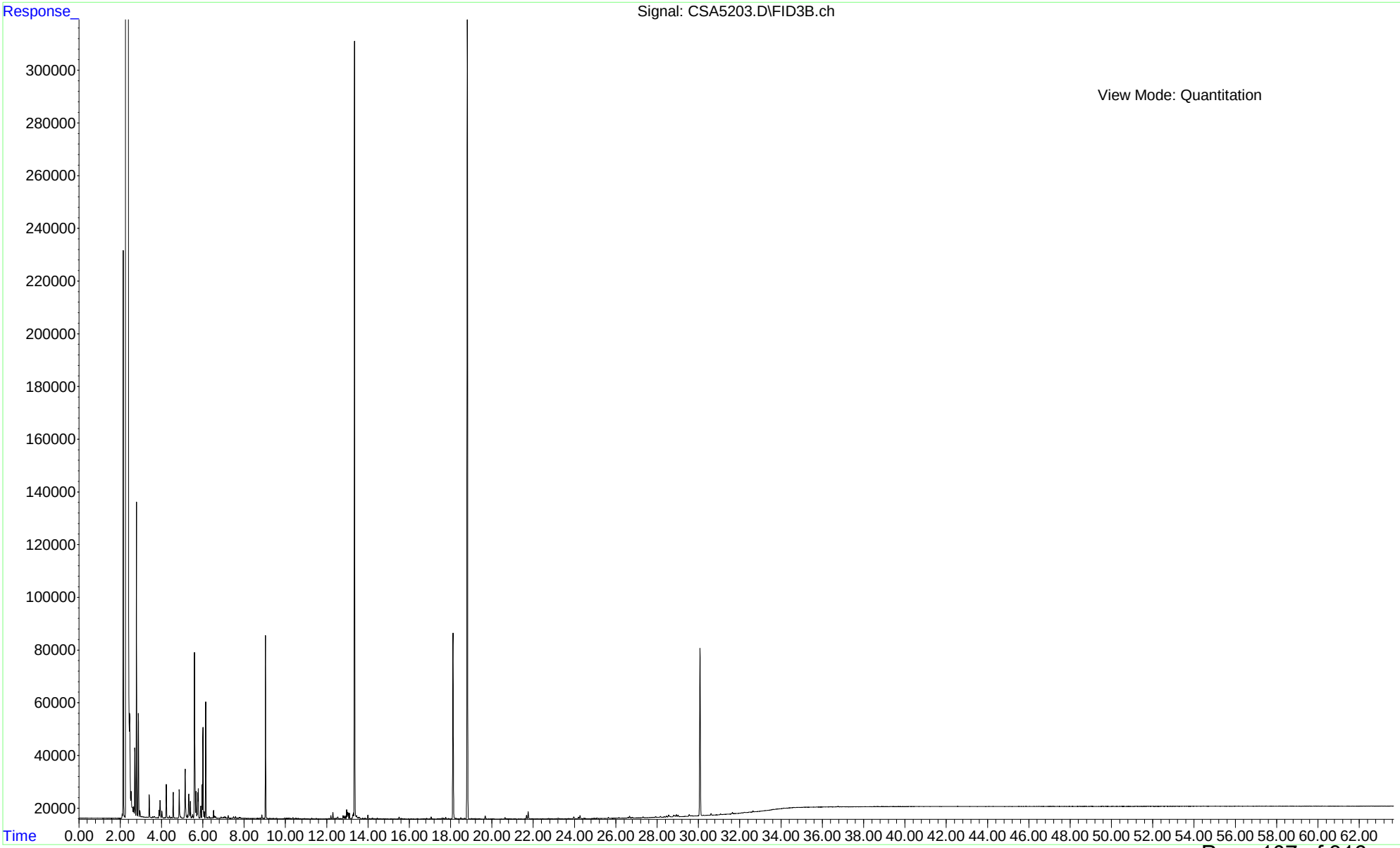
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5202.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 12:50     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-6|sw_s|hc|01
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5203.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 15:06     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-6|sw_s|hc|02
Misc Info  :
```



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File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5204.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 16:14     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-6|sw_m|hc|01
Misc Info  :
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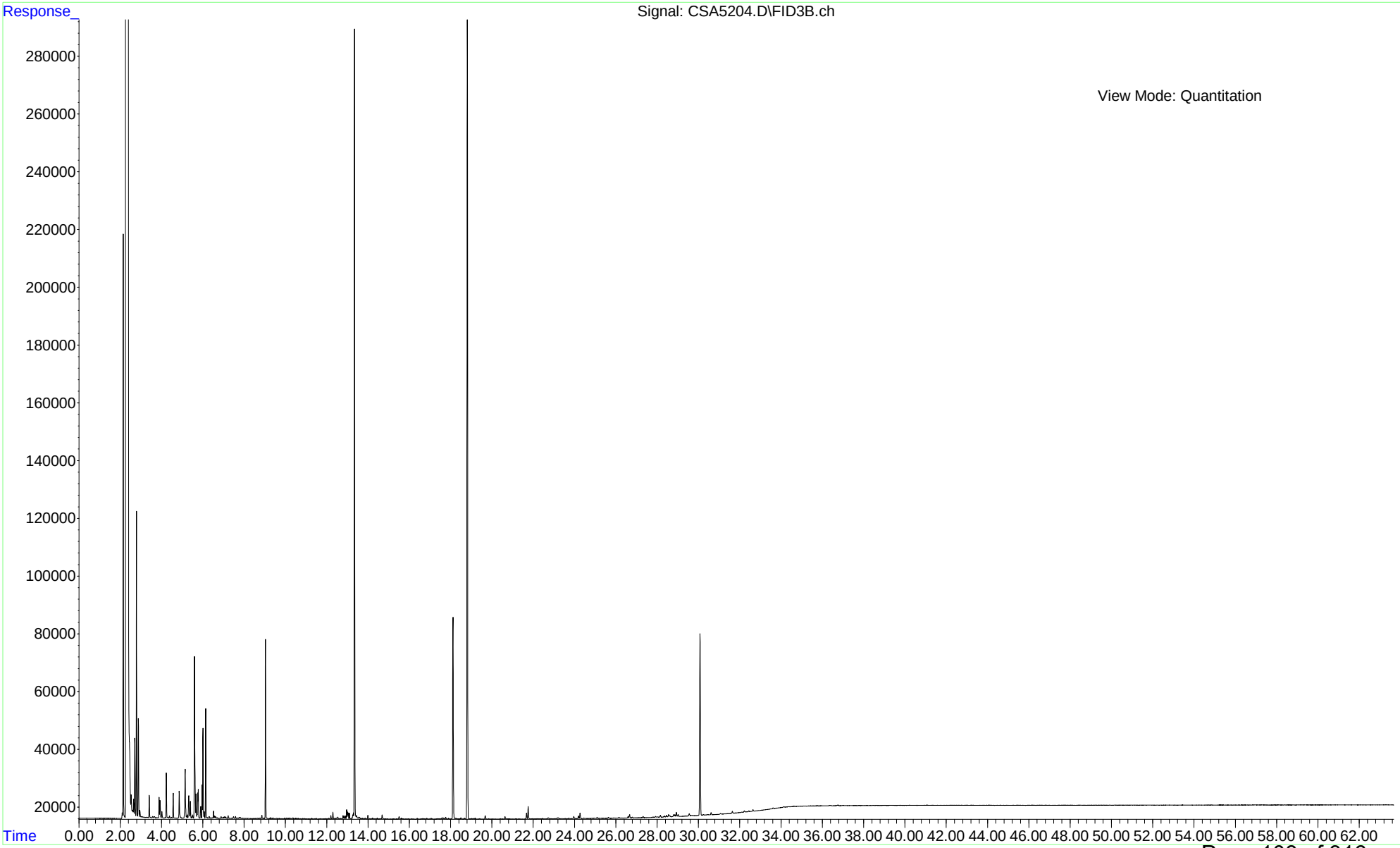
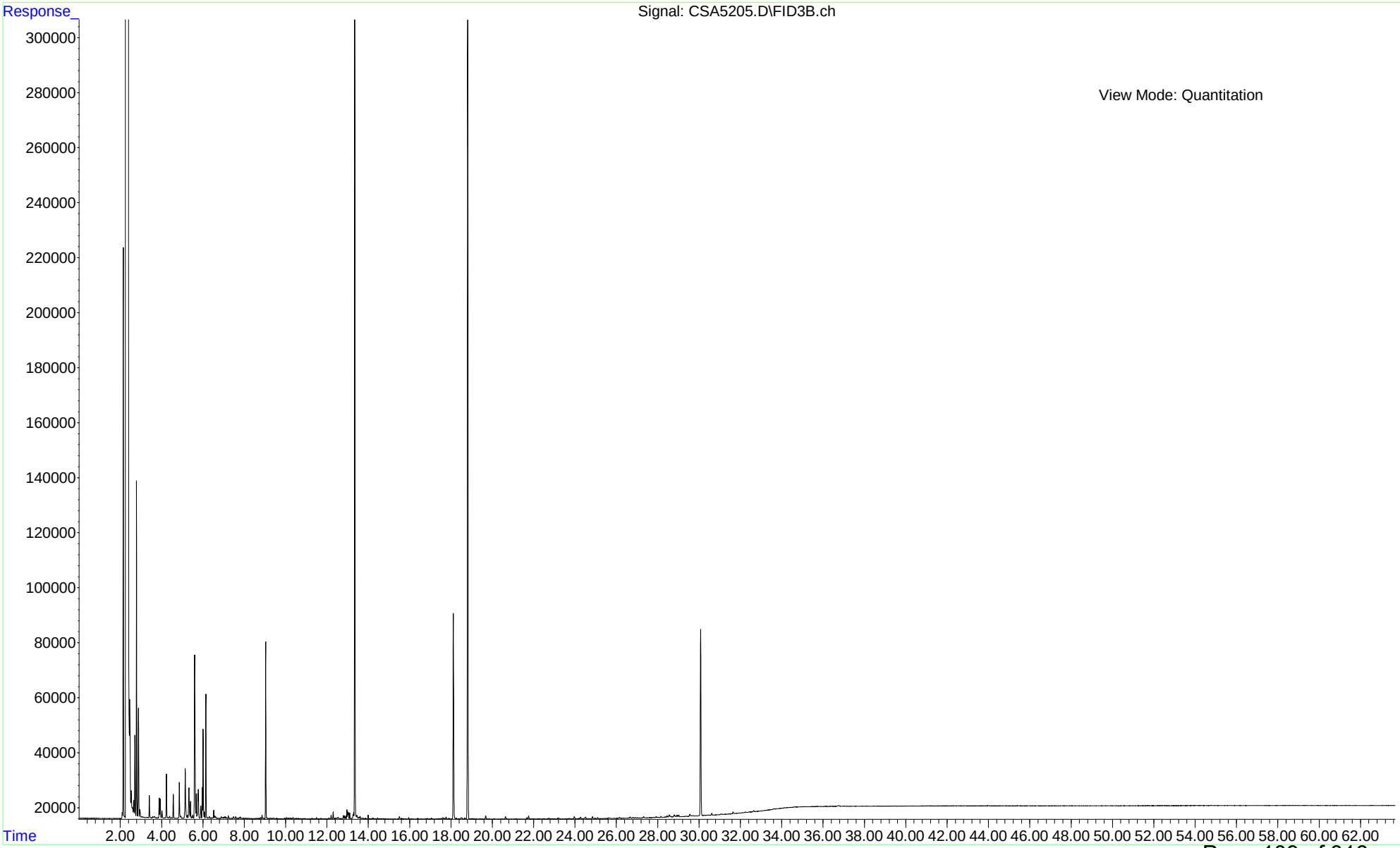


```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5205.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 17:22     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-6|sw_m|hc|02
Misc Info  :
```



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File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5206.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 18:29     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-6|sw_b|hc|01
Misc Info  :
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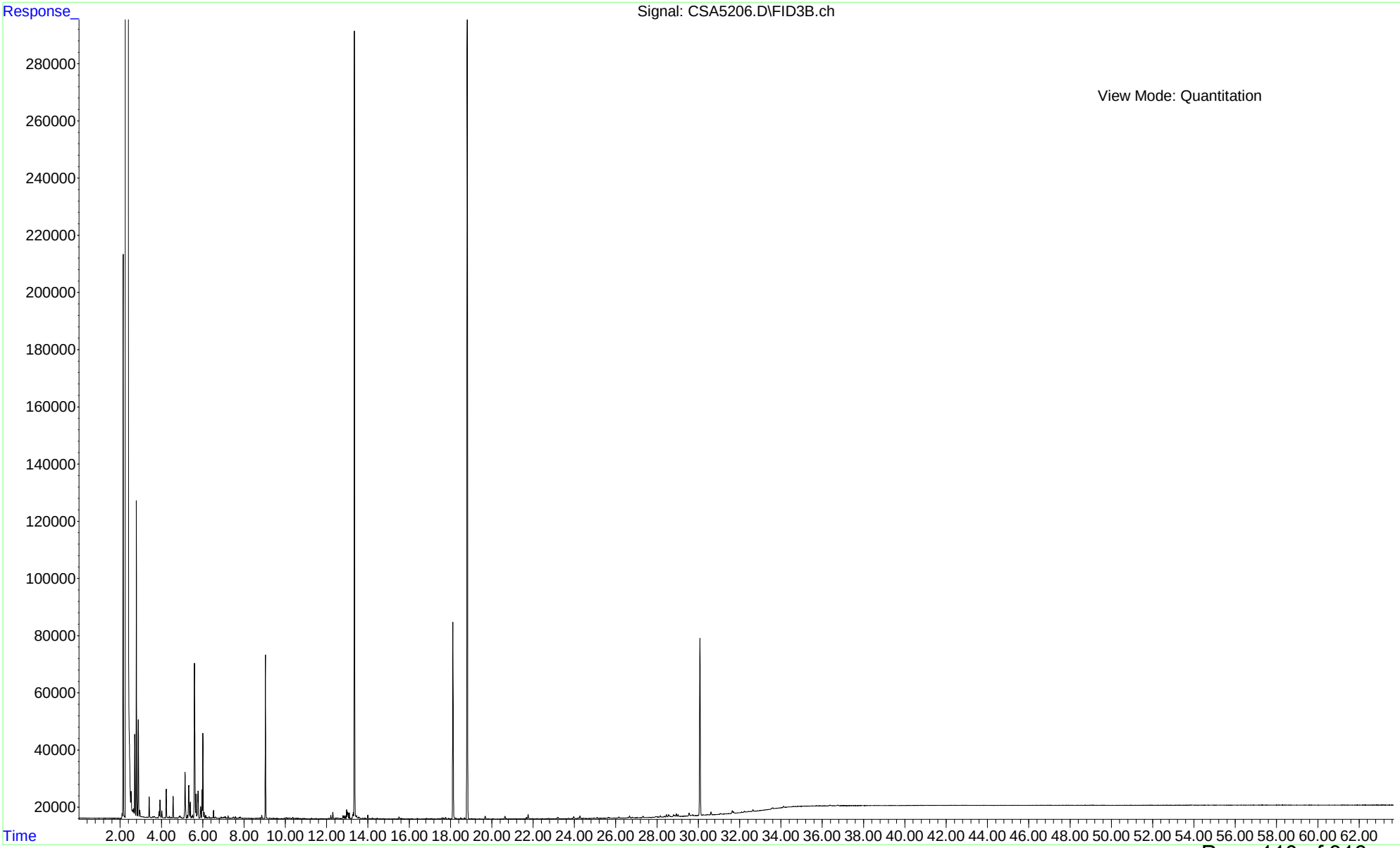

```
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5207.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 19:37     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-6|sw_b|hc|02
Misc Info  :
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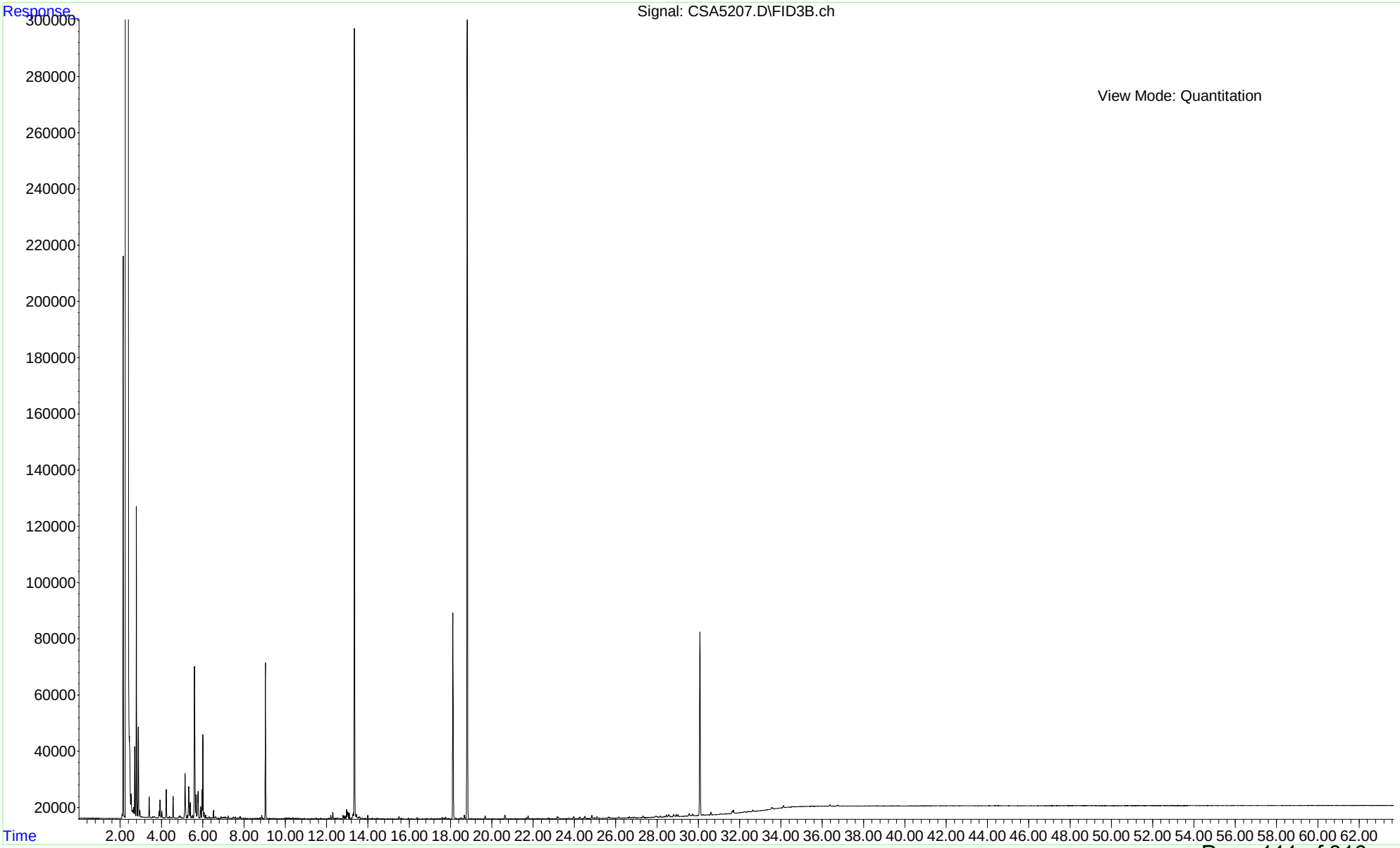
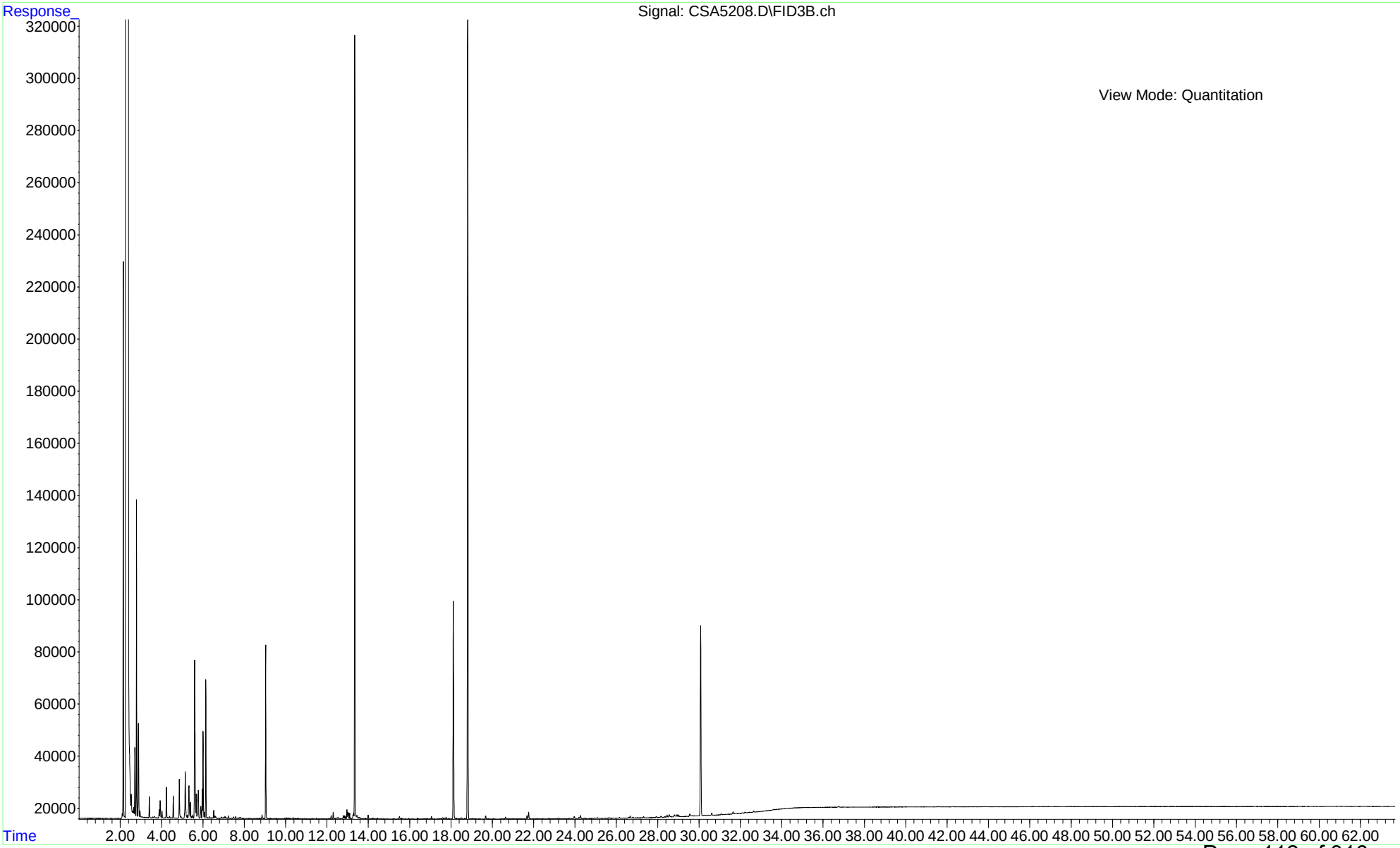


File :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
... 6-00.SC\CSA5208.D
Operator : Chase Brewster
Instrument : GCI
Acquired : 24-Mar-2020, 20:45 using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-1|sw_s|hc|01
Misc Info :



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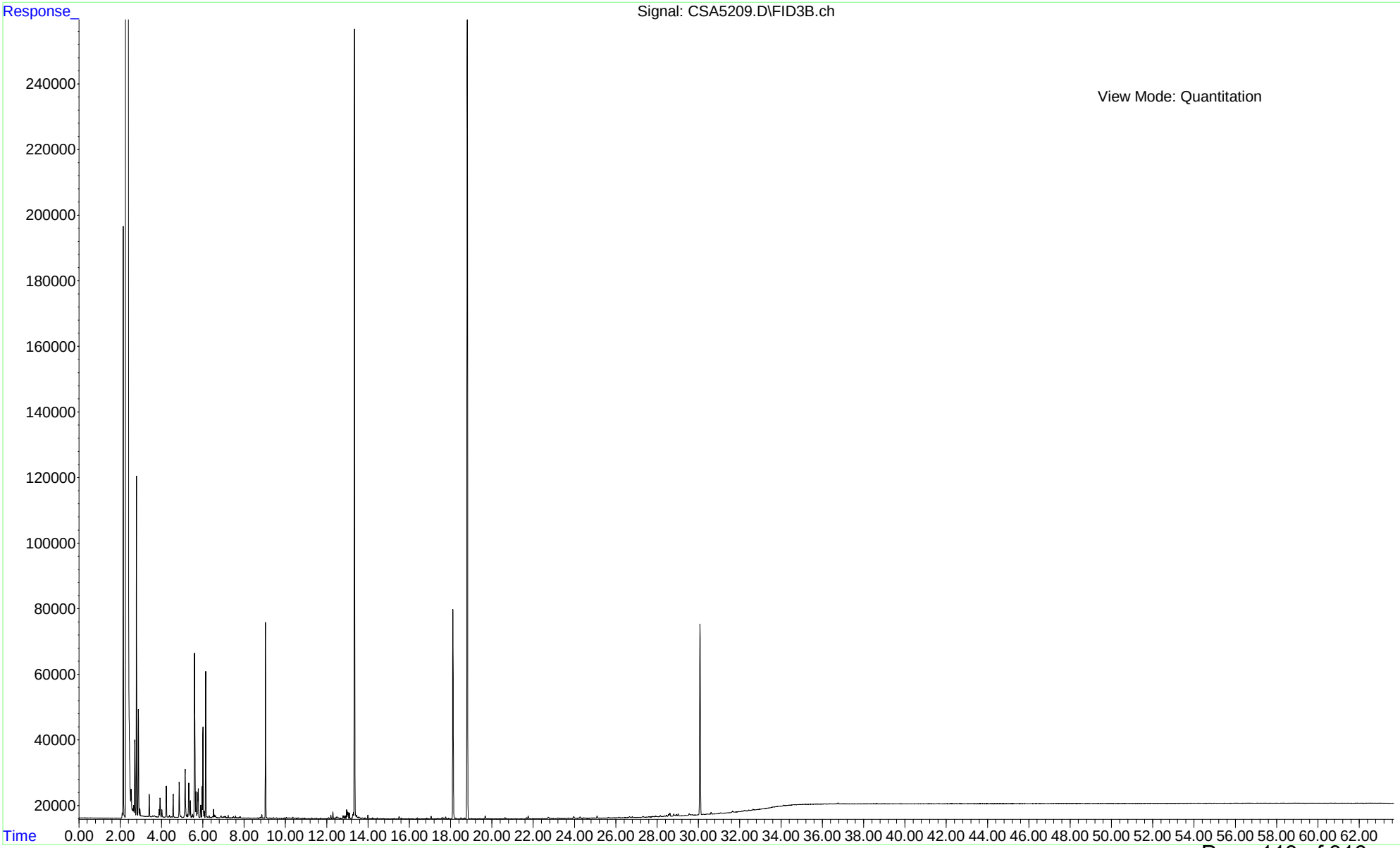
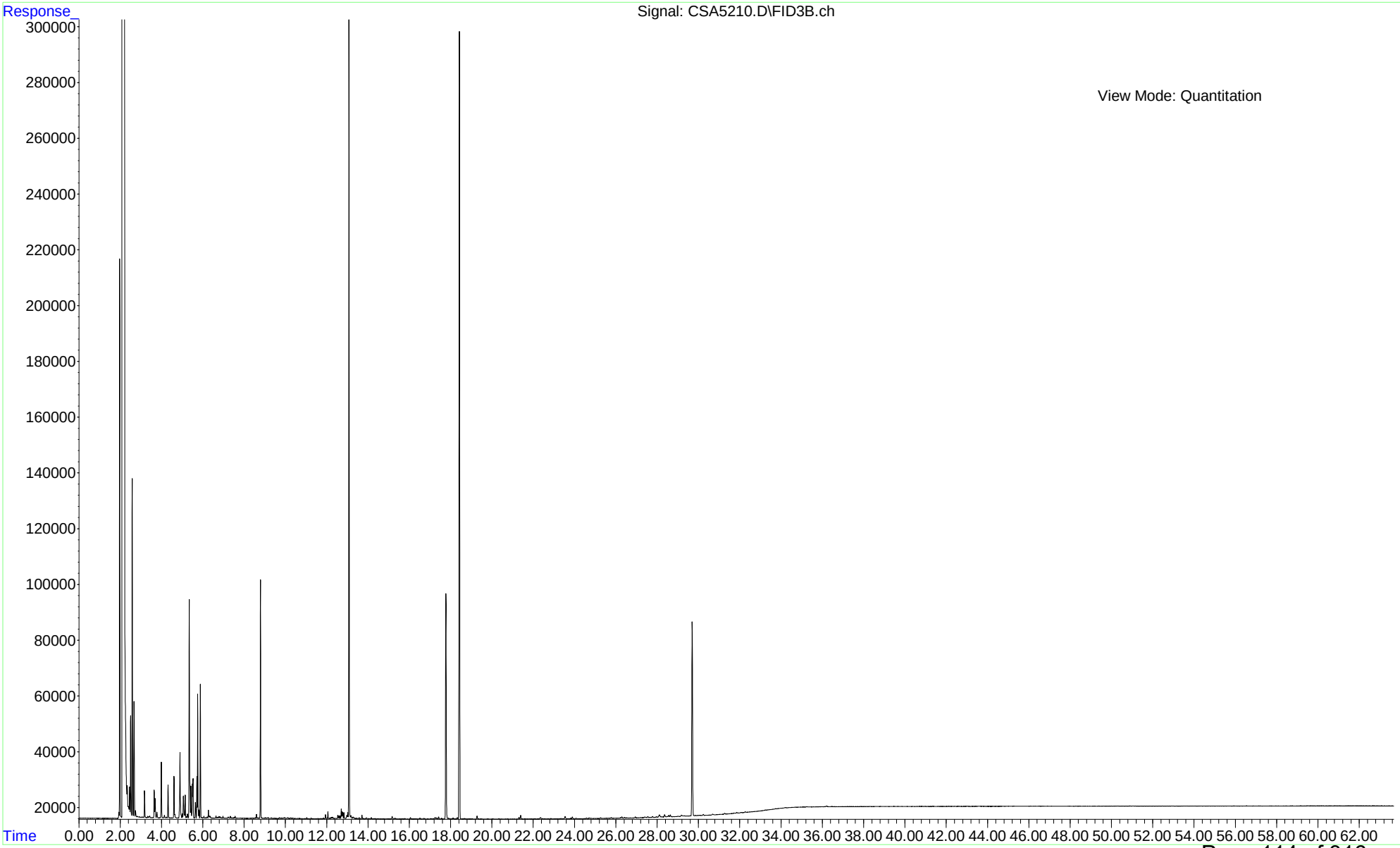
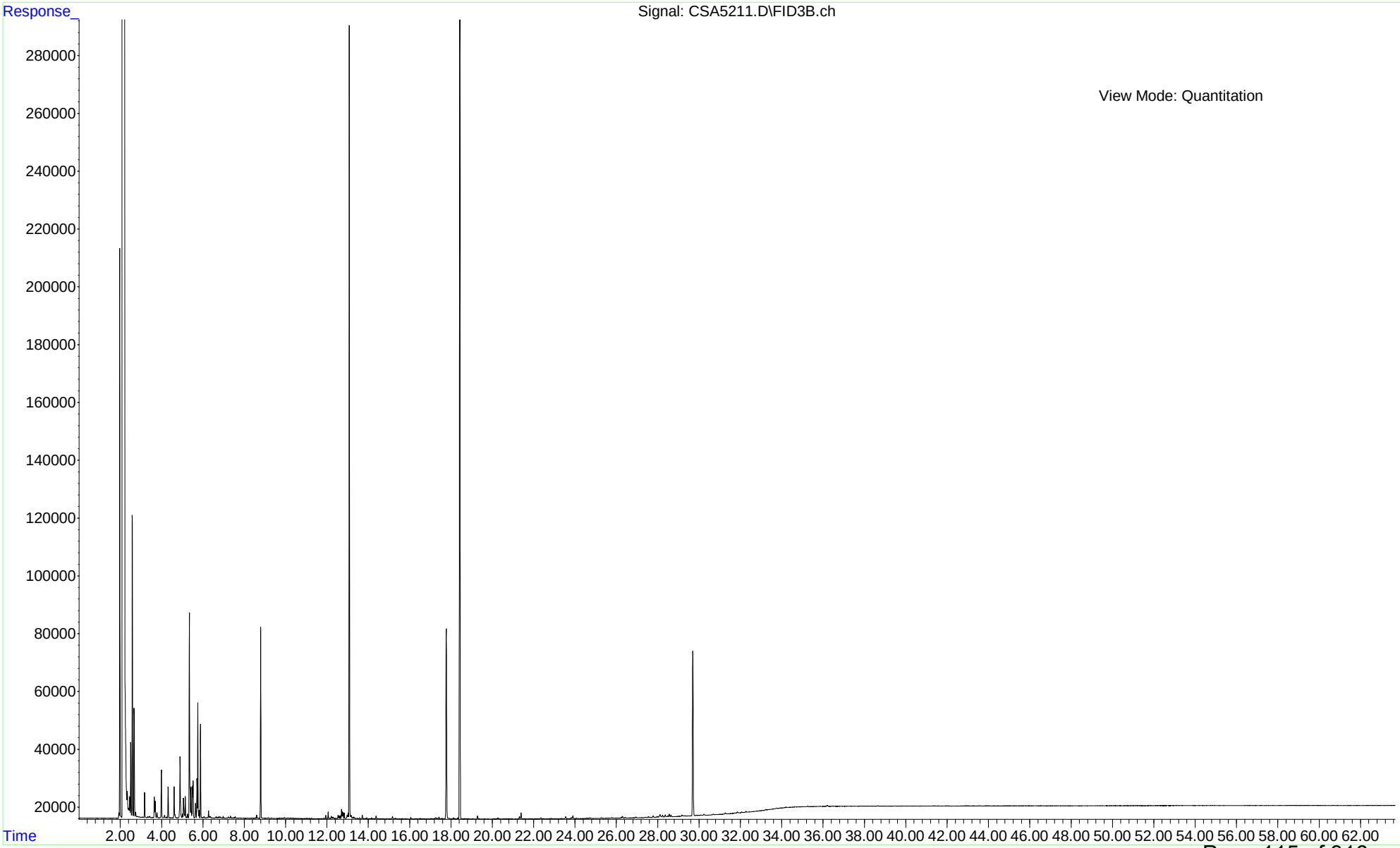
File       :P:\2020\J20453 CSA 3532\ALI\ENV4073\FID60115 2020-03-23 10-4
...         6-00.SC\CSA5209.D
Operator   : Chase Brewster
Instrument :   GCI
Acquired   : 24-Mar-2020, 21:53     using AcqMethod ALIBACK.M
Sample Name: 3532|03_20|HH-1|sw_s|hc|02
Misc Info  :
```



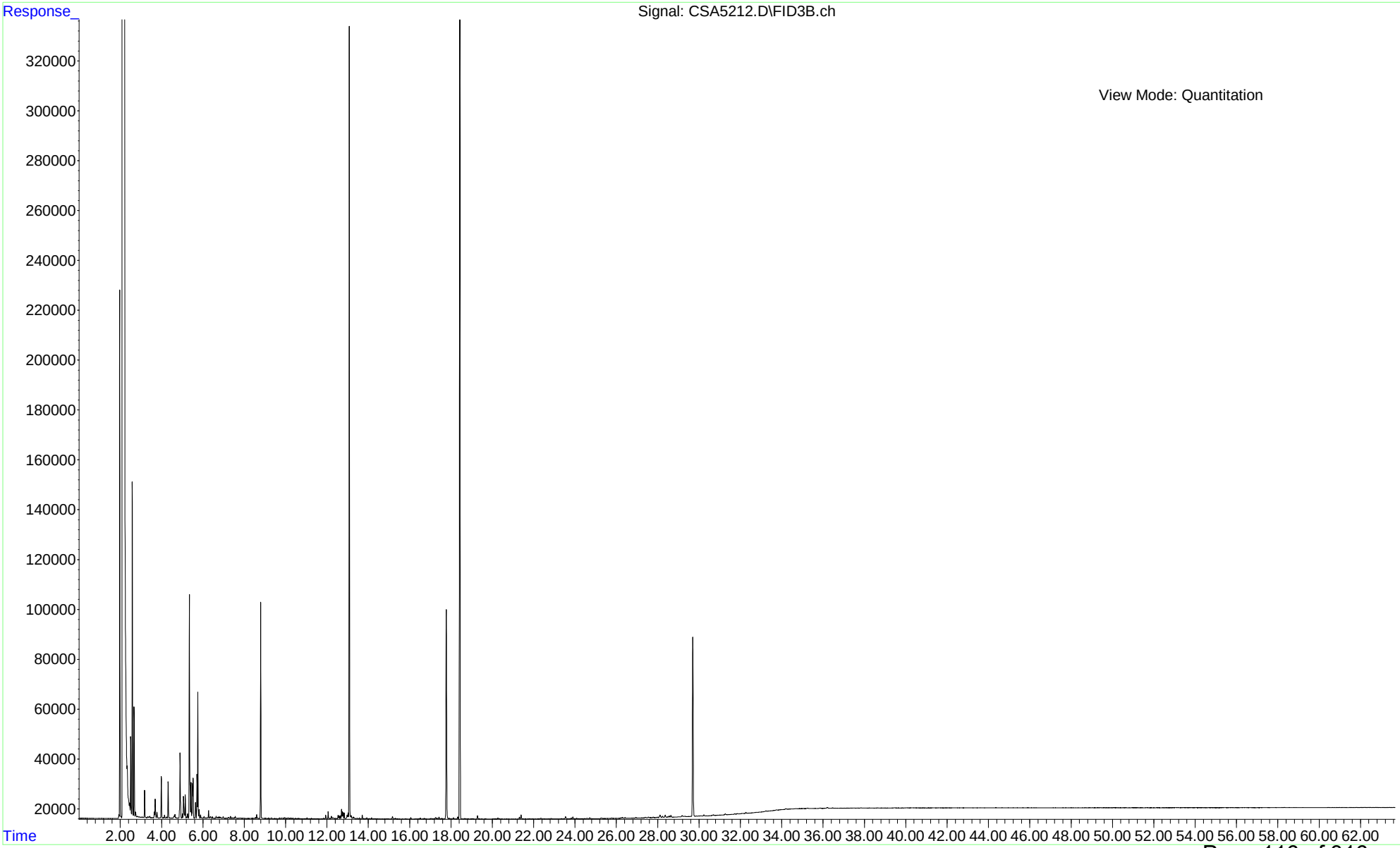
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5210.D
Operator : Chase Brewster
Acquired : 25-Mar-2020, 21:38 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-1|sw_m|hc|01
Misc Info :
Vial Number: 58



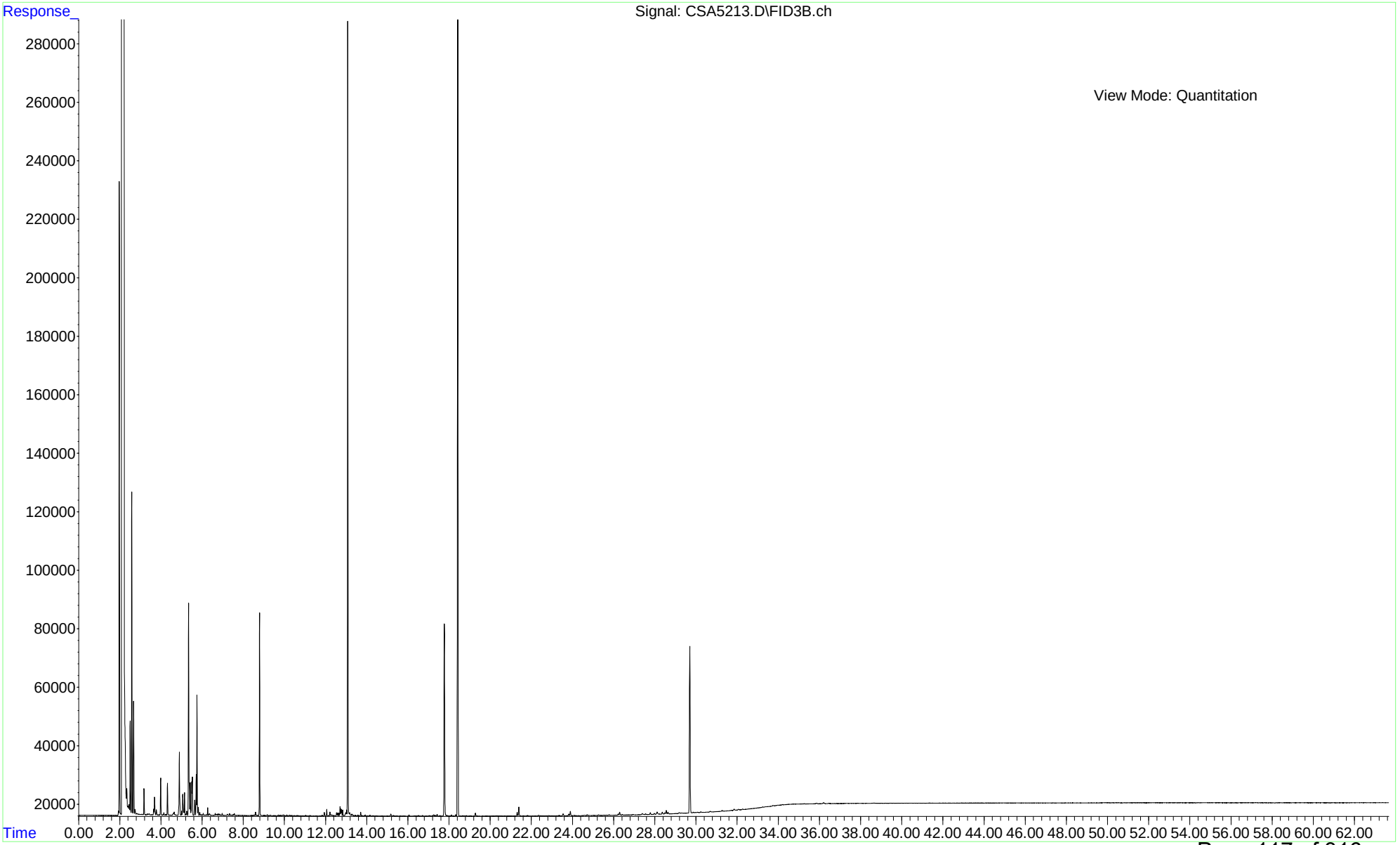
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5211.D
Operator : Chase Brewster
Acquired : 25-Mar-2020, 22:47 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-1|sw_m|hc|02
Misc Info :
Vial Number: 59



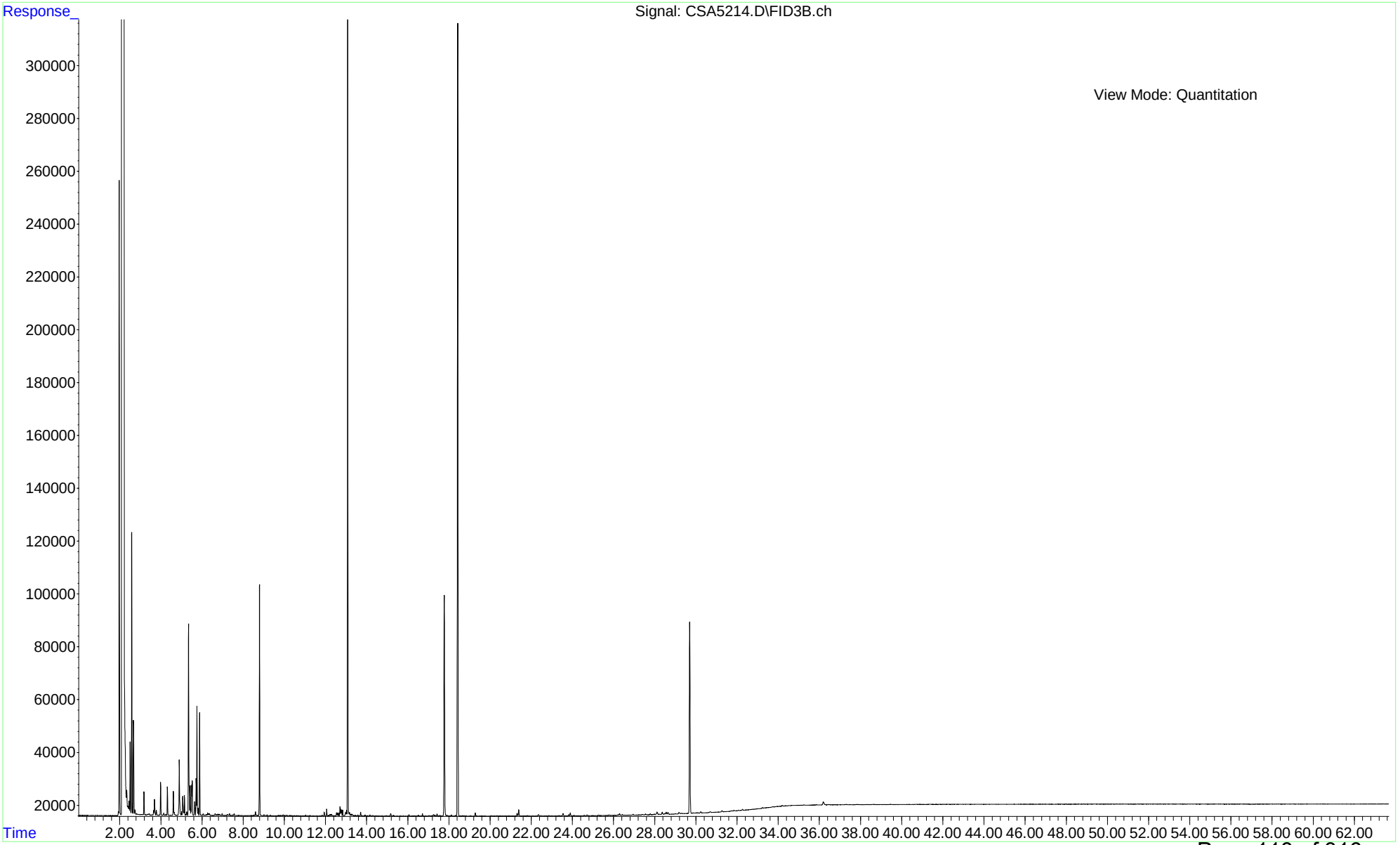
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5212.D
Operator : Chase Brewster
Acquired : 25-Mar-2020, 23:55 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-1|sw_b|hc|01
Misc Info :
Vial Number: 60



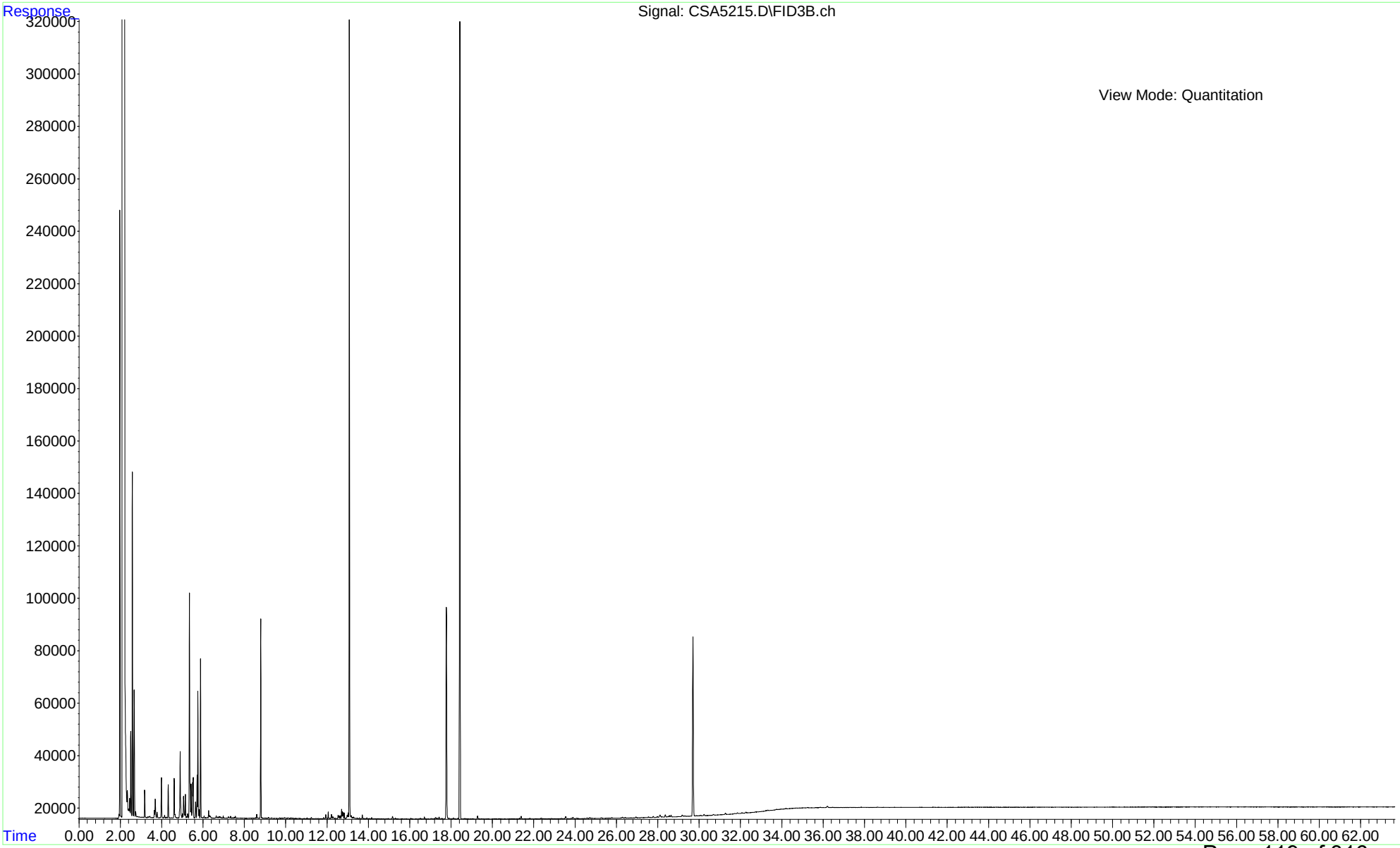
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5213.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 01:04 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-1|sw_b|hc|02
Misc Info :
Vial Number: 61



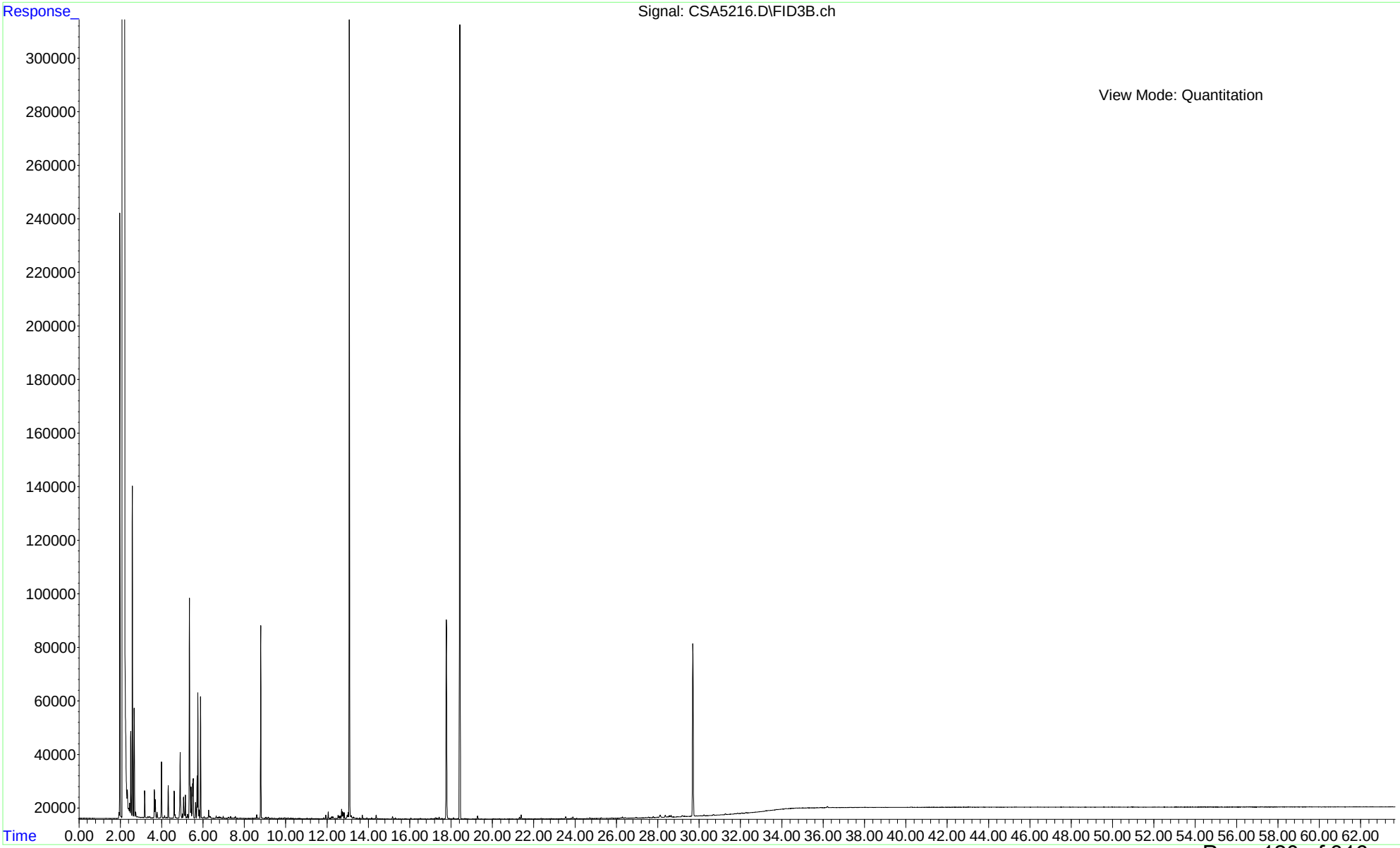
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5214.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 03:20 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-2|sw_s|hc|01
Misc Info :
Vial Number: 63



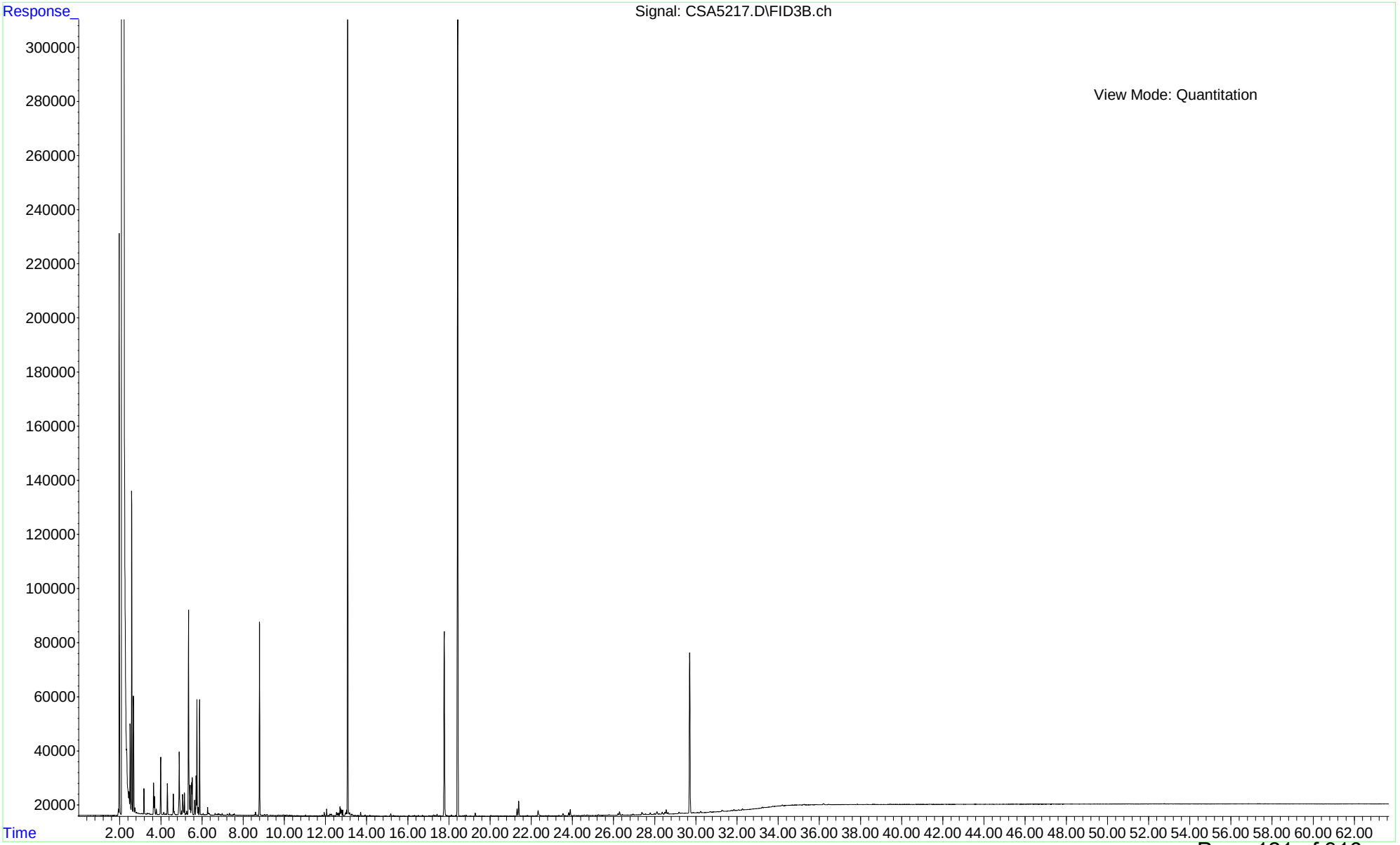
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5215.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 04:29 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-2|sw_s|hc|02
Misc Info :
Vial Number: 64



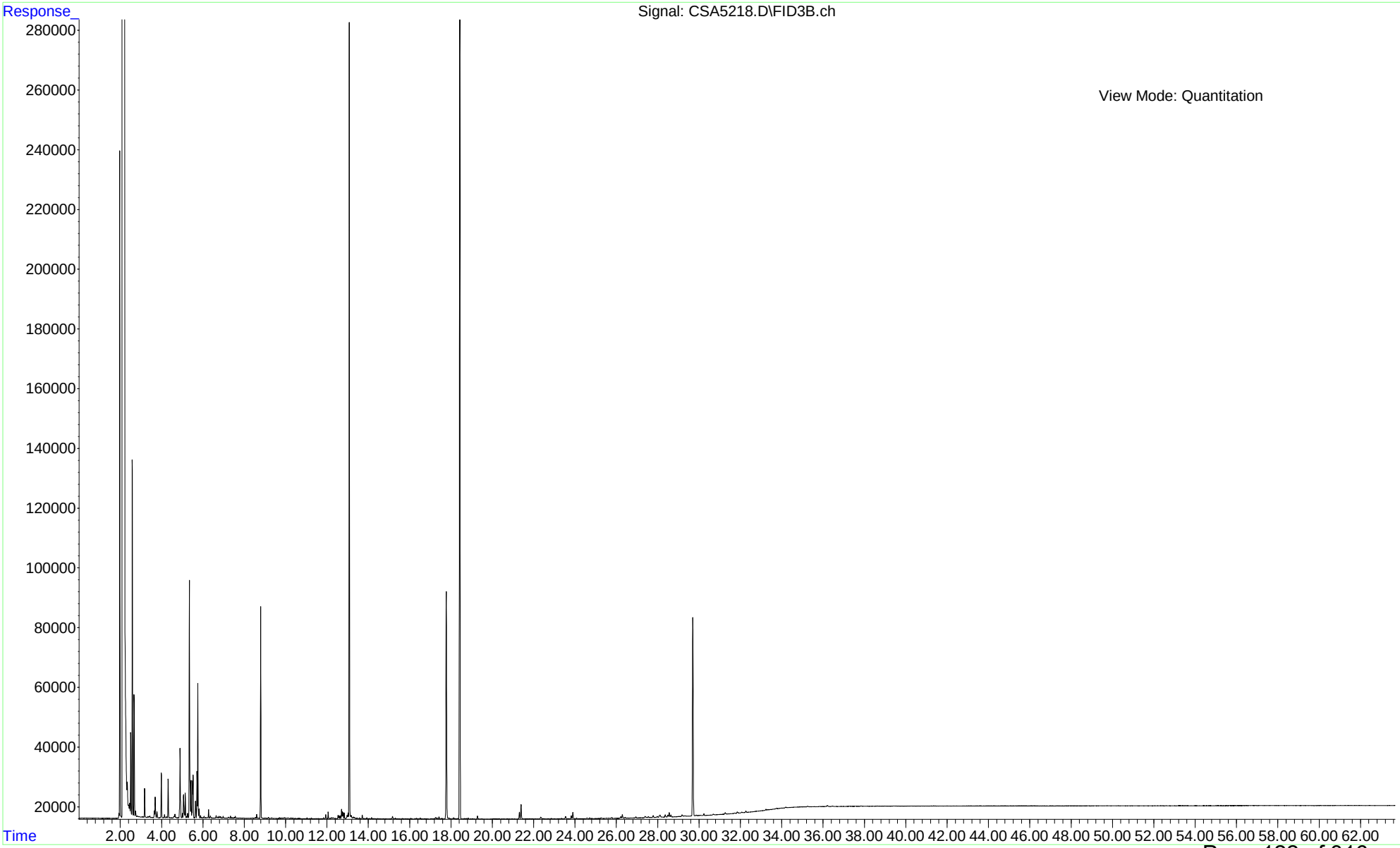
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5216.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 05:37 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-2|sw_m|hc|01
Misc Info :
Vial Number: 65



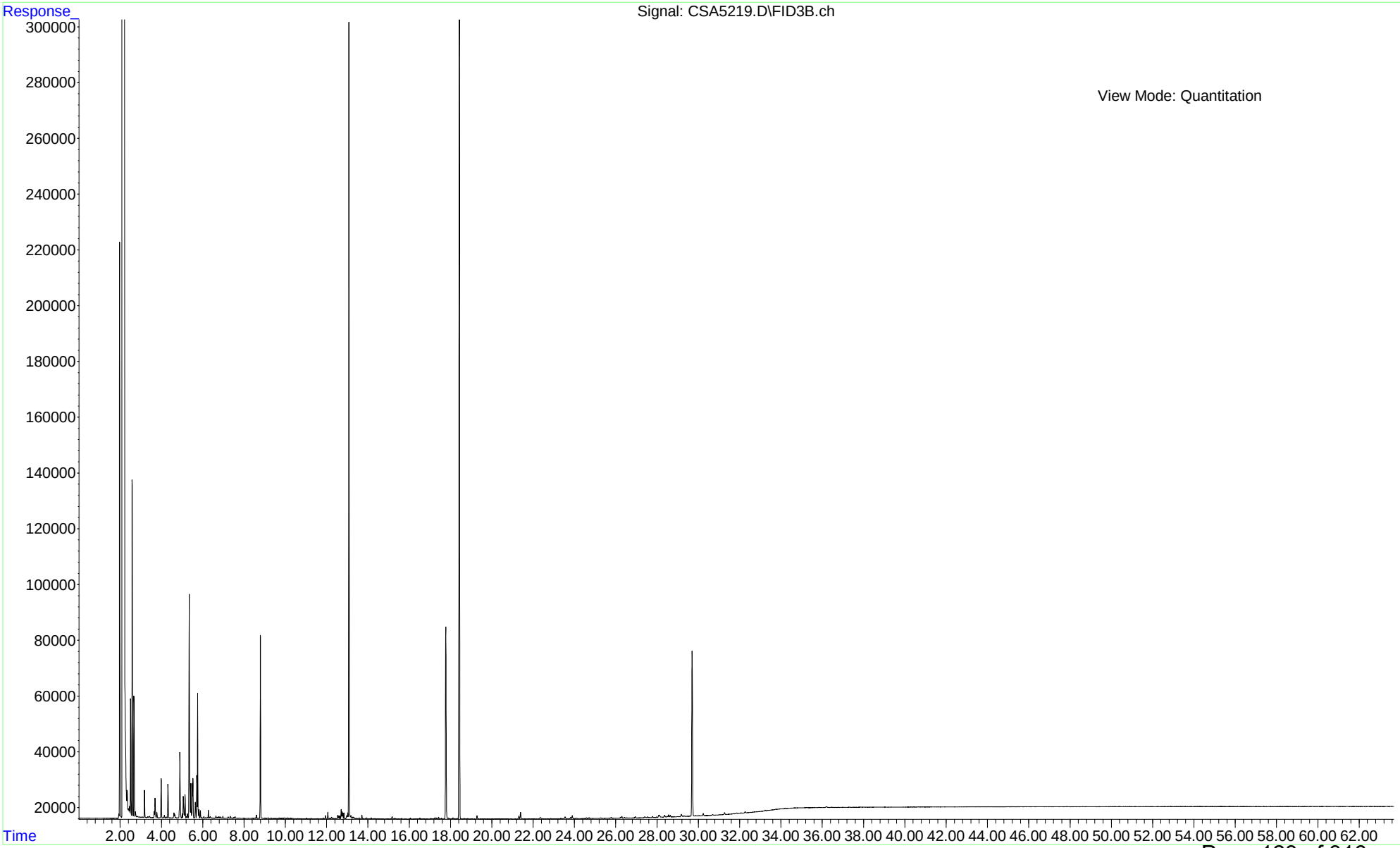
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5217.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 06:45 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-2|sw_m|hc|02
Misc Info :
Vial Number: 66



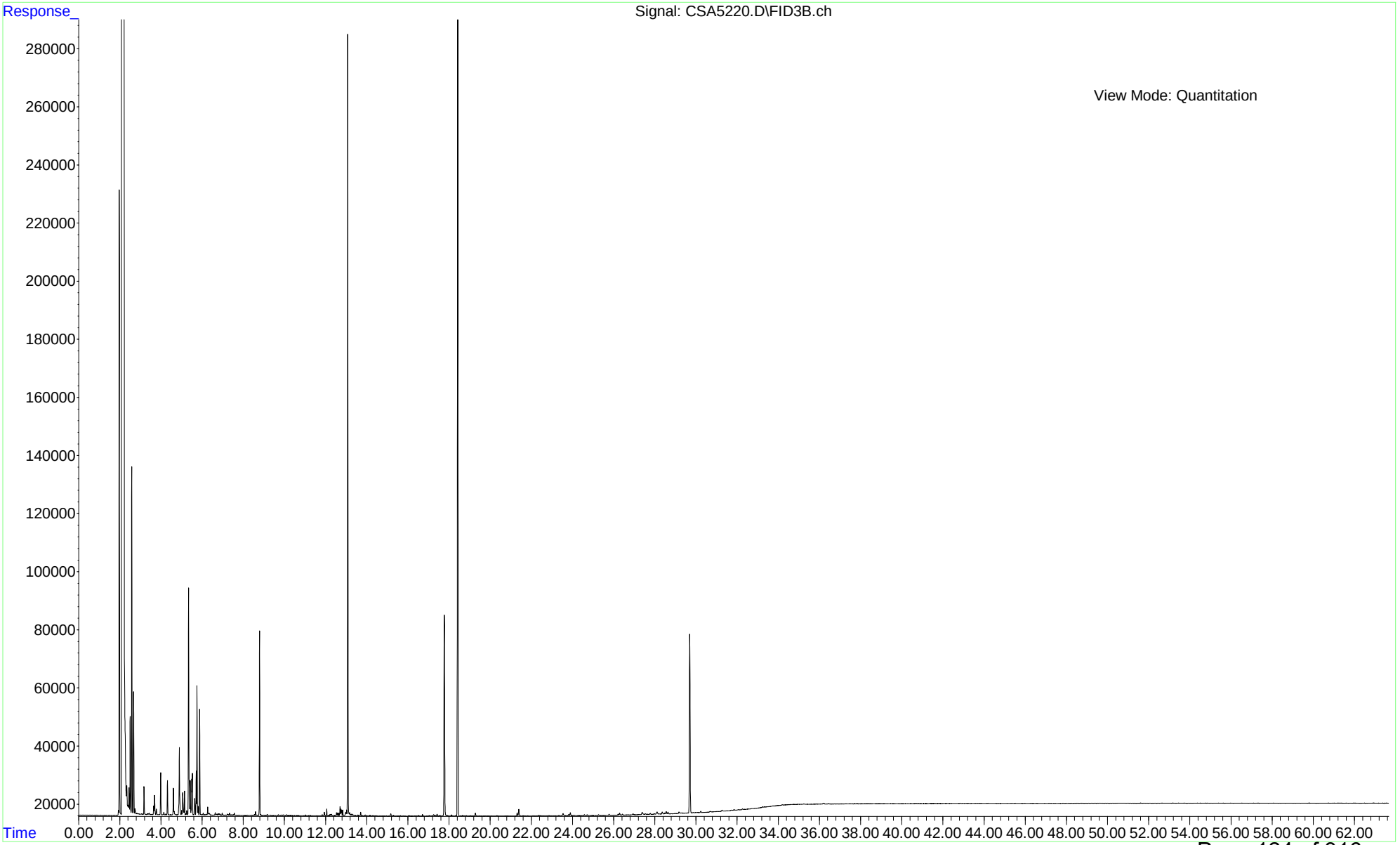
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5218.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 07:54 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-2|sw_b|hc|01
Misc Info :
Vial Number: 67



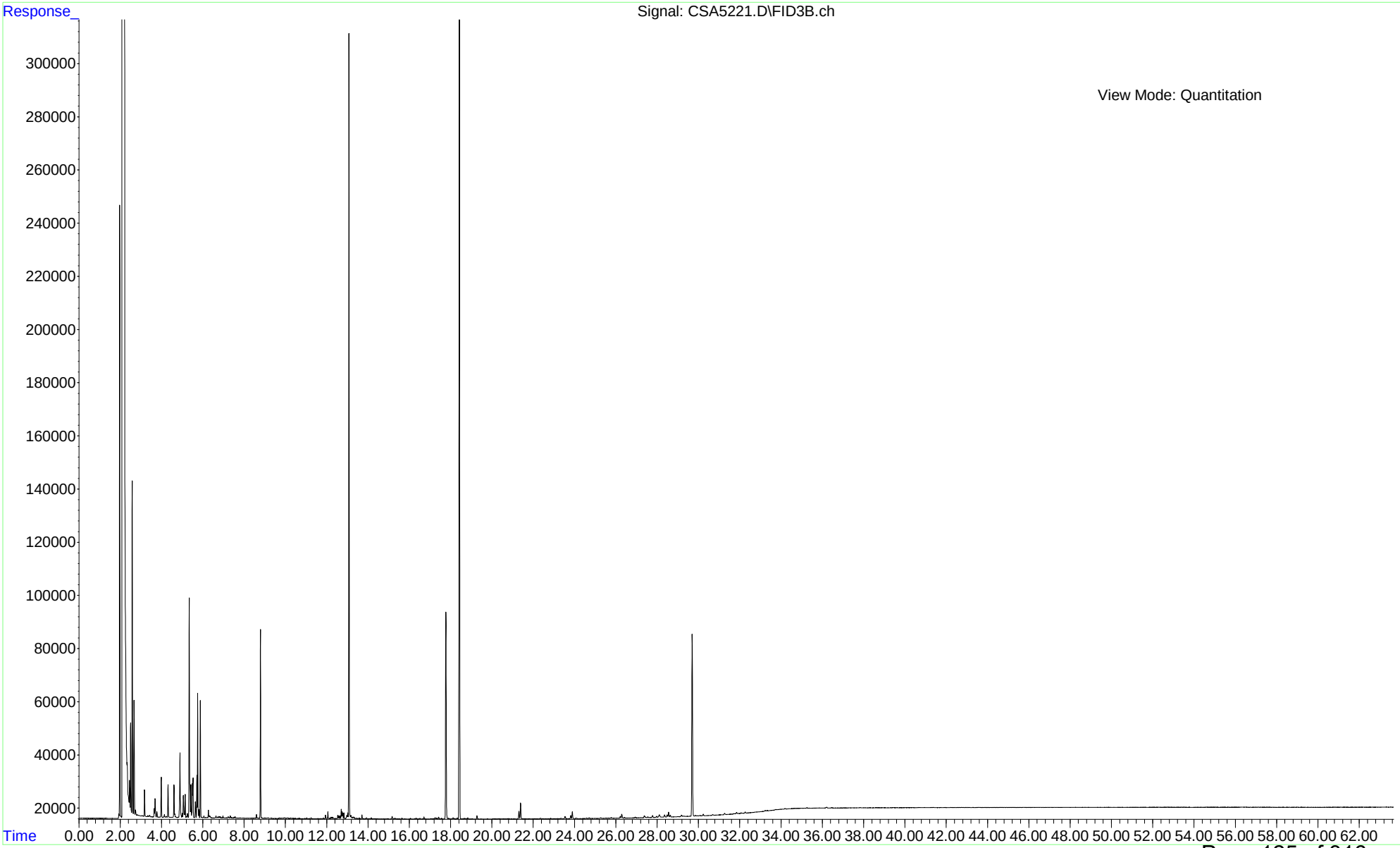
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5219.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 09:02 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-2|sw_b|hc|02
Misc Info :
Vial Number: 68



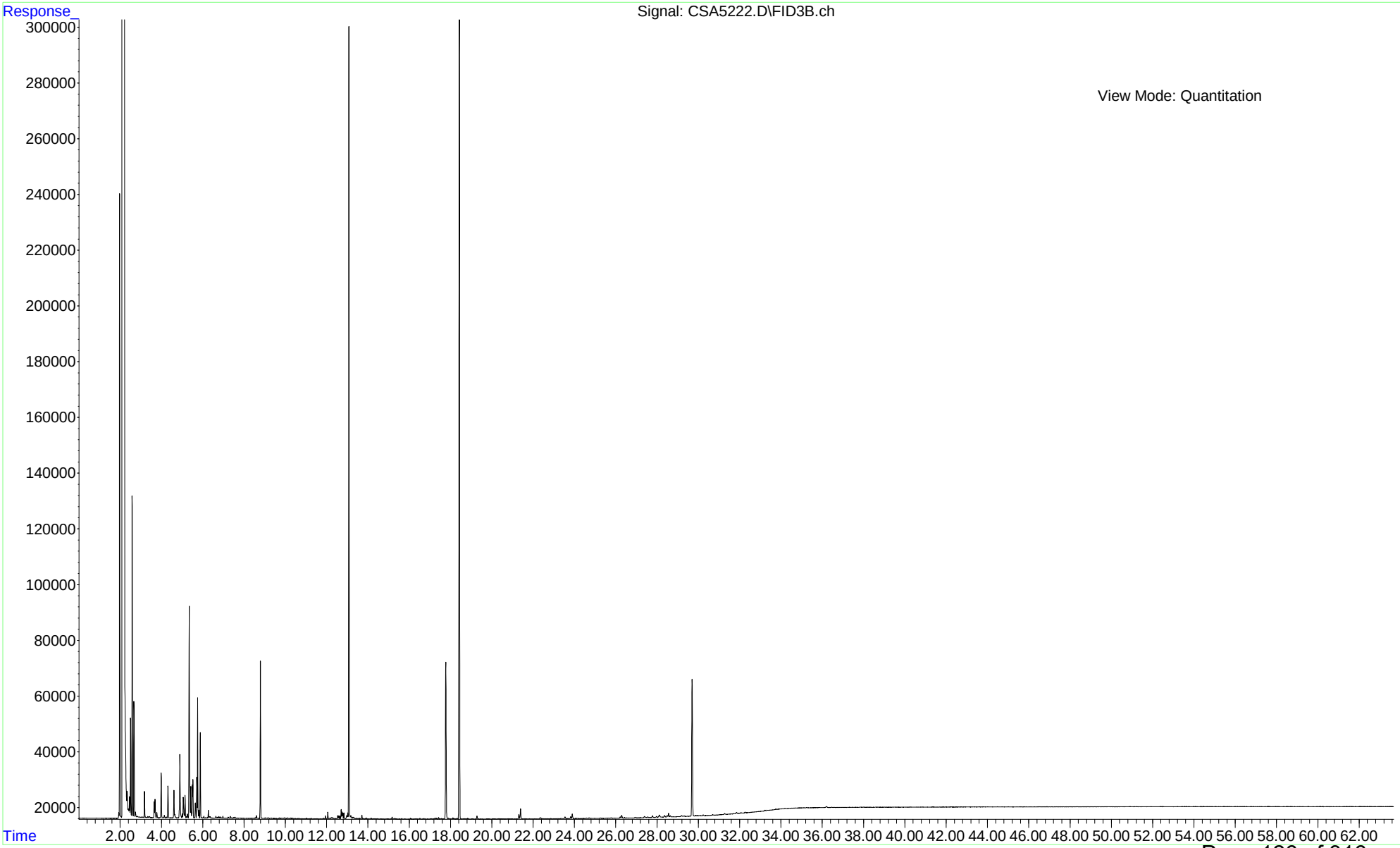
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5220.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 10:11 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-3|sw_s|hc|01
Misc Info :
Vial Number: 69



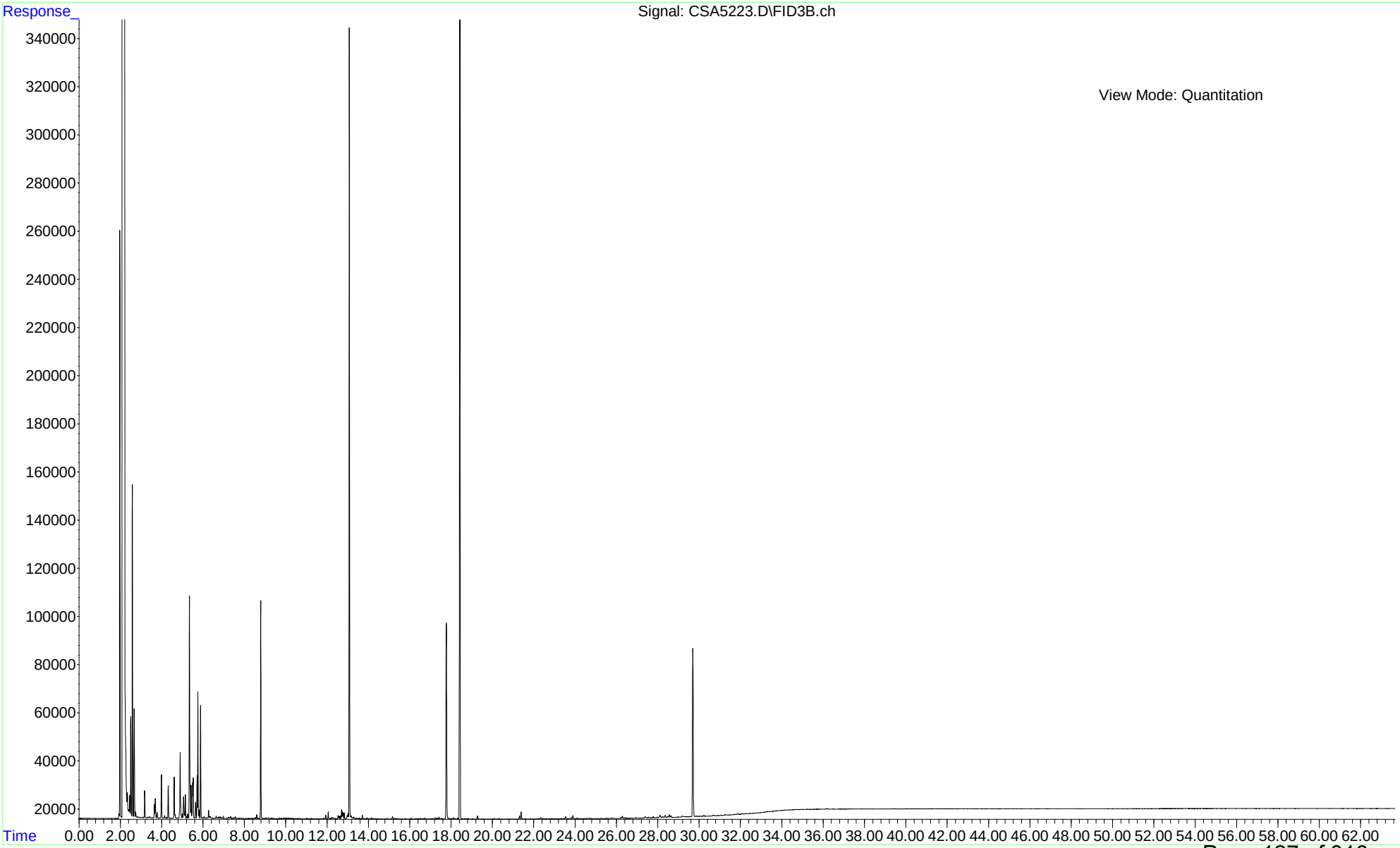
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5221.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 11:19 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-3|sw_s|hc|02
Misc Info :
Vial Number: 70



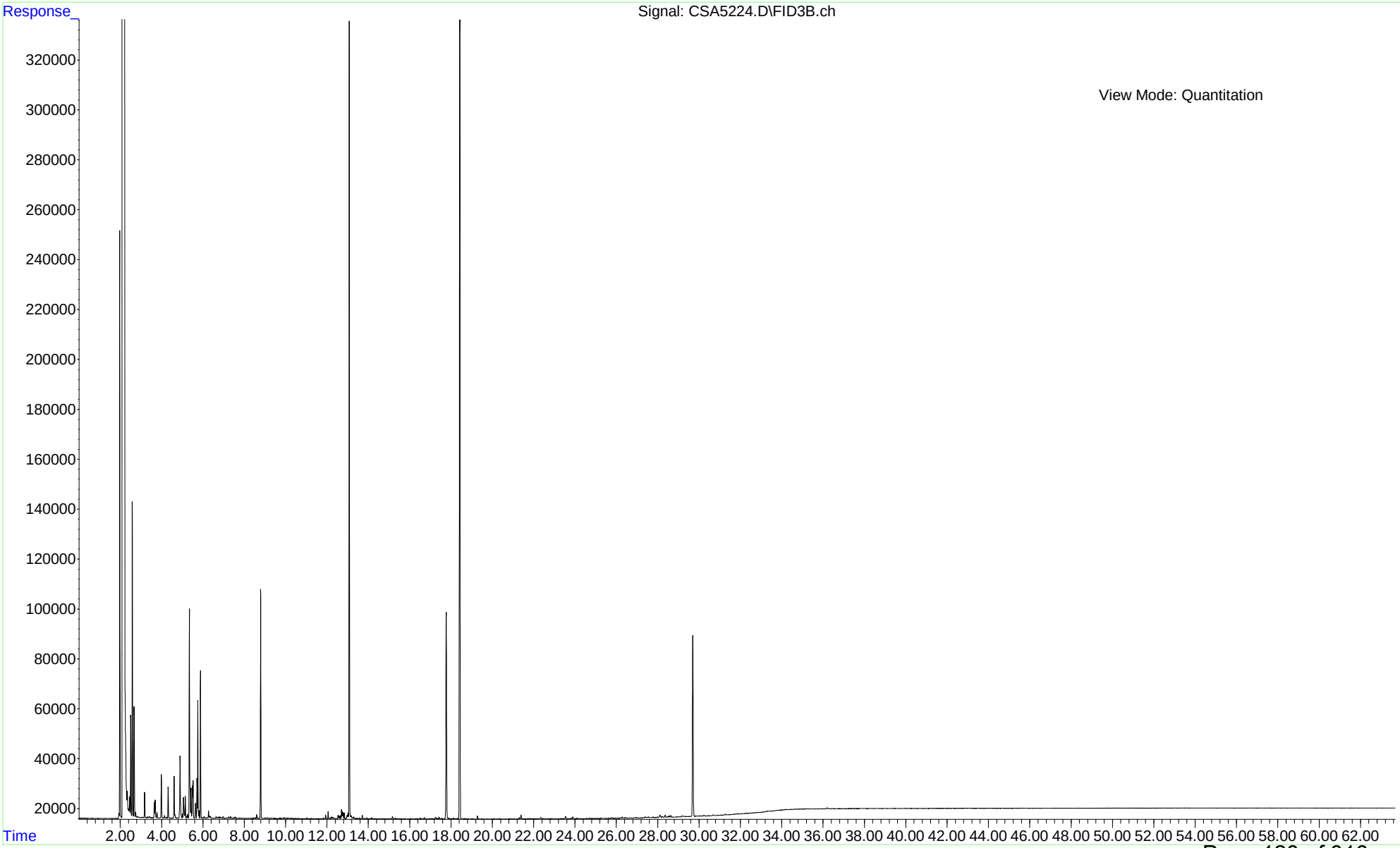
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5222.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 12:28 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-3|sw_m|hc|01
Misc Info :
Vial Number: 71



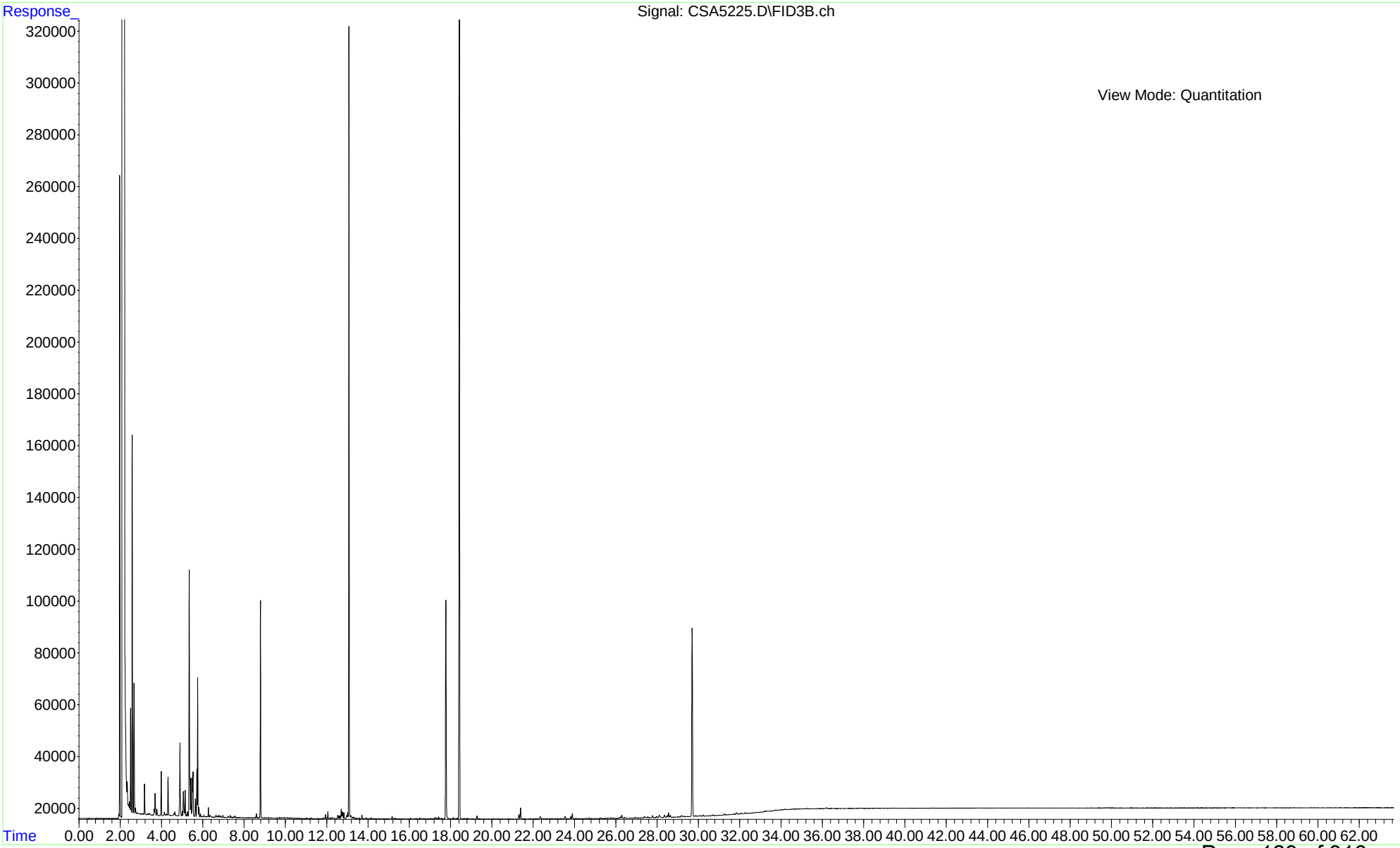
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5223.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 14:45 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-3|sw_m|hc|02
Misc Info :
Vial Number: 73



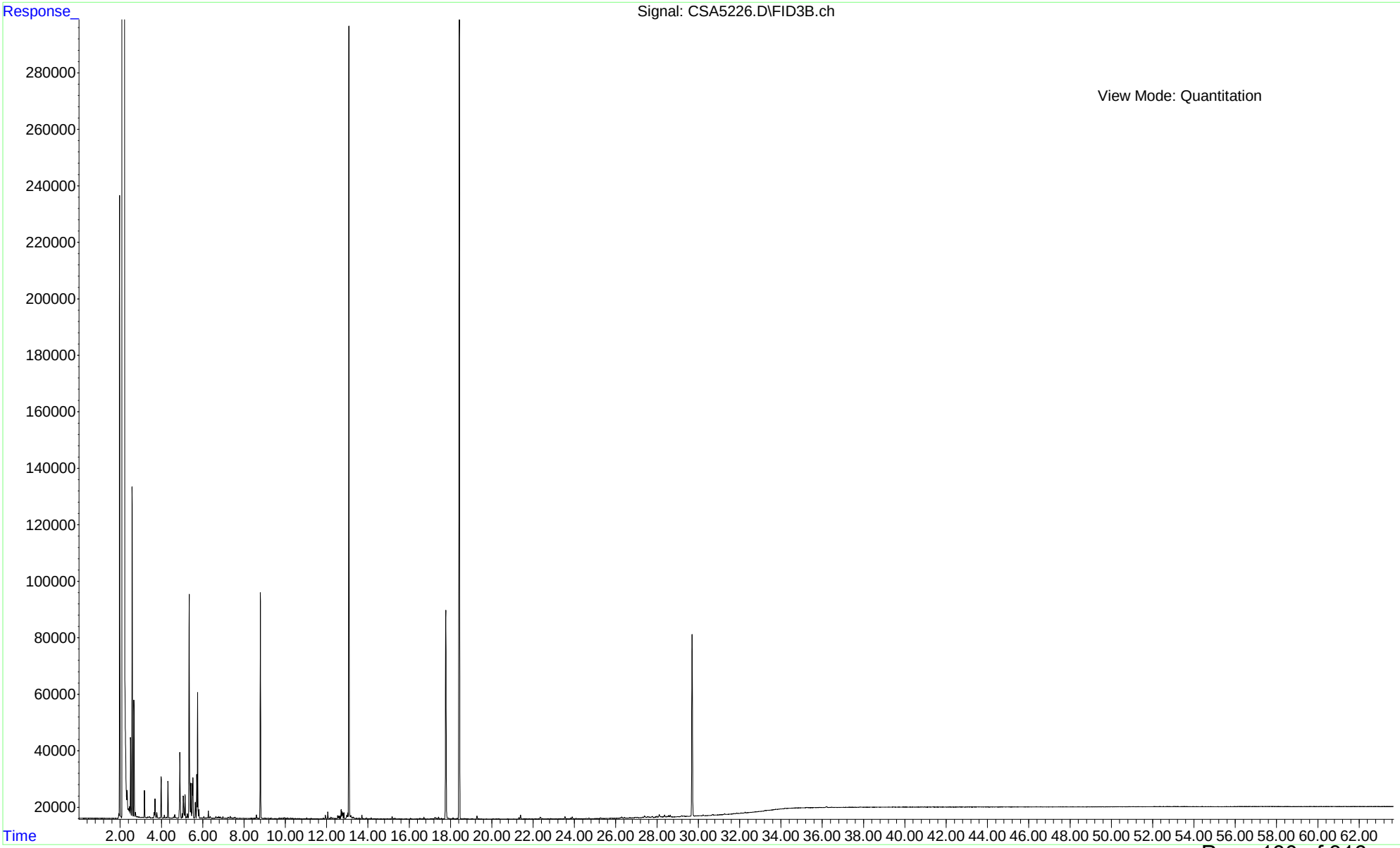
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5224.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 15:53 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-3|sw_b|hc|01
Misc Info :
Vial Number: 74



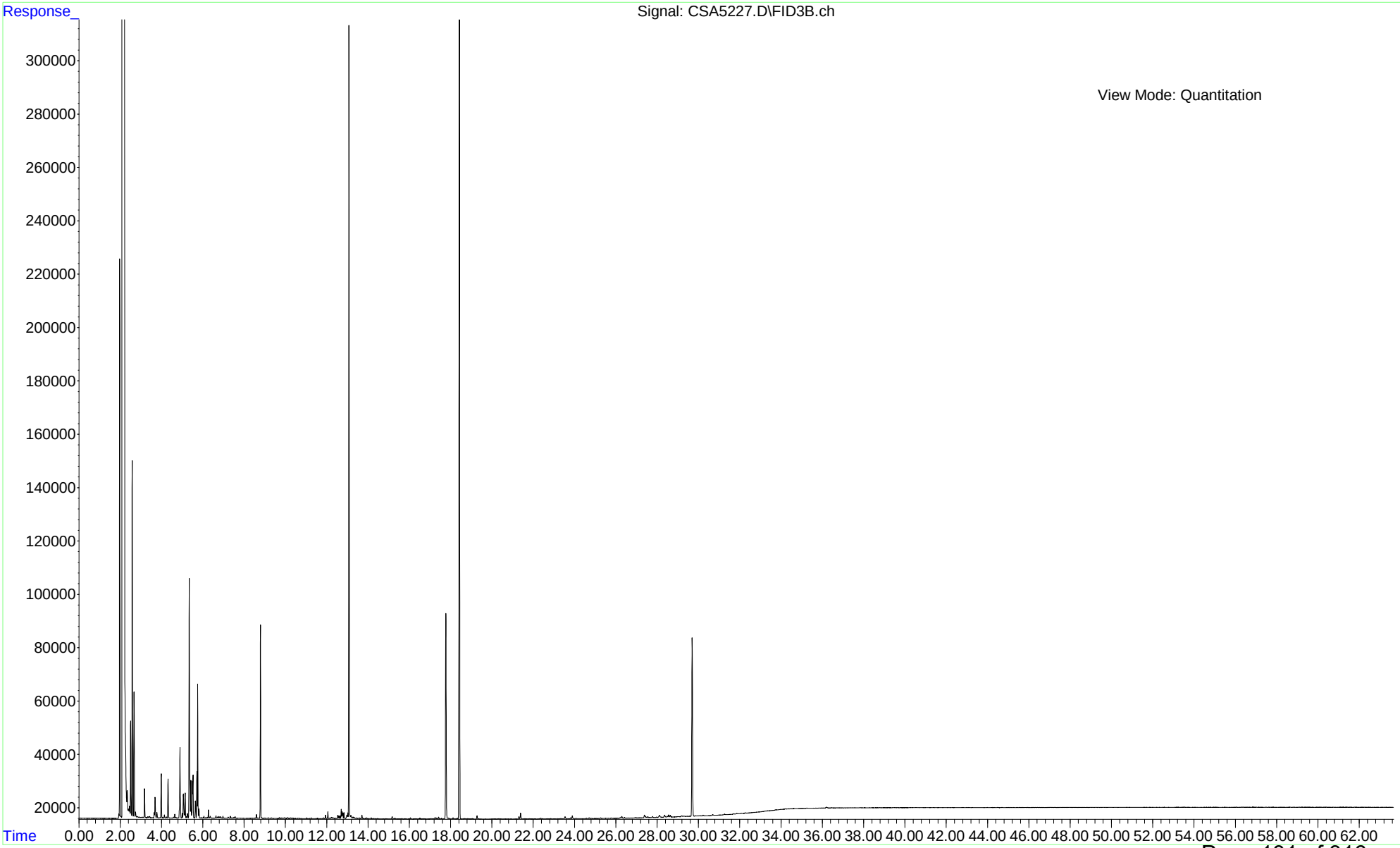
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5225.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 17:01 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-3|sw_b|hc|02
Misc Info :
Vial Number: 75



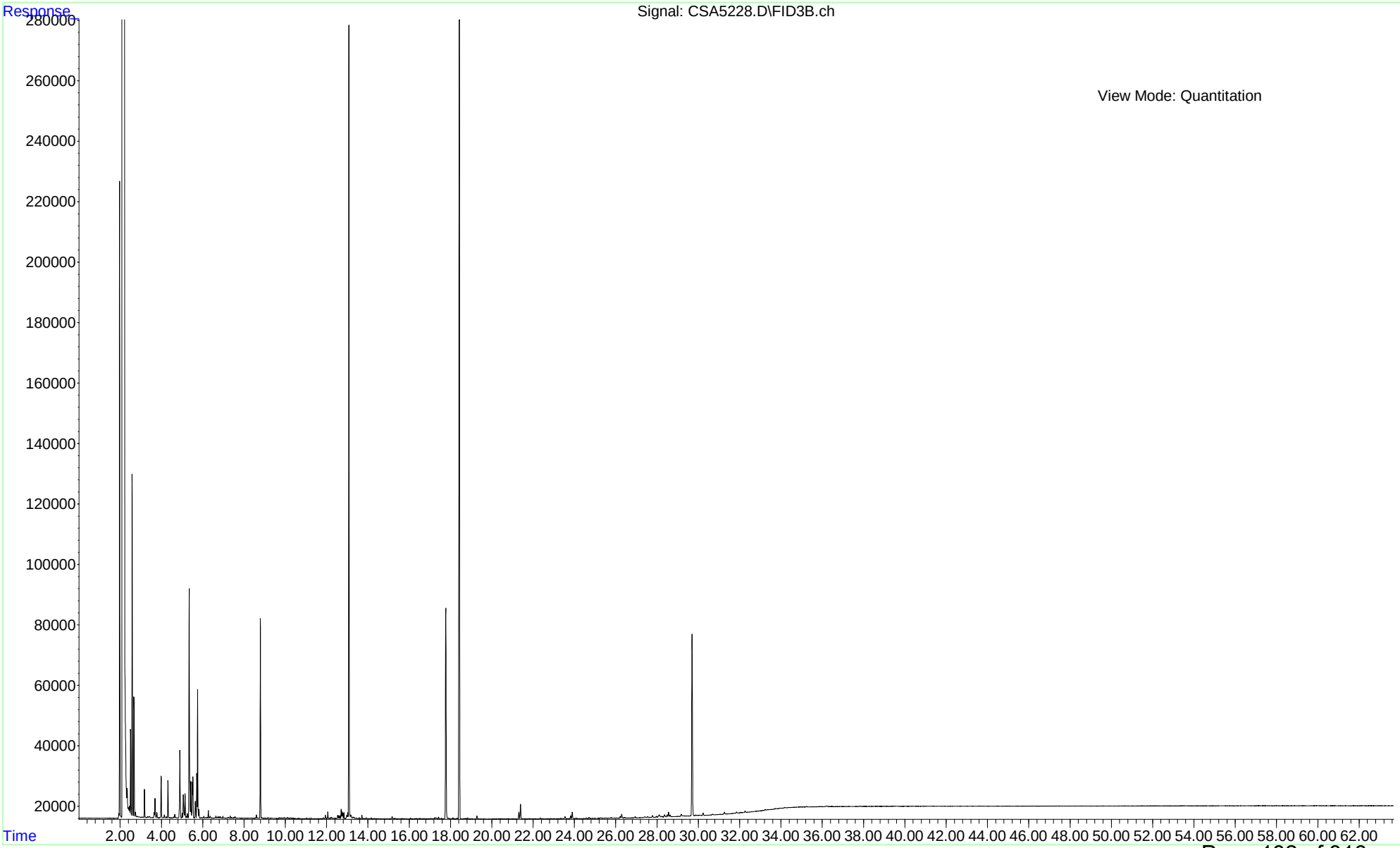
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5226.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 18:10 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|EB|diw|hc|01
Misc Info :
Vial Number: 76



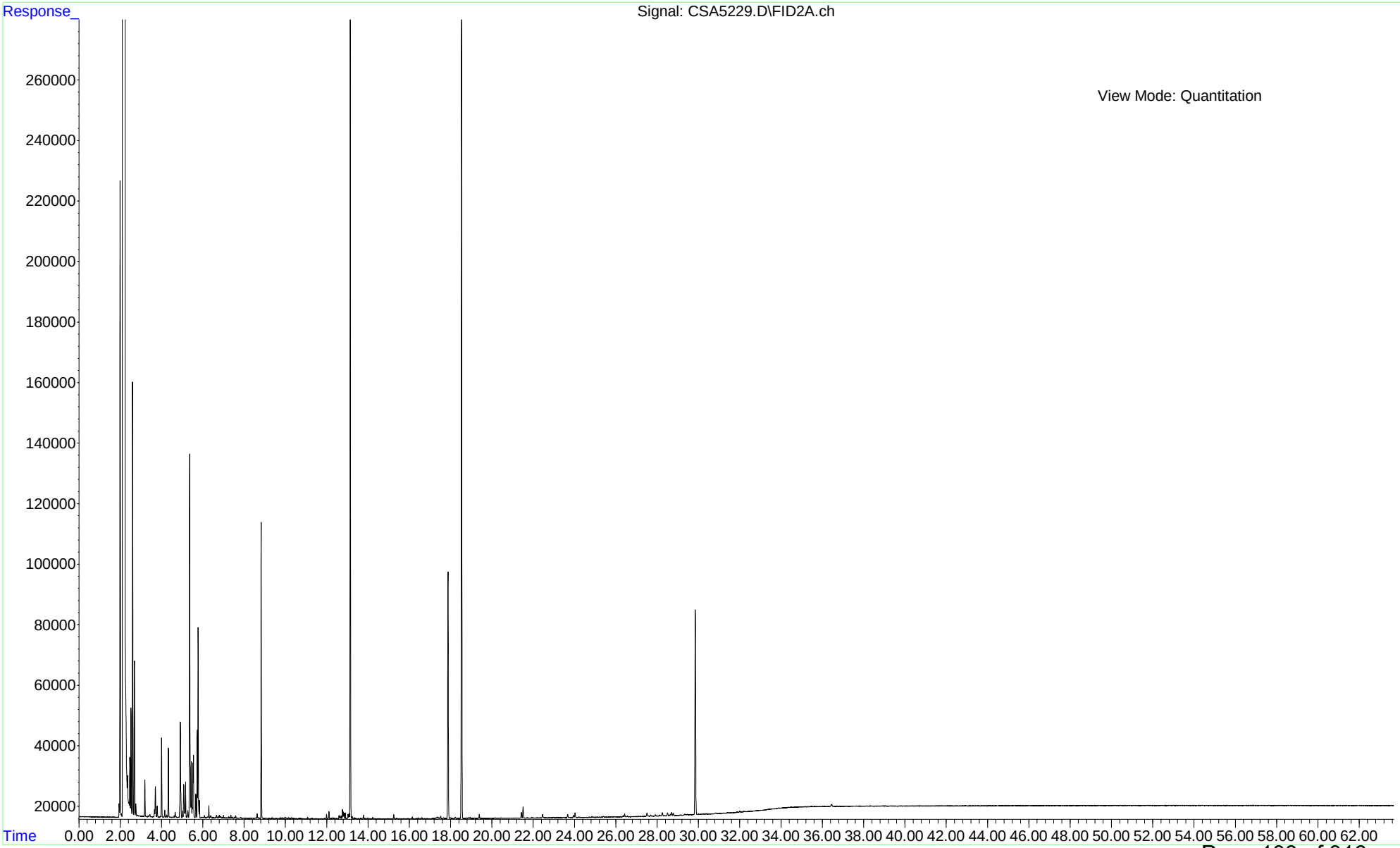
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5227.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 19:18 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|FB|diw|hc|01
Misc Info :
Vial Number: 77



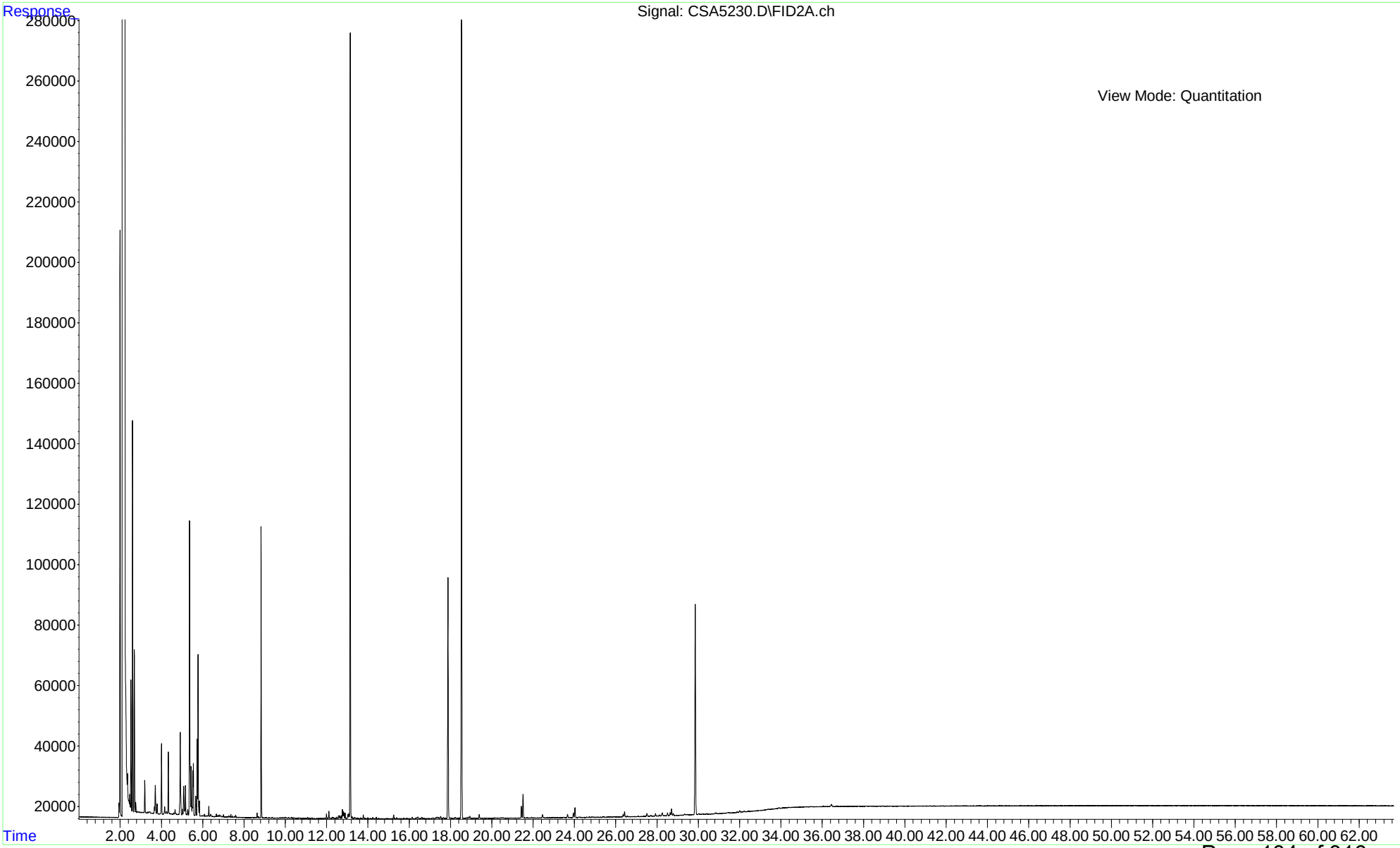
File :P:\2020\J20453 CSA 3532\ALI\ENV4074\FID60117\CSA5228.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 20:27 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|DI|diw|hc|01
Misc Info :
Vial Number: 78



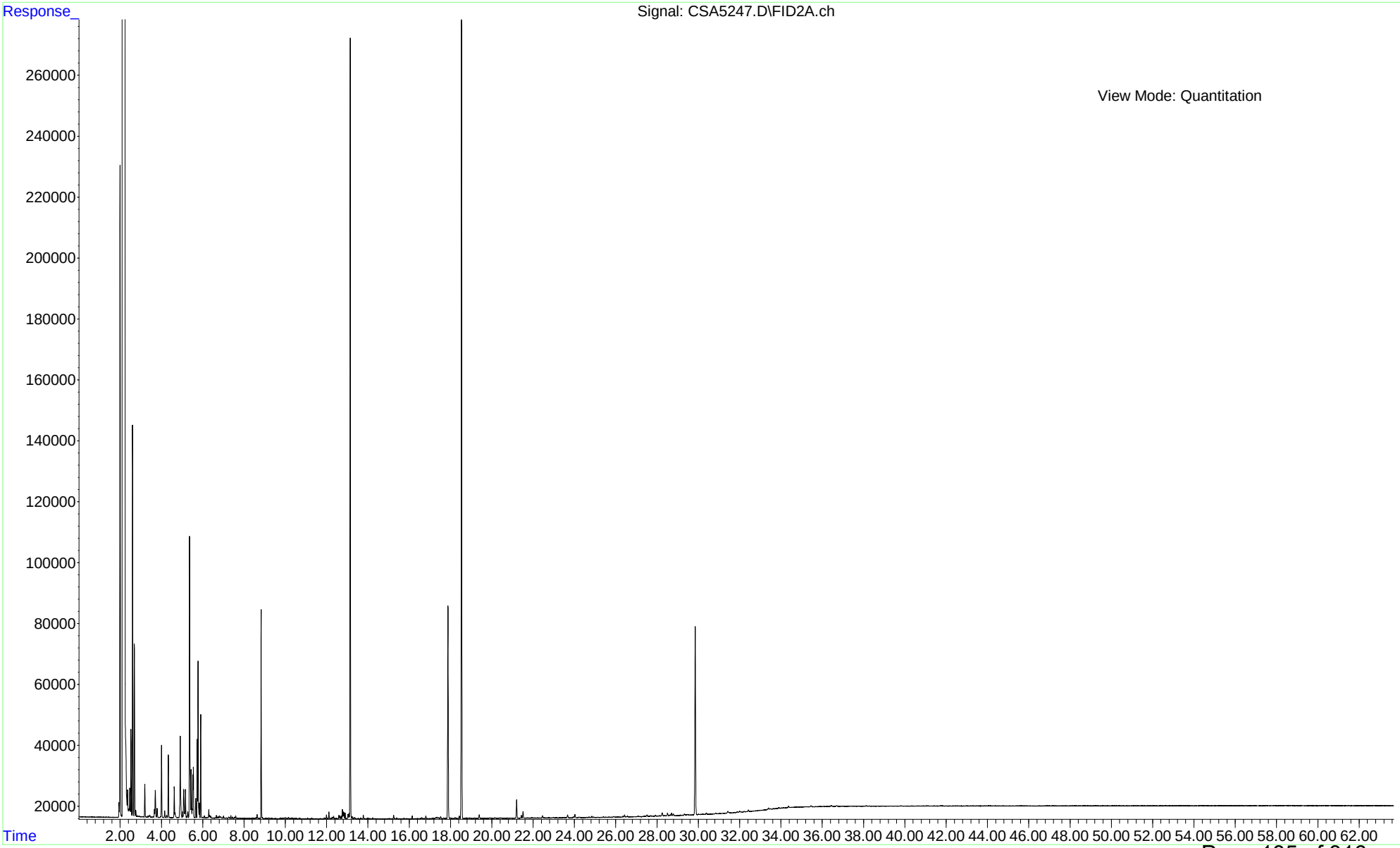
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5229.D
Operator : Chase Brewster
Acquired : 25-Mar-2020, 21:38 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|CH2Cl2|hc|01
Misc Info :
Vial Number: 8



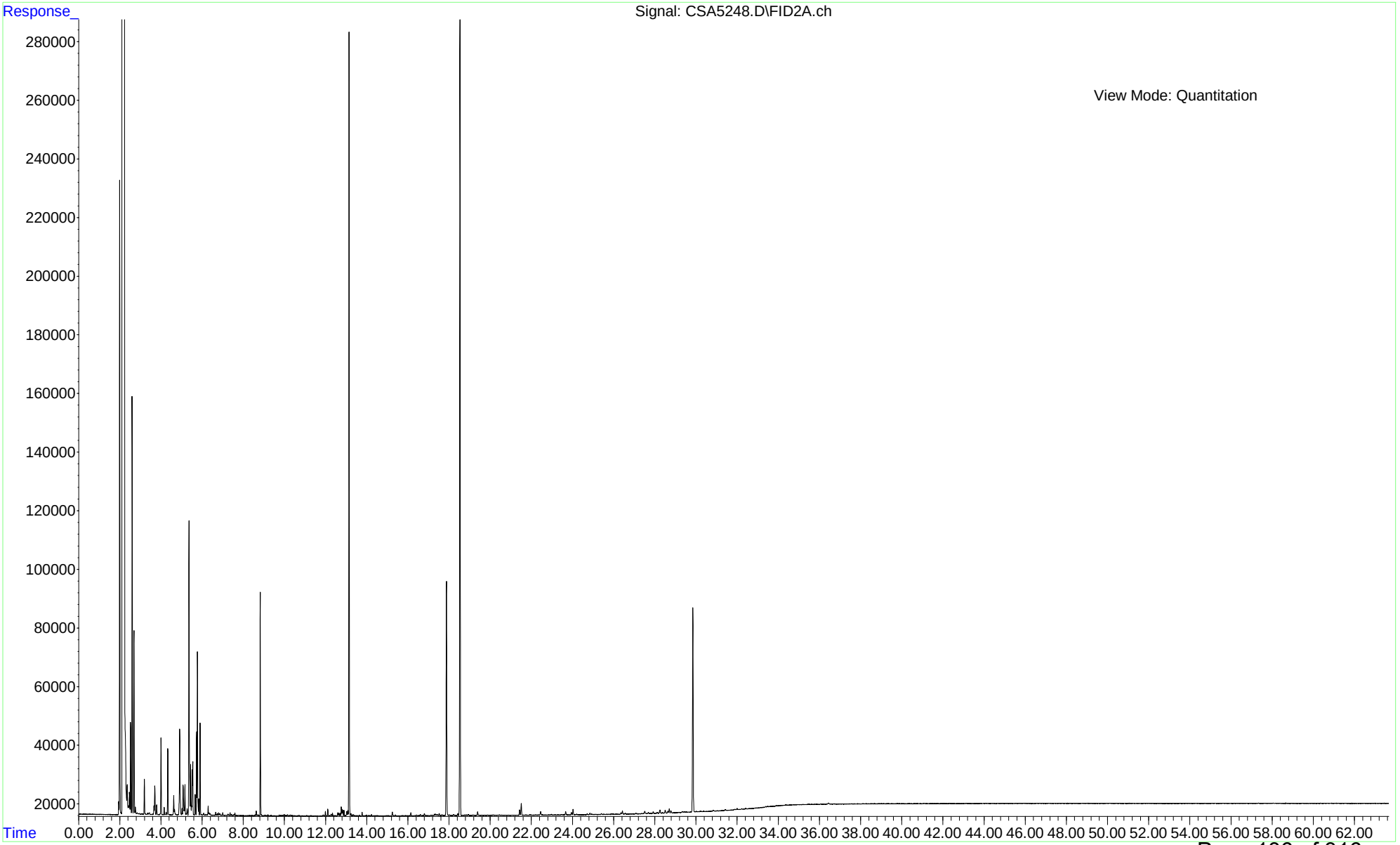
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5230.D
Operator : Chase Brewster
Acquired : 25-Mar-2020, 22:47 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|DI|hc|01
Misc Info :
Vial Number: 9



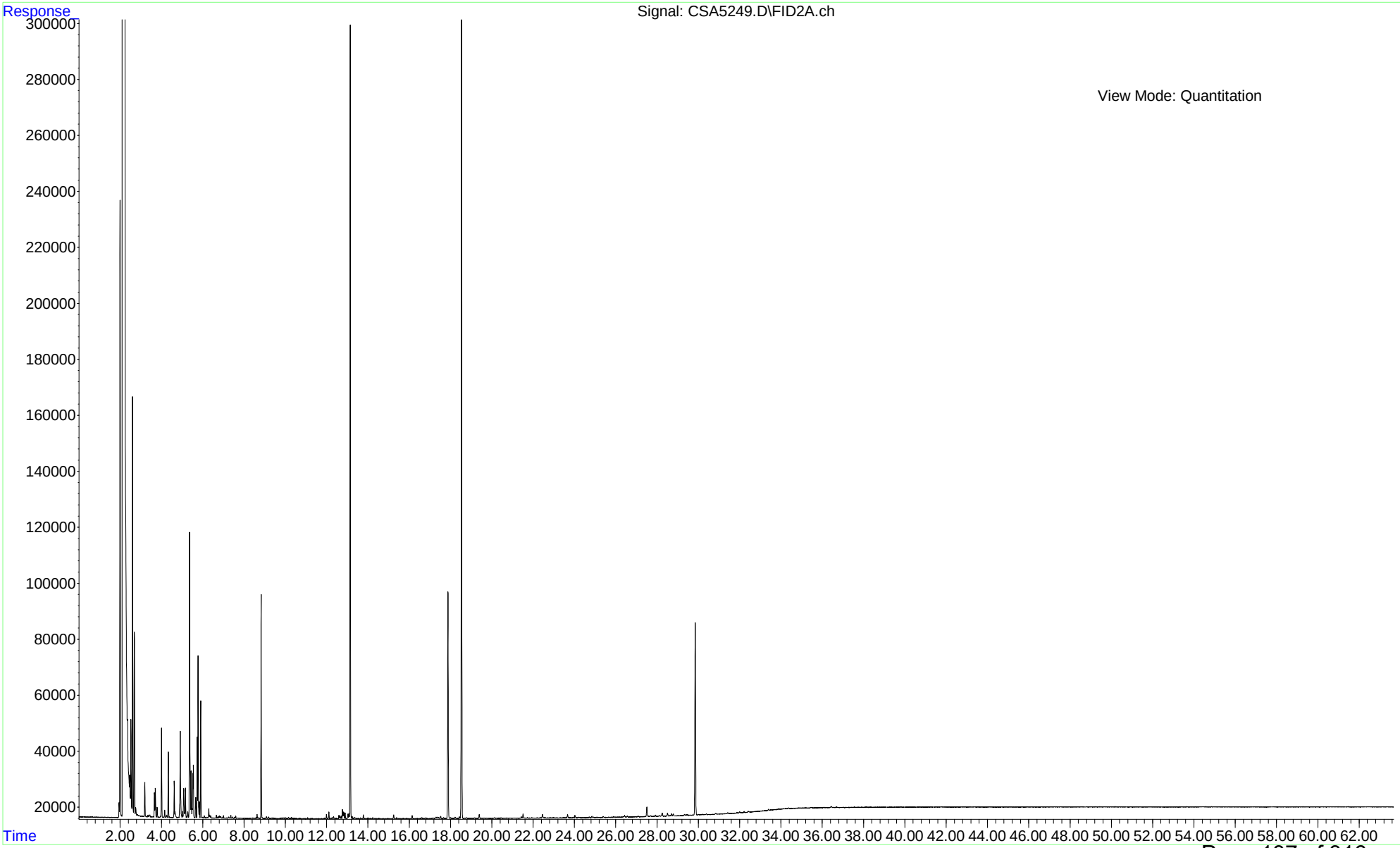
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5247.D
Operator : Chase Brewster
Acquired : 25-Mar-2020, 23:55 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-5|sw_s|hc|01
Misc Info :
Vial Number: 10



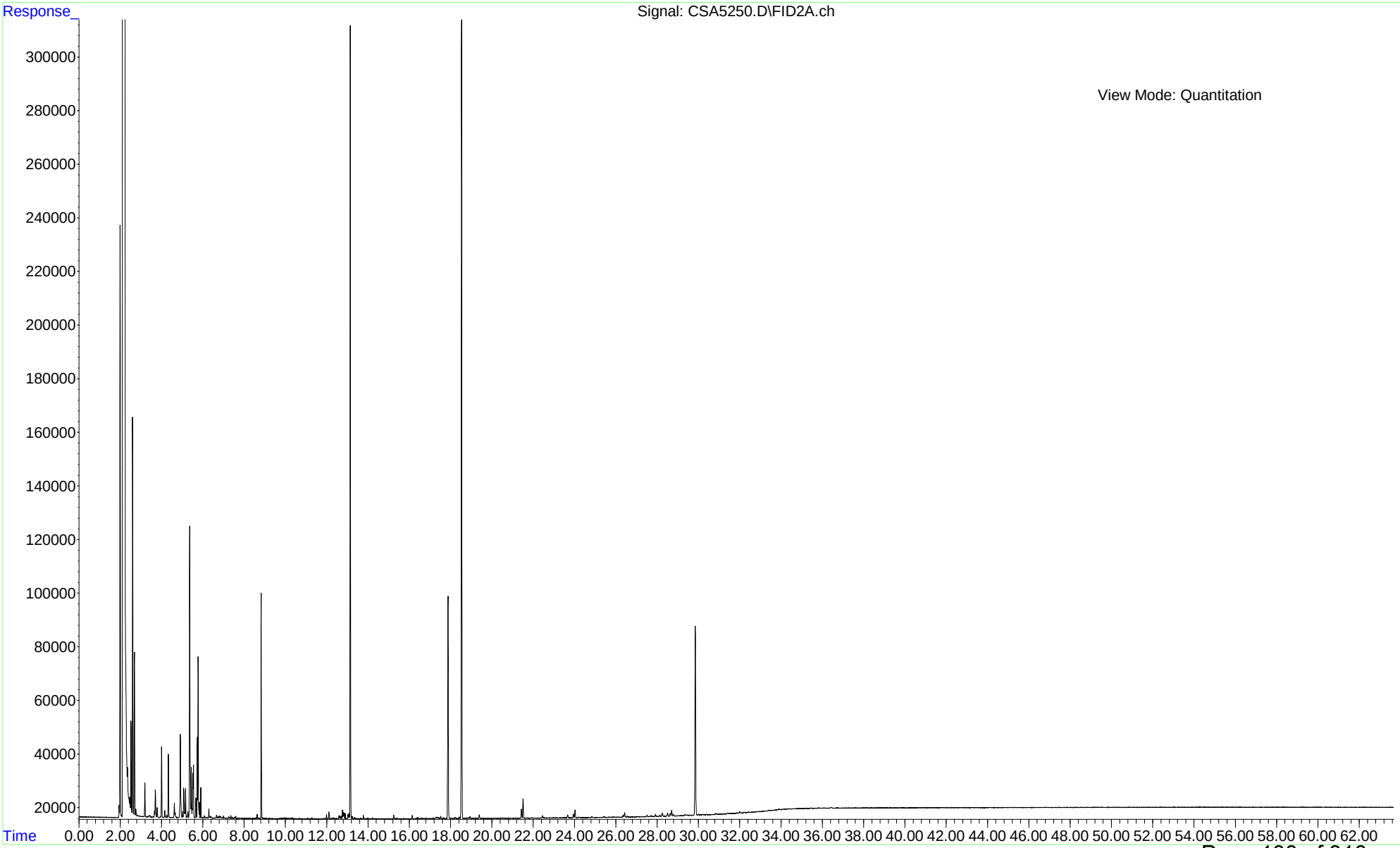
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5248.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 01:04 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-5|sw_s|hc|02
Misc Info :
Vial Number: 11



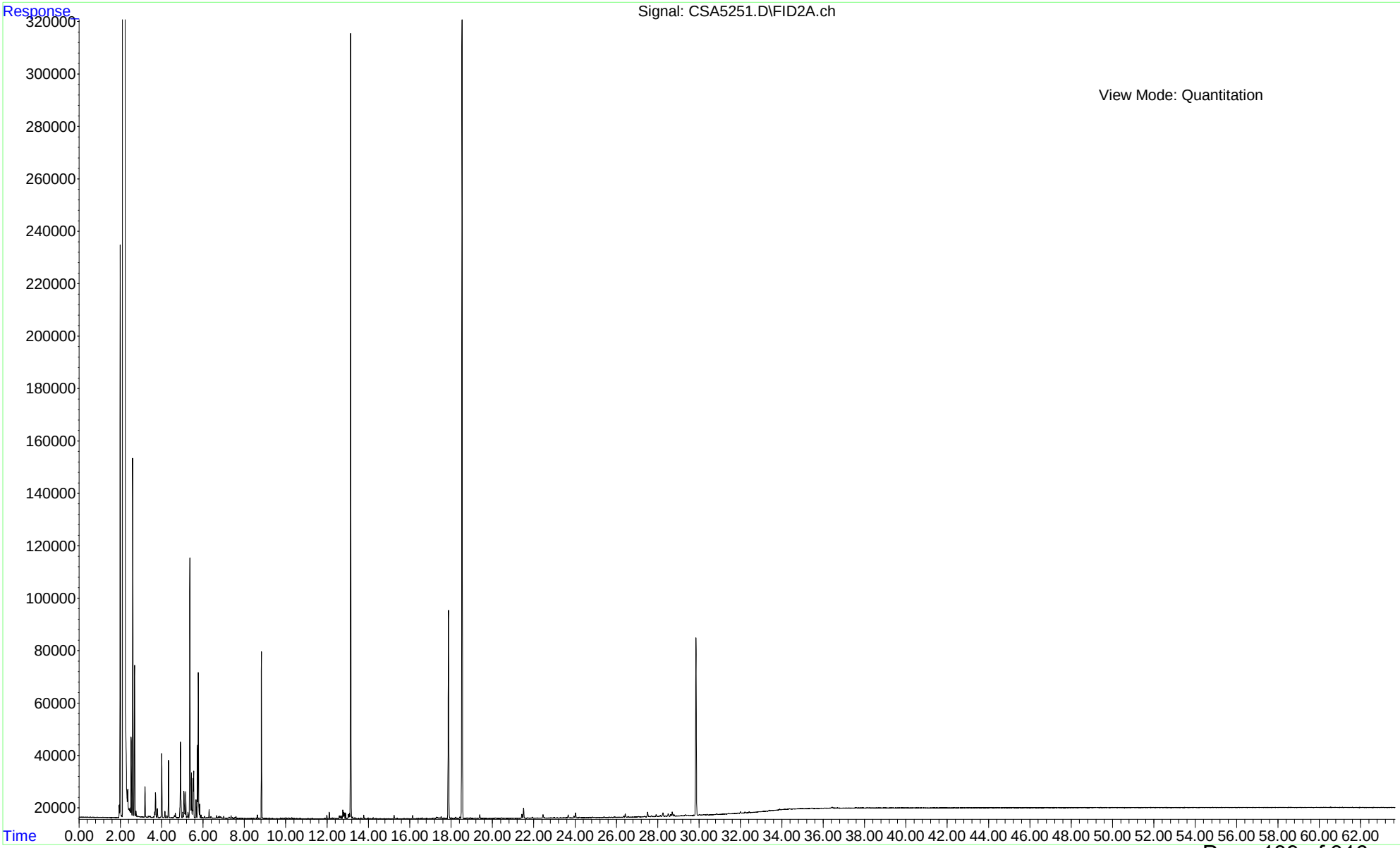
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5249.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 03:20 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-5|sw_m|hc|01
Misc Info :
Vial Number: 13



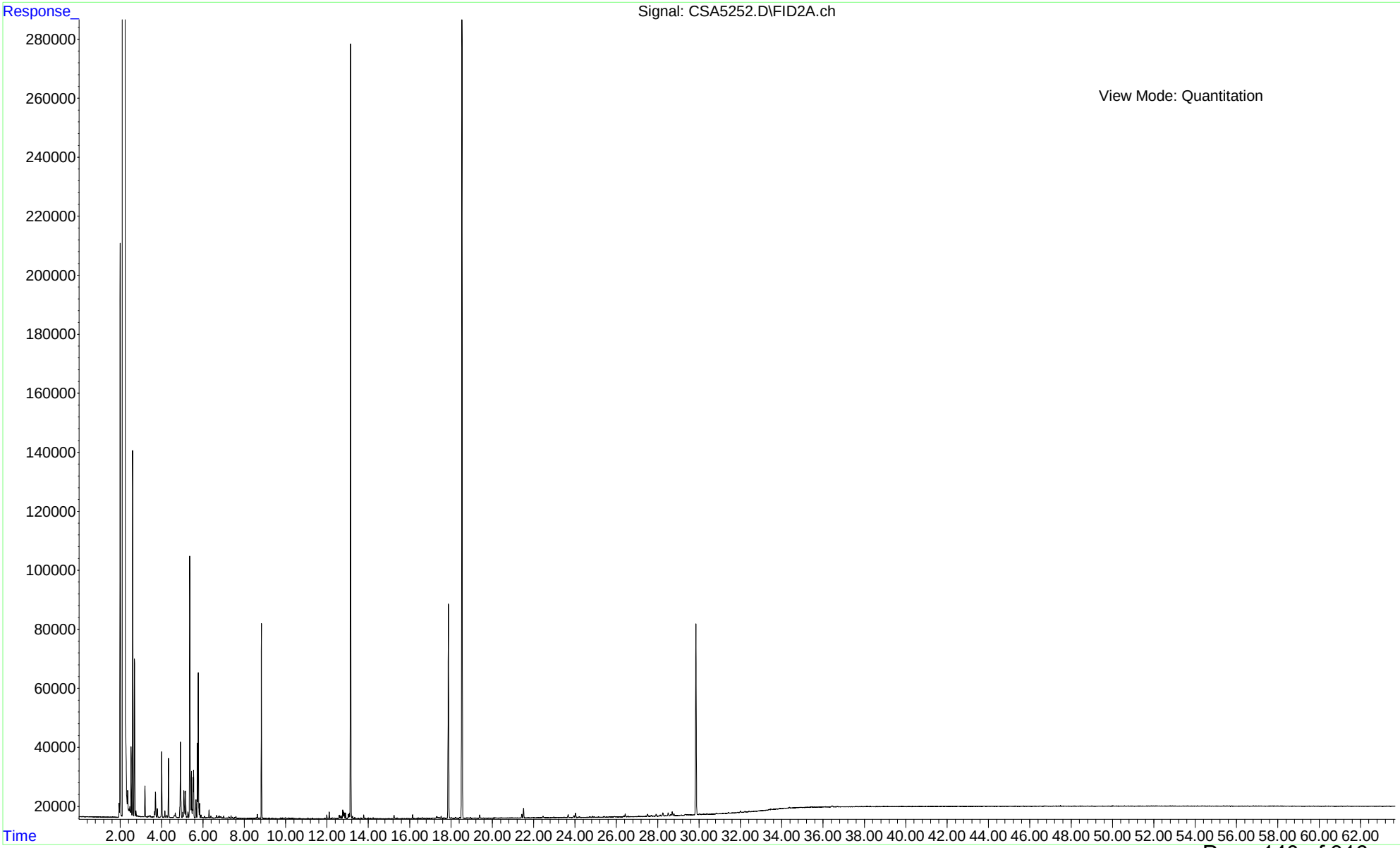
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5250.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 04:29 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-5|sw_m|hc|02
Misc Info :
Vial Number: 14



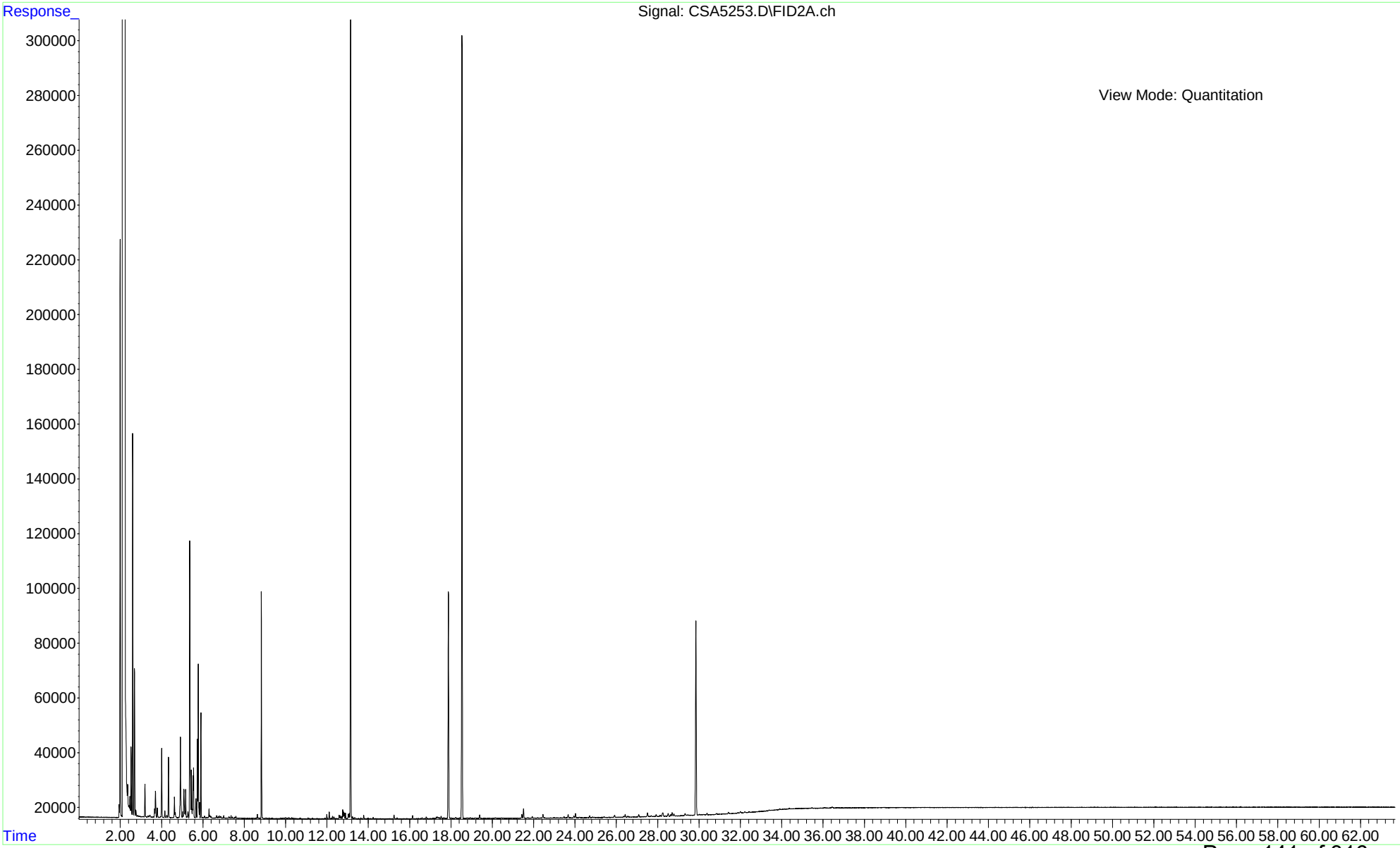
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5251.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 05:37 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-5|sw_b|hc|01
Misc Info :
Vial Number: 15



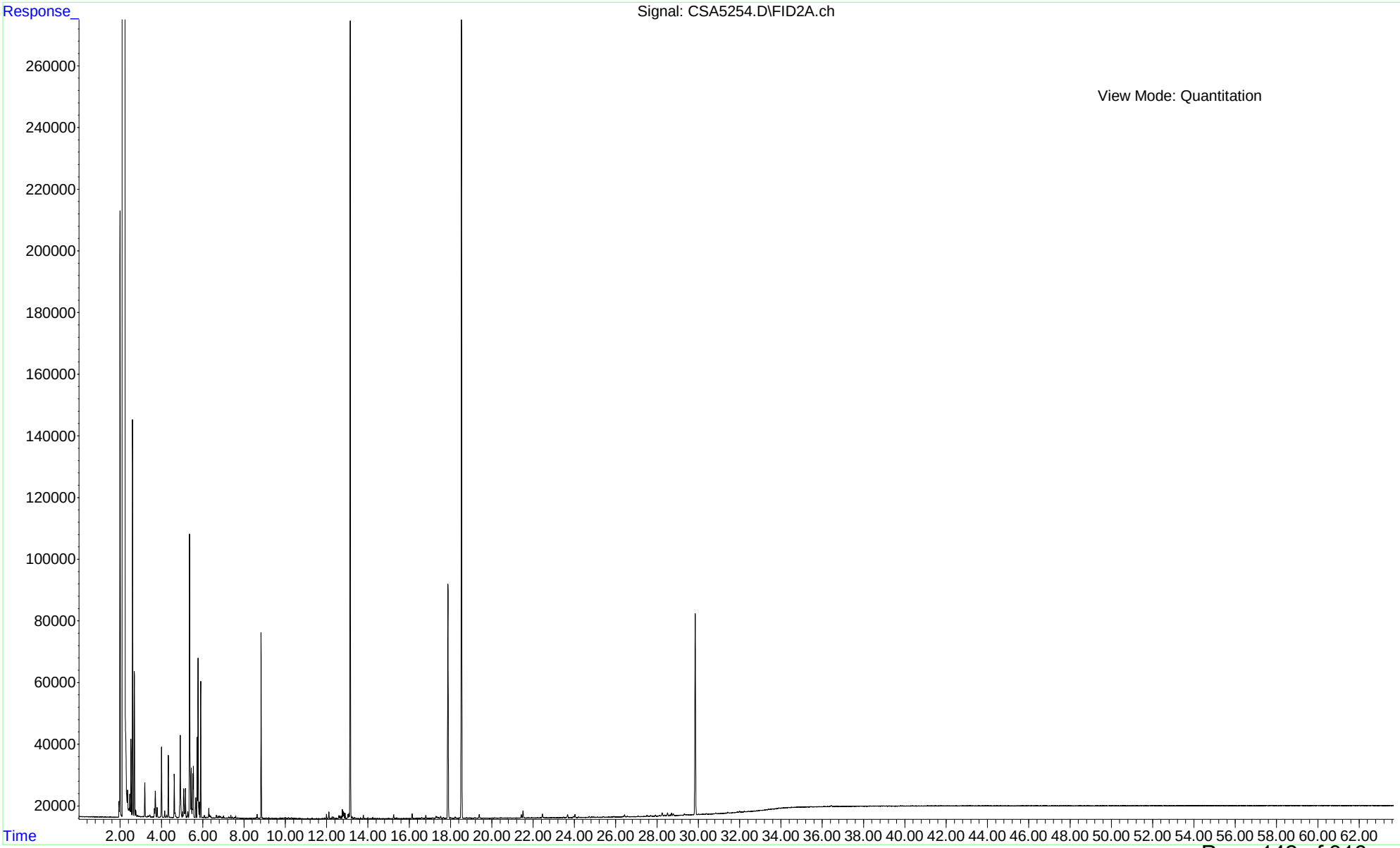
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5252.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 06:45 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-5|sw_b|hc|02
Misc Info :
Vial Number: 16



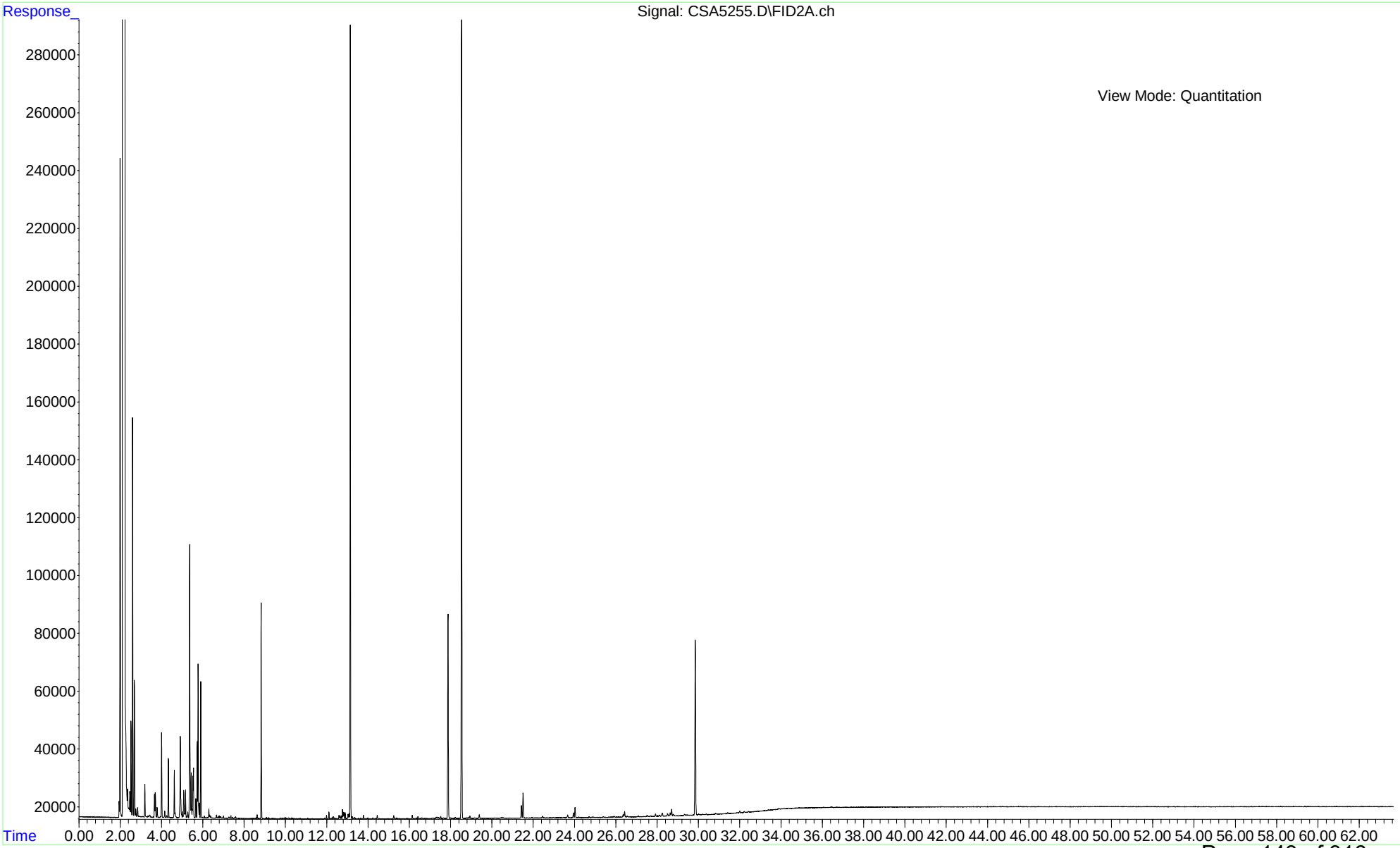
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5253.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 07:54 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-7|sw_s|hc|01
Misc Info :
Vial Number: 17



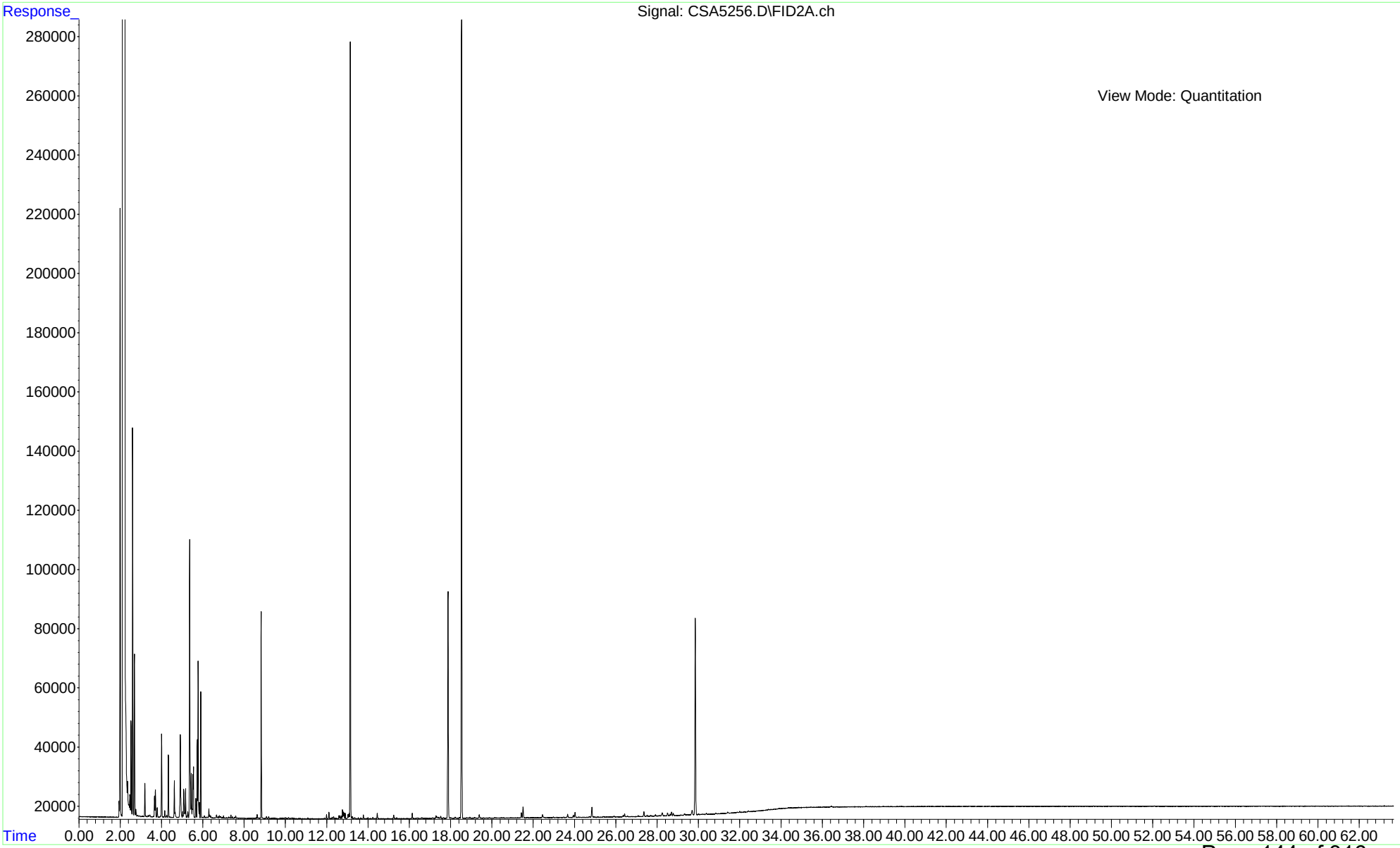
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5254.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 09:02 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-7|sw_s|hc|02
Misc Info :
Vial Number: 18



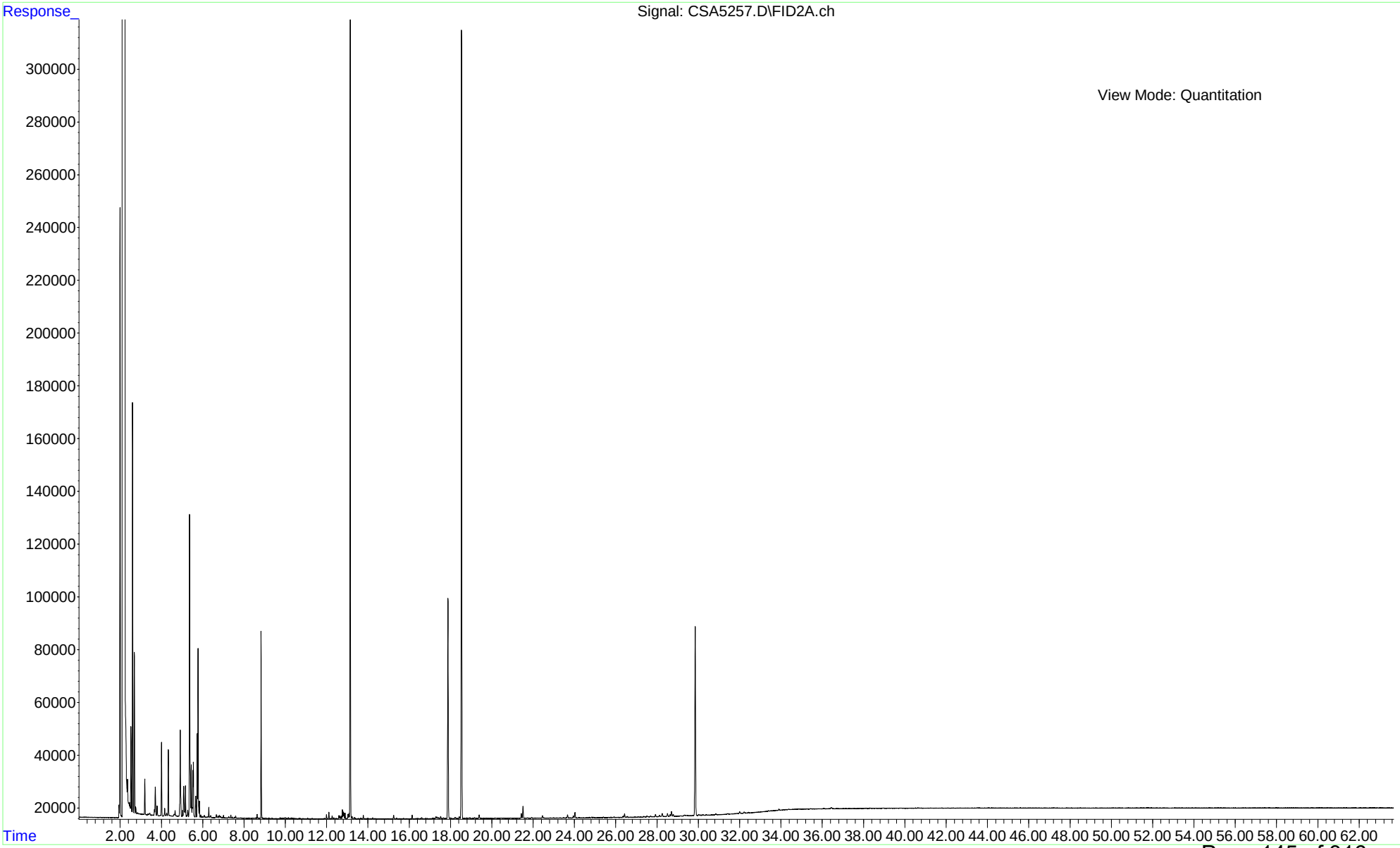
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5255.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 10:11 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-7|sw_m|hc|01
Misc Info :
Vial Number: 19



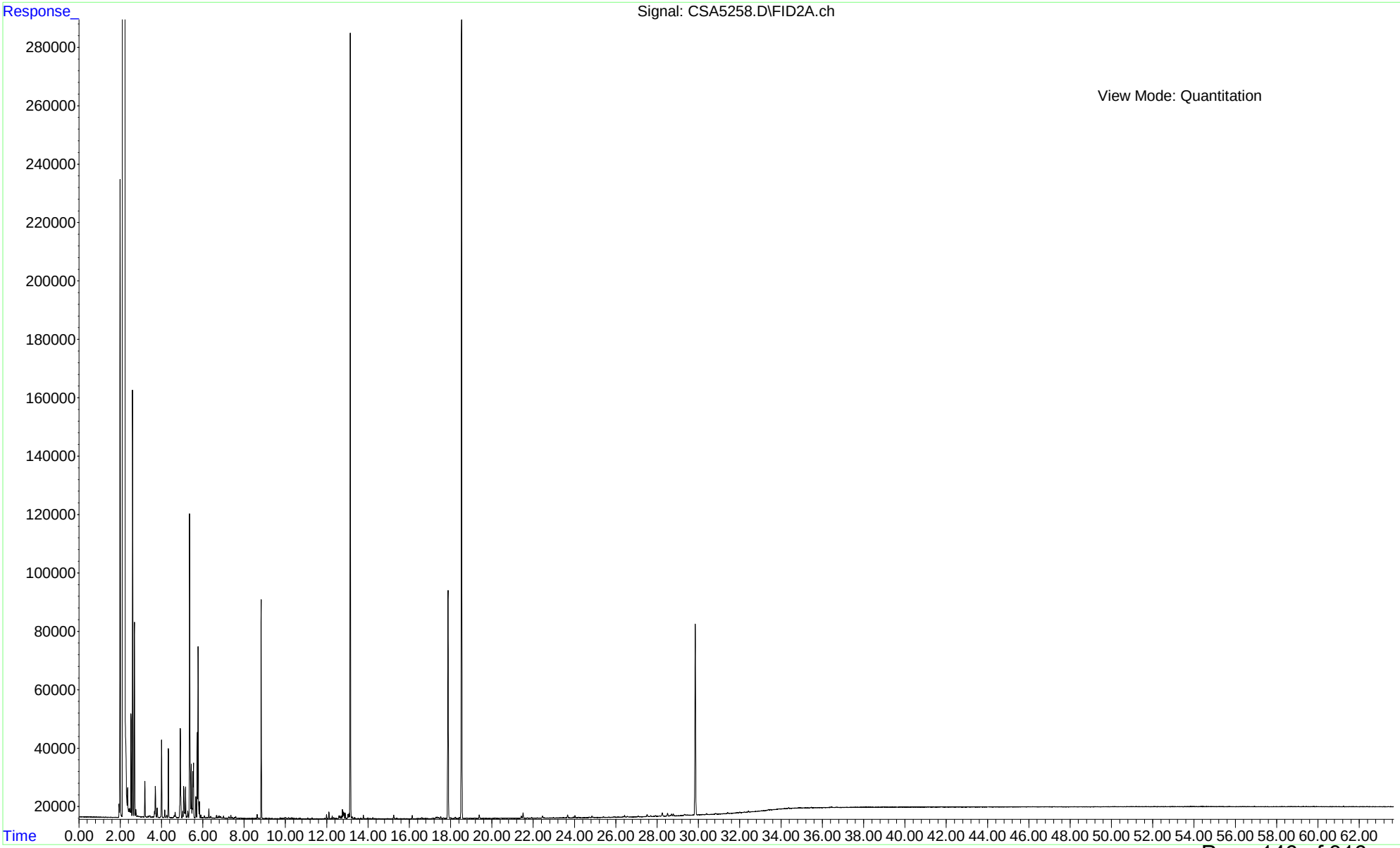
File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5256.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 11:19 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-7|sw_m|hc|02
Misc Info :
Vial Number: 20



File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5257.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 12:28 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-7|sw_b|hc|01
Misc Info :
Vial Number: 21



File :P:\2020\J20453 CSA 3532\ALI\ENV4075\FID60118\CSA5258.D
Operator : Chase Brewster
Acquired : 26-Mar-2020, 14:45 using AcqMethod ALI2012.M
Instrument : GCI
Sample Name: 3532|03_20|HH-7|sw_b|hc|02
Misc Info :
Vial Number: 23



Polycyclic Aromatic Hydrocarbon Concentration

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5190.D	CSA5191.D	CSA5192.D	CSA5193.D
Sample ID	3532|03_20|HH-8|sw_s|hc|01	3532|03_20|HH-8|sw_s|hc|02	3532|03_20|HH-8|sw_m|hc|01	3532|03_20|HH-8|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	20-Mar-2020 23:34	21-Mar-2020 0:42	21-Mar-2020 1:50	21-Mar-2020 2:58
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.03	1.00	1.03
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	3.94		4.34		2.87	J	<2.9	U
C1-Naphthalenes	2.84		3.65		<1.4	U	<1.4	U
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	3.82		4.01		<2.3	U	<2.3	U
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	1.28		<1.1	U	<1.1	U	<1.1	U
Pyrene	2.21		2.27		<1.4	U	<1.4	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	14.1		14.3		2.87		0.0	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5190.D	CSA5191.D	CSA5192.D	CSA5193.D
Sample ID	3532|03_20|HH-8|sw_s|hc|01	3532|03_20|HH-8|sw_s|hc|02	3532|03_20|HH-8|sw_m|hc|01	3532|03_20|HH-8|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	20-Mar-2020 23:34	21-Mar-2020 0:42	21-Mar-2020 1:50	21-Mar-2020 2:58
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.03	1.00	1.03
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	3.00		3.68		<1.1	U	<1.1	U
1-Methylnaphthalene	1.56		2.18		<1.4	U	<1.4	U
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	70		71		83		75	
Acenaphthene-d10	72		85		86		83	
Phenanthrene-d10	81		81		83		85	
Chrysene-d12	73		76		78		80	
Perylene-d12	83		85		98		93	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5194.D	CSA5195.D	CSA5196.D	CSA5197.D
Sample ID	3532|03_20|HH-8|sw_b|hc|01	3532|03_20|HH-8|sw_b|hc|02	3532|03_20|HH-4|sw_s|hc|01	3532|03_20|HH-4|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 5:15	21-Mar-2020 6:23	21-Mar-2020 7:31	21-Mar-2020 8:39
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.02	1.04	1.02	1.03
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	<2.9	U	4.53		3.87		3.88	
C1-Naphthalenes	<1.4	U	<1.4	U	<1.4	U	3.32	
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	<2.3	U	<2.3	U	3.07		3.12	
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	<1.1	U	<1.1	U	2.38		2.67	
Pyrene	<1.4	U	<1.4	U	4.34		5.11	
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	0.0		4.53		13.7		18.1	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5194.D	CSA5195.D	CSA5196.D	CSA5197.D
Sample ID	3532|03_20|HH-8|sw_b|hc|01	3532|03_20|HH-8|sw_b|hc|02	3532|03_20|HH-4|sw_s|hc|01	3532|03_20|HH-4|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 5:15	21-Mar-2020 6:23	21-Mar-2020 7:31	21-Mar-2020 8:39
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.02	1.04	1.02	1.03
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	<1.1	U	<1.1	U	<1.1	U	3.46	
1-Methylnaphthalene	<1.4	U	<1.4	U	<1.4	U	1.88	
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	77		69		68		67	
Acenaphthene-d10	84		76		74		75	
Phenanthrene-d10	84		75		75		76	
Chrysene-d12	79		71		70		69	
Perylene-d12	91		82		81		81	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5198.D	CSA5199.D	CSA5200.D	CSA5201.D
Sample ID	3532|03_20|HH-4|sw_m|hc|01	3532|03_20|HH-4|sw_m|hc|02	3532|03_20|HH-4|sw_b|hc|01	3532|03_20|HH-4|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 9:47	21-Mar-2020 10:55	21-Mar-2020 12:03	21-Mar-2020 13:11
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.03	1.02	1.03	1.02
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	2.82	J	2.23	J	<2.9	U	2.98	
C1-Naphthalenes	2.05		<1.4	U	<1.4	U	<1.4	U
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	4.88		2.23		0.0		2.98	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5198.D	CSA5199.D	CSA5200.D	CSA5201.D
Sample ID	3532|03_20|HH-4|sw_m|hc|01	3532|03_20|HH-4|sw_m|hc|02	3532|03_20|HH-4|sw_b|hc|01	3532|03_20|HH-4|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 9:47	21-Mar-2020 10:55	21-Mar-2020 12:03	21-Mar-2020 13:11
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.03	1.02	1.03	1.02
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	2.03		<1.1	U	<1.1	U	<1.1	U
1-Methylnaphthalene	1.27	J	<1.4	U	<1.4	U	<1.4	U
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	75		68		61		73	
Acenaphthene-d10	82		74		75		80	
Phenanthrene-d10	81		74		68		78	
Chrysene-d12	75		67		61		72	
Perylene-d12	86		79		71		85	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5202.D	CSA5203.D	CSA5204.D	CSA5205.D
Sample ID	3532|03_20|HH-6|sw_s|hc|01	3532|03_20|HH-6|sw_s|hc|02	3532|03_20|HH-6|sw_m|hc|01	3532|03_20|HH-6|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 15:28	21-Mar-2020 16:36	21-Mar-2020 17:44	21-Mar-2020 18:52
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.03	1.04	1.03	1.02
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	3.92		2.83	J	3.05		<2.9	U
C1-Naphthalenes	3.74		2.52		2.70		<1.4	U
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	3.46		<0.8	U	3.30		<0.8	U
Phenanthrene	3.48		3.01		3.28		<2.3	U
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	2.91		2.24		<1.1	U	<1.1	U
Pyrene	5.14		4.00		<1.4	U	<1.4	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	22.6		14.6		12.3		0.0	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5202.D	CSA5203.D	CSA5204.D	CSA5205.D
Sample ID	3532|03_20|HH-6|sw_s|hc|01	3532|03_20|HH-6|sw_s|hc|02	3532|03_20|HH-6|sw_m|hc|01	3532|03_20|HH-6|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 15:28	21-Mar-2020 16:36	21-Mar-2020 17:44	21-Mar-2020 18:52
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.03	1.04	1.03	1.02
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	3.50		2.41		2.45		<1.1	U
1-Methylnaphthalene	2.52		1.64		1.91		<1.4	U
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U

Surrogate Standards				
Naphthalene-d8	67	69	66	67
Acenaphthene-d10	74	75	74	78
Phenanthrene-d10	75	71	74	76
Chrysene-d12	71	65	69	71
Perylene-d12	82	76	80	81

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5206.D	CSA5207.D	CSA5208.D	CSA5209.D
Sample ID	3532|03_20|HH-6|sw_b|hc|01	3532|03_20|HH-6|sw_b|hc|02	3532|03_20|HH-1|sw_s|hc|01	3532|03_20|HH-1|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 20:00	21-Mar-2020 21:08	21-Mar-2020 22:16	21-Mar-2020 23:24
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.02	1.03	1.04	1.00
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	<2.9	U	<2.9	U	2.75	J	5.07	
C1-Naphthalenes	<1.4	U	<1.4	U	1.83		4.00	
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	<2.3	U	<2.3	U	2.67		4.25	
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	<1.1	U	<1.1	U	2.05		3.76	
Pyrene	<1.4	U	<1.4	U	3.51		7.07	
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	0.0		0.0		12.8		24.1	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5206.D	CSA5207.D	CSA5208.D	CSA5209.D
Sample ID	3532|03_20|HH-6|sw_b|hc|01	3532|03_20|HH-6|sw_b|hc|02	3532|03_20|HH-1|sw_s|hc|01	3532|03_20|HH-1|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073	ENV4073	ENV4073
Date Acquired	21-Mar-2020 20:00	21-Mar-2020 21:08	21-Mar-2020 22:16	21-Mar-2020 23:24
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.02	1.03	1.04	1.00
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	<1.1	U	<1.1	U	2.06		4.36	
1-Methylnaphthalene	<1.4	U	<1.4	U	0.86	J	2.05	
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	63		64		69		71	
Acenaphthene-d10	73		76		77		78	
Phenanthrene-d10	73		74		78		79	
Chrysene-d12	67		71		75		74	
Perylene-d12	77		79		84		85	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5210.D	CSA5211.D	CSA5212.D	CSA5213.D
Sample ID	3532|03_20|HH-1|sw_m|hc|01	3532|03_20|HH-1|sw_m|hc|02	3532|03_20|HH-1|sw_b|hc|01	3532|03_20|HH-1|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 2:16	26-Mar-2020 3:24	26-Mar-2020 4:32	26-Mar-2020 5:40
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	0.98	1.03	0.97	1.01
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.2	U	<1.1	U	<1.2	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.3	U
Naphthalene	2.70	J	<2.9	U	2.31	J	2.20	J
C1-Naphthalenes	2.01		<1.4	U	1.75		1.80	
C2-Naphthalenes	<5.9	U	<5.8	U	<6	U	<5.8	U
C3-Naphthalenes	<5.9	U	<5.8	U	<6	U	<5.8	U
C4-Naphthalenes	<5.9	U	<5.8	U	<6	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.6	U
Biphenyl	0.817	J	<5.1	U	<5.2	U	<5.1	U
Acenaphthylene	0.849	J	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.5	U	<1.4	U	<1.5	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.7	U	<1.6	U	<1.7	U	<1.6	U
C2-Fluorenes	<1.7	U	<1.6	U	<1.7	U	<1.6	U
C3-Fluorenes	<1.7	U	<1.6	U	<1.7	U	<1.6	U
Carbazole	<0.9	U	<0.8	U	<0.9	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	1.78	J	2.48		1.44	J	1.14	J
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3.1	U	<3	U	<3.1	U	<3	U
C3-Phenanthrenes/Anthracenes	<3.1	U	<3	U	<3.1	U	<3	U
C4-Phenanthrenes/Anthracenes	<3.1	U	<3	U	<3.1	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.4	U	<1.3	U	<1.4	U	<1.3	U
C3-Dibenzothiophenes	<1.4	U	<1.3	U	<1.4	U	<1.3	U
C4-Dibenzothiophenes	<1.4	U	<1.3	U	<1.4	U	<1.3	U
Fluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1.1	U	<1	U	<1.1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.8	U	<0.7	U	<0.8	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	1.26	J	1.06	J	1.03	J	<2.4	U
Benzo(k,j)fluoranthene	1.44	J	1.11	J	0.84	J	<2.5	U
Benzo(a)fluoranthene	<2.6	U	<2.5	U	<2.6	U	<2.5	U
Benzo(e)pyrene	1.32	J	1.13	J	<2.8	U	<2.7	U
Benzo(a)pyrene	1.11	J	<1.9	U	<2	U	<1.9	U
Perylene	1.20		<0.6	U	<0.7	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.2	U	<1.1	U	<1.2	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	1.08	J	<2.5	U	<2.6	U	<2.5	U
Total PAHs	15.5		5.78		7.37		5.14	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5210.D	CSA5211.D	CSA5212.D	CSA5213.D
Sample ID	3532|03_20|HH-1|sw_m|hc|01	3532|03_20|HH-1|sw_m|hc|02	3532|03_20|HH-1|sw_b|hc|01	3532|03_20|HH-1|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 2:16	26-Mar-2020 3:24	26-Mar-2020 4:32	26-Mar-2020 5:40
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	0.98	1.03	0.97	1.01
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	1.95		<1.1	U	1.65		1.78	
1-Methylnaphthalene	1.07	J	<1.4	U	0.980	J	0.922	J
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<1	U	<0.9	U	<1	U	<0.9	U
2-Methylphenanthrene	<1	U	<0.9	U	<1	U	<0.9	U
2-Methylanthracene	<1	U	<0.9	U	<1	U	<0.9	U
4/9-Methylphenanthrene	<1	U	<0.9	U	<1	U	<0.9	U
1-Methylphenanthrene	<1	U	<0.9	U	<1	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.2	U	<1.1	U	<1.2	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.4	U	<8.2	U	<8.4	U	<8.2	U
18a-Oleanane	<8.4	U	<8.2	U	<8.4	U	<8.2	U
C30-Hopane	<8.4	U	<8.2	U	<8.4	U	<8.2	U
C20-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U
C21-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U
C26(20S)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U
C28(20S)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U
C27(20R)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U
C28(20R)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.6	U

Surrogate Standards				
Naphthalene-d8	89	75	80	75
Acenaphthene-d10	86	76	78	74
Phenanthrene-d10	91	77	80	75
Chrysene-d12	83	74	76	71
Perylene-d12	83	76	80	75

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5214.D	CSA5215.D	CSA5216.D	CSA5217.D
Sample ID	3532|03_20|HH-2|sw_s|hc|01	3532|03_20|HH-2|sw_s|hc|02	3532|03_20|HH-2|sw_m|hc|01	3532|03_20|HH-2|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 7:56	26-Mar-2020 9:05	26-Mar-2020 10:13	26-Mar-2020 11:21
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.00	1.01	0.99	1.00
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.2	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	4.71		4.25		2.96		2.71	J
C1-Naphthalenes	4.35		3.64		2.39		1.93	
C2-Naphthalenes	<5.8	U	<5.8	U	<5.9	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.9	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.9	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.5	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	0.385	J	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	3.73		3.19		2.82		2.22	J
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3.1	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3.1	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3.1	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.4	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.4	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.4	U	<1.3	U
Fluoranthene	3.67		2.43		0.568	J	0.994	J
Pyrene	7.23		4.31		1.19	J	1.50	
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	24.1		17.8		9.93		9.36	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5214.D	CSA5215.D	CSA5216.D	CSA5217.D
Sample ID	3532|03_20|HH-2|sw_s|hc|01	3532|03_20|HH-2|sw_s|hc|02	3532|03_20|HH-2|sw_m|hc|01	3532|03_20|HH-2|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 7:56	26-Mar-2020 9:05	26-Mar-2020 10:13	26-Mar-2020 11:21
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.00	1.01	0.99	1.00
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	4.03		3.47		2.47		1.94	
1-Methylnaphthalene	2.53		2.00		1.11	J	0.958	J
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.2	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.3	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.3	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.3	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	83		83		77		73	
Acenaphthene-d10	84		83		76		74	
Phenanthrene-d10	83		87		77		76	
Chrysene-d12	79		83		73		73	
Perylene-d12	86		85		75		75	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5218.D	CSA5219.D	CSA5220.D	CSA5221.D
Sample ID	3532|03_20|HH-2|sw_b|hc|01	3532|03_20|HH-2|sw_b|hc|02	3532|03_20|HH-3|sw_s|hc|01	3532|03_20|HH-3|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 12:29	26-Mar-2020 13:37	26-Mar-2020 14:46	26-Mar-2020 15:54
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.01	1.00	0.97
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.2	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.4	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.4	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.4	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.4	U
Naphthalene	<2.9	U	2.74	J	4.45		4.48	
C1-Naphthalenes	<1.4	U	2.53		3.54		3.75	
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<6	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<6	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<6	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.7	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.2	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.5	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.7	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.7	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.7	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	3.95	
Anthracene	1.37		<0.8	U	<0.8	U	3.53	
Phenanthrene	1.52	J	1.57	J	3.25		3.75	
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3.1	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3.1	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3.1	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.4	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.4	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.4	U
Fluoranthene	<1.1	U	<1.1	U	2.43		3.47	
Pyrene	<1.4	U	<1.4	U	4.10		6.81	
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1.1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.8	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.5	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.6	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.6	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.8	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<2	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.7	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.2	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.6	U
Total PAHs	2.89		6.84		17.8		29.7	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5218.D	CSA5219.D	CSA5220.D	CSA5221.D
Sample ID	3532|03_20|HH-2|sw_b|hc|01	3532|03_20|HH-2|sw_b|hc|02	3532|03_20|HH-3|sw_s|hc|01	3532|03_20|HH-3|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 12:29	26-Mar-2020 13:37	26-Mar-2020 14:46	26-Mar-2020 15:54
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.01	1.00	0.97
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	<1.1	U	2.60		3.35		3.74	
1-Methylnaphthalene	<1.4	U	1.19	J	1.97		1.88	
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<1	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<1	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<1	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<1	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<1	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.2	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.4	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.4	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.4	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.7	U

Surrogate Standards				
Naphthalene-d8	88	76	82	80
Acenaphthene-d10	88	76	81	80
Phenanthrene-d10	89	77	83	80
Chrysene-d12	86	73	79	79
Perylene-d12	88	75	83	82

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5222.D	CSA5223.D	CSA5224.D	CSA5225.D
Sample ID	3532|03_20|HH-3|sw_m|hc|01	3532|03_20|HH-3|sw_m|hc|02	3532|03_20|HH-3|sw_b|hc|01	3532|03_20|HH-3|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 18:10	26-Mar-2020 19:18	26-Mar-2020 20:26	26-Mar-2020 21:34
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	0.98	0.99	0.95	0.93
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.2	U	<1.2	U	<1.2	U	<1.2	U
C1-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.5	U
C2-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.5	U
C3-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.5	U
C4-Decalins	<2.3	U	<2.3	U	<2.4	U	<2.5	U
Naphthalene	<3	U	2.29	J	2.90	J	3.76	
C1-Naphthalenes	<1.4	U	2.00		2.76		1.08	J
C2-Naphthalenes	<5.9	U	<5.9	U	<6.1	U	<6.3	U
C3-Naphthalenes	<5.9	U	<5.9	U	<6.1	U	<6.3	U
C4-Naphthalenes	<5.9	U	<5.9	U	<6.1	U	<6.3	U
Benzothiophene	<1.3	U	<1.3	U	<1.4	U	<1.4	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.8	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.8	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.8	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.7	U	<2.8	U
Biphenyl	<5.2	U	<5.1	U	<5.4	U	<5.5	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.3	U
Acenaphthene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
Dibenzofuran	<1.2	U	<1.2	U	<1.3	U	<1.3	U
Fluorene	<0.8	U	<0.8	U	<0.9	U	<0.9	U
C1-Fluorenes	<1.7	U	<1.6	U	<1.7	U	<1.7	U
C2-Fluorenes	<1.7	U	<1.6	U	<1.7	U	<1.7	U
C3-Fluorenes	<1.7	U	<1.6	U	<1.7	U	<1.7	U
Carbazole	<0.9	U	<0.8	U	<0.9	U	<0.9	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	1.99	J	2.09	J	2.51		<2.4	U
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.8	U
C2-Phenanthrenes/Anthracenes	<3.1	U	<3.1	U	<3.2	U	<3.3	U
C3-Phenanthrenes/Anthracenes	<3.1	U	<3.1	U	<3.2	U	<3.3	U
C4-Phenanthrenes/Anthracenes	<3.1	U	<3.1	U	<3.2	U	<3.3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.9	U	<0.9	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C3-Dibenzothiophenes	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C4-Dibenzothiophenes	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Fluoranthene	<1.1	U	0.948	J	1.32		<1.2	U
Pyrene	<1.4	U	1.24	J	2.13		<1.5	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.6	U	<2.7	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.6	U	<2.7	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.6	U	<2.7	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.6	U	<2.7	U
Naphthobenzothiophene	<1.1	U	<1	U	<1.1	U	<1.1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.2	U	<2.2	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.2	U	<2.2	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.2	U	<2.2	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.2	U	<2.2	U
Benz(a)anthracene	<0.8	U	<0.7	U	<0.8	U	<0.8	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.9	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.7	U	<1.7	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.7	U	<1.7	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.7	U	<1.7	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.7	U	<1.7	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.5	U	<2.6	U
Benzo(k,j)fluoranthene	<2.6	U	<2.5	U	<2.6	U	<2.7	U
Benzo(a)fluoranthene	<2.6	U	<2.5	U	<2.6	U	<2.7	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.8	U	<2.9	U
Benzo(a)pyrene	<2	U	<1.9	U	<2	U	<2.1	U
Perylene	<0.6	U	<0.6	U	<0.7	U	<0.7	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.5	U	<1.5	U
Dibenzo(a,h)anthracene	<1.2	U	<1.1	U	<1.2	U	<1.2	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.4	U	<2.4	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.4	U	<2.4	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.4	U	<2.4	U
Benzo(g,h,i)perylene	<2.6	U	<2.5	U	<2.6	U	<2.7	U
Total PAHs	1.99		8.57		11.6		4.84	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5222.D	CSA5223.D	CSA5224.D	CSA5225.D
Sample ID	3532|03_20|HH-3|sw_m|hc|01	3532|03_20|HH-3|sw_m|hc|02	3532|03_20|HH-3|sw_b|hc|01	3532|03_20|HH-3|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4074
Date Acquired	26-Mar-2020 18:10	26-Mar-2020 19:18	26-Mar-2020 20:26	26-Mar-2020 21:34
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	0.98	0.99	0.95	0.93
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	<1.1	U	1.95		2.62		1.13	J
1-Methylnaphthalene	<1.4	U	1.06	J	1.53		0.50	J
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.6	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<1	U	<0.9	U	<1	U	<1	U
2-Methylphenanthrene	<1	U	<0.9	U	<1	U	<1	U
2-Methylanthracene	<1	U	<0.9	U	<1	U	<1	U
4/9-Methylphenanthrene	<1	U	<0.9	U	<1	U	<1	U
1-Methylphenanthrene	<1	U	<0.9	U	<1	U	<1	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.8	U	<1.8	U
Retene	<1.6	U	<1.6	U	<1.7	U	<1.7	U
2-Methylfluoranthene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.5	U
C29-Hopane	<8.4	U	<8.3	U	<8.6	U	<8.8	U
18a-Oleanane	<8.4	U	<8.3	U	<8.6	U	<8.8	U
C30-Hopane	<8.4	U	<8.3	U	<8.6	U	<8.8	U
C20-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U
C21-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U
C26(20S)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U
C26(20R)/C27(20S)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U
C28(20S)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U
C27(20R)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U
C28(20R)-TAS	<2.7	U	<2.6	U	<2.7	U	<2.8	U

Surrogate Standards				
Naphthalene-d8	62	76	82	85
Acenaphthene-d10	62	76	81	85
Phenanthrene-d10	64	82	85	86
Chrysene-d12	64	75	79	82
Perylene-d12	63	76	82	84

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5226.D	CSA5227.D	CSA5228.D	CSA5229.D	CSA5230.D
Sample ID	3532|03_20|EB|diw|hc|01	3532|03_20|FB|diw|hc|01	3532|03_20|DI|diw|hc|01	3532|03_20|CH2Cl2|hc|01	3532|03_20|DI|hc|01
Matrix	Water	Water	Water	Reagent Blank	Reagent Blank
Species	NA	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4075	ENV4075
Date Acquired	26-Mar-2020 22:42	26-Mar-2020 23:50	27-Mar-2020 0:58	27-Mar-2020 7:47	27-Mar-2020 8:55
Method	SOP1006	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	0.97	1.04	0.06	0.04
Dilution	1X	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.2	U	<1.1	U	<19	U	<28.5	U
C1-Decalins	<2.3	U	<2.4	U	<2.3	U	<38.1	U	<57.1	U
C2-Decalins	<2.3	U	<2.4	U	<2.3	U	<38.1	U	<57.1	U
C3-Decalins	<2.3	U	<2.4	U	<2.3	U	<38.1	U	<57.1	U
C4-Decalins	<2.3	U	<2.4	U	<2.3	U	<38.1	U	<57.1	U
Naphthalene	3.21		<3	U	2.65	J	<48.5	U	<72.7	U
C1-Naphthalenes	2.32		<1.4	U	2.00		<22.7	U	<34.1	U
C2-Naphthalenes	<5.8	U	<6	U	<5.8	U	<96.9	U	<145.4	U
C3-Naphthalenes	<5.8	U	<6	U	<5.8	U	<96.9	U	<145.4	U
C4-Naphthalenes	<5.8	U	<6	U	<5.8	U	<96.9	U	<145.4	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<21.4	U	<32.2	U
C1-Benzothiophenes	<2.6	U	<2.7	U	<2.6	U	<42.9	U	<64.3	U
C2-Benzothiophenes	<2.6	U	<2.7	U	<2.6	U	<42.9	U	<64.3	U
C3-Benzothiophenes	<2.6	U	<2.7	U	<2.6	U	<42.9	U	<64.3	U
C4-Benzothiophenes	<2.6	U	<2.7	U	<2.6	U	<42.9	U	<64.3	U
Biphenyl	<5.1	U	<5.2	U	<5.1	U	<84.8	U	<127.2	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<19.6	U	<29.4	U
Acenaphthene	<1.4	U	<1.5	U	<1.4	U	<24	U	<35.9	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<19.8	U	<29.7	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<13.6	U	<20.3	U
C1-Fluorenes	<1.6	U	<1.7	U	<1.6	U	<27.1	U	<40.7	U
C2-Fluorenes	<1.6	U	<1.7	U	<1.6	U	<27.1	U	<40.7	U
C3-Fluorenes	<1.6	U	<1.7	U	<1.6	U	<27.1	U	<40.7	U
Carbazole	<0.8	U	<0.9	U	<0.8	U	<13.9	U	<20.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<12.8	U	<19.2	U
Phenanthrene	1.88	J	1.27	J	1.47	J	<37.7	U	<56.6	U
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<11.7	U	<17.5	U
C2-Phenanthrenes/Anthracenes	<3	U	<3.1	U	<3	U	<50.5	U	<75.8	U
C3-Phenanthrenes/Anthracenes	<3	U	<3.1	U	<3	U	<50.5	U	<75.8	U
C4-Phenanthrenes/Anthracenes	<3	U	<3.1	U	<3	U	<50.5	U	<75.8	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<13.7	U	<20.6	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<11.2	U	<16.7	U
C2-Dibenzothiophenes	<1.3	U	<1.4	U	<1.3	U	<22.3	U	<33.5	U
C3-Dibenzothiophenes	<1.3	U	<1.4	U	<1.3	U	<22.3	U	<33.5	U
C4-Dibenzothiophenes	<1.3	U	<1.4	U	<1.3	U	<22.3	U	<33.5	U
Fluoranthene	0.883	J	<1.1	U	<1.1	U	<18.2	U	<27.4	U
Pyrene	1.29	J	<1.4	U	<1.4	U	<22.9	U	<34.3	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<41.1	U	<61.7	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<41.1	U	<61.7	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<41.1	U	<61.7	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<41.1	U	<61.7	U
Naphthobenzothiophene	<1	U	<1.1	U	<1	U	<17.2	U	<25.8	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<34.4	U	<51.7	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<34.4	U	<51.7	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<34.4	U	<51.7	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<34.4	U	<51.7	U
Benz(a)anthracene	<0.7	U	<0.8	U	<0.7	U	<12.3	U	<18.4	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<13.3	U	<20	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<26.6	U	<40	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<26.6	U	<40	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<26.6	U	<40	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<26.6	U	<40	U
Benzo(b)fluoranthene	<2.4	U	<2.5	U	<2.4	U	<39.7	U	<59.6	U
Benzo(k,j)fluoranthene	<2.5	U	<2.6	U	<2.5	U	<41.8	U	<62.8	U
Benzo(a)fluoranthene	<2.5	U	<2.6	U	<2.5	U	<41.8	U	<62.8	U
Benzo(e)pyrene	<2.7	U	<2.8	U	<2.7	U	<44.9	U	<67.3	U
Benzo(a)pyrene	<1.9	U	<2	U	<1.9	U	<31.9	U	<47.8	U
Perylene	<0.6	U	<0.7	U	<0.6	U	<10.6	U	<15.9	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<23.2	U	<34.8	U
Dibenzo(a,h)anthracene	<1.1	U	<1.2	U	<1.1	U	<18.9	U	<28.4	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<37.9	U	<56.8	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<37.9	U	<56.8	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<37.9	U	<56.8	U
Benzo(g,h,i)perylene	<2.5	U	<2.6	U	<2.5	U	<41.8	U	<62.7	U
Total PAHs	9.58		1.27		6.11		0.0		0.0	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5226.D	CSA5227.D	CSA5228.D	CSA5229.D	CSA5230.D
Sample ID	3532|03_20|EB|diw|hc|01	3532|03_20|FB|diw|hc|01	3532|03_20|DI|diw|hc|01	3532|03_20|CH2Cl2|hc|01	3532|03_20|DI|hc|01
Matrix	Water	Water	Water	Reagent Blank	Reagent Blank
Species	NA	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/17/2020	03/17/2020	03/17/2020	03/17/2020	03/17/2020
Extraction Date	03/19/2020	03/19/2020	03/19/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4074	ENV4074	ENV4074	ENV4075	ENV4075
Date Acquired	26-Mar-2020 22:42	26-Mar-2020 23:50	27-Mar-2020 0:58	27-Mar-2020 7:47	27-Mar-2020 8:55
Method	SOP1006	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	0.97	1.04	0.06	0.04
Dilution	1X	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes										
2-Methylnaphthalene	2.19		<1.1	U	1.83		<18.4	U	<27.5	U
1-Methylnaphthalene	1.30	J	<1.5	U	1.17	J	<23.6	U	<35.5	U
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<11.6	U	<17.4	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<11.1	U	<16.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<24.5	U	<36.8	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<16.1	U	<24.1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<16.1	U	<24.1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<16.1	U	<24.1	U
3-Methylphenanthrene	<0.9	U	<1	U	<0.9	U	<15.6	U	<23.5	U
2-Methylphenanthrene	<0.9	U	<1	U	<0.9	U	<15.6	U	<23.5	U
2-Methylanthracene	<0.9	U	<1	U	<0.9	U	<15.6	U	<23.5	U
4/9-Methylphenanthrene	<0.9	U	<1	U	<0.9	U	<15.6	U	<23.5	U
1-Methylphenanthrene	<0.9	U	<1	U	<0.9	U	<15.6	U	<23.5	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<27.8	U	<41.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<26.6	U	<39.8	U
2-Methylfluoranthene	<1.1	U	<1.2	U	<1.1	U	<19.1	U	<28.6	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<22.9	U	<34.3	U
C29-Hopane	<8.2	U	<8.4	U	<8.2	U	<136.6	U	<204.8	U
18a-Oleanane	<8.2	U	<8.4	U	<8.2	U	<136.6	U	<204.8	U
C30-Hopane	<8.2	U	<8.4	U	<8.2	U	<136.6	U	<204.8	U
C20-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U
C21-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U
C26(20S)-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U
C28(20S)-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U
C27(20R)-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U
C28(20R)-TAS	<2.6	U	<2.7	U	<2.6	U	<43.3	U	<65	U

Surrogate Standards					
Naphthalene-d8	82	80	80	93	98
Acenaphthene-d10	81	80	80	91	94
Phenanthrene-d10	82	82	82	90	91
Chrysene-d12	74	77	79	86	88
Perylene-d12	80	79	82	82	84

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5247.D	CSA5248.D	CSA5249.D	CSA5250.D
Sample ID	3532|03_20|HH-5|sw_s|hc|01	3532|03_20|HH-5|sw_s|hc|02	3532|03_20|HH-5|sw_m|hc|01	3532|03_20|HH-5|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Date	03/20/2020	03/20/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075	ENV4075	ENV4075
Date Acquired	27-Mar-2020 10:03	27-Mar-2020 11:11	27-Mar-2020 12:20	27-Mar-2020 14:36
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.05	1.04	1.04
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	5.14		4.17		2.31	J	2.27	J
C1-Naphthalenes	3.84		3.38		2.11		1.32	J
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	3.85		3.60		1.69	J	1.24	J
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	3.87		3.44		<1.1	U	<1.1	U
Pyrene	7.10		5.53		<1.4	U	<1.4	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	23.8		20.1		6.11		4.83	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5247.D	CSA5248.D	CSA5249.D	CSA5250.D
Sample ID	3532|03_20|HH-5|sw_s|hc|01	3532|03_20|HH-5|sw_s|hc|02	3532|03_20|HH-5|sw_m|hc|01	3532|03_20|HH-5|sw_m|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Date	03/20/2020	03/20/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075	ENV4075	ENV4075
Date Acquired	27-Mar-2020 10:03	27-Mar-2020 11:11	27-Mar-2020 12:20	27-Mar-2020 14:36
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.05	1.04	1.04
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	3.75		3.30		2.23		1.41	
1-Methylnaphthalene	2.03		1.78		0.937	J	0.572	J
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	80		87		88		86	
Acenaphthene-d10	79		83		85		85	
Phenanthrene-d10	82		86		86		86	
Chrysene-d12	77		84		84		84	
Perylene-d12	83		87		87		86	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5251.D	CSA5252.D	CSA5253.D	CSA5254.D
Sample ID	3532|03_20|HH-5|sw_b|hc|01	3532|03_20|HH-5|sw_b|hc|02	3532|03_20|HH-7|sw_s|hc|01	3532|03_20|HH-7|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Date	03/20/2020	03/20/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075	ENV4075	ENV4075
Date Acquired	27-Mar-2020 15:44	27-Mar-2020 16:52	27-Mar-2020 18:00	27-Mar-2020 19:08
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.04	1.02	1.02
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	1.92	J	2.01	J	3.58		2.68	J
C1-Naphthalenes	1.15	J	1.12	J	3.13		2.78	
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Phenanthrene	<2.3	U	<2.3	U	3.66		3.75	
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	<1.1	U	<1.1	U	2.30		3.39	
Pyrene	<1.4	U	<1.4	U	3.80		5.40	
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	3.07		3.13		16.5		18.0	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5251.D	CSA5252.D	CSA5253.D	CSA5254.D
Sample ID	3532|03_20|HH-5|sw_b|hc|01	3532|03_20|HH-5|sw_b|hc|02	3532|03_20|HH-7|sw_s|hc|01	3532|03_20|HH-7|sw_s|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Date	03/20/2020	03/20/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075	ENV4075	ENV4075
Date Acquired	27-Mar-2020 15:44	27-Mar-2020 16:52	27-Mar-2020 18:00	27-Mar-2020 19:08
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.04	1.04	1.02	1.02
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	1.15		1.23		3.01		2.73	
1-Methylnaphthalene	0.579	J	0.432	J	1.70		1.45	
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	81		86		87		85	
Acenaphthene-d10	79		81		86		86	
Phenanthrene-d10	79		83		87		88	
Chrysene-d12	80		81		85		86	
Perylene-d12	79		84		87		88	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5255.D	CSA5256.D	CSA5257.D	CSA5258.D
Sample ID	3532|03_20|HH-7|sw_m|hc|01	3532|03_20|HH-7|sw_m|hc|02	3532|03_20|HH-7|sw_b|hc|01	3532|03_20|HH-7|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Date	03/20/2020	03/20/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075	ENV4075	ENV4075
Date Acquired	27-Mar-2020 20:16	27-Mar-2020 21:24	27-Mar-2020 22:32	27-Mar-2020 23:40
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.05	1.05	1.05	1.05
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
cis/trans Decalin	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C4-Decalins	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Naphthalene	2.78	J	2.43	J	1.96	J	1.92	J
C1-Naphthalenes	1.75		2.62		1.08	J	1.24	J
C2-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C3-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
C4-Naphthalenes	<5.8	U	<5.8	U	<5.8	U	<5.8	U
Benzothiophene	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C1-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C2-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C3-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C4-Benzothiophenes	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Biphenyl	<5.1	U	<5.1	U	<5.1	U	<5.1	U
Acenaphthylene	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Acenaphthene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzofuran	<1.2	U	<1.2	U	<1.2	U	<1.2	U
Fluorene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Fluorenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Carbazole	<0.8	U	<0.8	U	<0.8	U	<0.8	U
Anthracene	<0.8	U	2.85		<0.8	U	<0.8	U
Phenanthrene	2.51		3.08		<2.3	U	<2.3	U
C1-Phenanthrenes/Anthracenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C3-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
C4-Phenanthrenes/Anthracenes	<3	U	<3	U	<3	U	<3	U
Dibenzothiophene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Dibenzothiophenes	<0.7	U	<0.7	U	<0.7	U	<0.7	U
C2-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C3-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
C4-Dibenzothiophenes	<1.3	U	<1.3	U	<1.3	U	<1.3	U
Fluoranthene	0.61	J	0.81	J	<1.1	U	<1.1	U
Pyrene	1.20	J	1.40		<1.4	U	<1.4	U
C1-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C2-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C3-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
C4-Fluoranthenes/Pyrenes	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Naphthobenzothiophene	<1	U	<1	U	<1	U	<1	U
C1-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C2-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C3-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
C4-Naphthobenzothiophenes	<2.1	U	<2.1	U	<2.1	U	<2.1	U
Benz(a)anthracene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
Chrysene/Triphenylene	<0.8	U	<0.8	U	<0.8	U	<0.8	U
C1-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C2-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C3-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
C4-Chrysenes	<1.6	U	<1.6	U	<1.6	U	<1.6	U
Benzo(b)fluoranthene	<2.4	U	<2.4	U	<2.4	U	<2.4	U
Benzo(k,j)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(a)fluoranthene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Benzo(e)pyrene	<2.7	U	<2.7	U	<2.7	U	<2.7	U
Benzo(a)pyrene	<1.9	U	<1.9	U	<1.9	U	<1.9	U
Perylene	<0.6	U	<0.6	U	<0.6	U	<0.6	U
Indeno(1,2,3-c,d)pyrene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
Dibenzo(a,h)anthracene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
C1-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C2-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
C3-Dibenzo(a,h)anthracenes	<2.3	U	<2.3	U	<2.3	U	<2.3	U
Benzo(g,h,i)perylene	<2.5	U	<2.5	U	<2.5	U	<2.5	U
Total PAHs	8.84		13.2		3.05		3.16	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Laboratory ID	CSA5255.D	CSA5256.D	CSA5257.D	CSA5258.D
Sample ID	3532|03_20|HH-7|sw_m|hc|01	3532|03_20|HH-7|sw_m|hc|02	3532|03_20|HH-7|sw_b|hc|01	3532|03_20|HH-7|sw_b|hc|02
Matrix	Water	Water	Water	Water
Species	NA	NA	NA	NA
Collection Date	03/13/2020	03/13/2020	03/13/2020	03/13/2020
Received Date	03/18/2020	03/18/2020	03/18/2020	03/18/2020
Extraction Date	03/20/2020	03/20/2020	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075	ENV4075	ENV4075
Date Acquired	27-Mar-2020 20:16	27-Mar-2020 21:24	27-Mar-2020 22:32	27-Mar-2020 23:40
Method	SOP1006	SOP1006	SOP1006	SOP1006
Sample Volume (L)	1.05	1.05	1.05	1.05
Dilution	1X	1X	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q	Su. Corrected Conc. (ng/L)	Q
Individual Alkyl Isomers and Hopanes								
2-Methylnaphthalene	1.58		2.59		1.17		1.24	
1-Methylnaphthalene	1.07	J	1.35	J	0.452	J	0.614	J
2,6-Dimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1,6,7-Trimethylnaphthalene	<0.7	U	<0.7	U	<0.7	U	<0.7	U
1-Methylfluorene	<1.5	U	<1.5	U	<1.5	U	<1.5	U
4-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
2/3-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
1-Methyldibenzothiophene	<1	U	<1	U	<1	U	<1	U
3-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
2-Methylanthracene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
4/9-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
1-Methylphenanthrene	<0.9	U	<0.9	U	<0.9	U	<0.9	U
3,6-Dimethylphenanthrene	<1.7	U	<1.7	U	<1.7	U	<1.7	U
Retene	<1.6	U	<1.6	U	<1.6	U	<1.6	U
2-Methylfluoranthene	<1.1	U	<1.1	U	<1.1	U	<1.1	U
Benzo(b)fluorene	<1.4	U	<1.4	U	<1.4	U	<1.4	U
C29-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
18a-Oleanane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C30-Hopane	<8.2	U	<8.2	U	<8.2	U	<8.2	U
C20-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C21-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C26(20R)/C27(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20S)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C27(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
C28(20R)-TAS	<2.6	U	<2.6	U	<2.6	U	<2.6	U
Surrogate Standards								
Naphthalene-d8	76		87		84		91	
Acenaphthene-d10	73		86		82		88	
Phenanthrene-d10	74		87		83		87	
Chrysene-d12	74		83		81		84	
Perylene-d12	73		86		84		87	

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4073A.D
Sample ID	Method Blank
Matrix	Water
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	03/18/2020
Extraction Batch	ENV4073
Date Acquired	20-Mar-2020 20:10
Method	SOP1006
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	3X MDL	Actual MDL
cis/trans Decalin	<1.1	U	3.43	1.14
C1-Decalins	<2.3	U	6.85	2.28
C2-Decalins	<2.3	U	6.85	2.28
C3-Decalins	<2.3	U	6.85	2.28
C4-Decalins	<2.3	U	6.85	2.28
Naphthalene	<2.9	U	8.72	2.91
C1-Naphthalenes	<1.4	U	4.09	1.36
C2-Naphthalenes	<5.8	U	17.4	5.82
C3-Naphthalenes	<5.8	U	17.4	5.82
C4-Naphthalenes	<5.8	U	17.45	5.82
Benzothiophene	<1.3	U	3.86	1.29
C1-Benzothiophenes	<2.6	U	7.72	2.57
C2-Benzothiophenes	<2.6	U	7.72	2.57
C3-Benzothiophenes	<2.6	U	7.72	2.57
C4-Benzothiophenes	<2.6	U	7.72	2.57
Biphenyl	<5.1	U	15.3	5.09
Acenaphthylene	<1.2	U	3.52	1.17
Acenaphthene	<1.4	U	4.31	1.44
Dibenzofuran	<1.2	U	3.57	1.19
Fluorene	<0.8	U	2.44	0.813
C1-Fluorenes	<1.6	U	4.88	1.63
C2-Fluorenes	<1.6	U	4.88	1.63
C3-Fluorenes	<1.6	U	4.88	1.63
Carbazole	<0.8	U	2.50	0.833
Anthracene	<0.8	U	2.30	0.767
Phenanthrene	<2.3	U	6.79	2.26
C1-Phenanthrenes/Anthracenes	<0.7	U	2.10	0.701
C2-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
C3-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
C4-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
Dibenzothiophene	<0.8	U	2.47	0.824
C1-Dibenzothiophenes	<0.7	U	2.01	0.670
C2-Dibenzothiophenes	<1.3	U	4.02	1.34
C3-Dibenzothiophenes	<1.3	U	4.02	1.34
C4-Dibenzothiophenes	<1.3	U	4.02	1.34
Fluoranthene	<1.1	U	3.28	1.09
Pyrene	<1.4	U	4.12	1.37
C1-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C2-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C3-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C4-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
Naphthobenzothiophene	<1	U	3.10	1.03
C1-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C2-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C3-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C4-Naphthobenzothiophenes	<2.1	U	6.20	2.07
Benz(a)anthracene	<0.7	U	2.21	0.737
Chrysene/Triphenylene	<0.8	U	2.40	0.799
C1-Chrysenes	<1.6	U	4.80	1.60
C2-Chrysenes	<1.6	U	4.80	1.60
C3-Chrysenes	<1.6	U	4.80	1.60
C4-Chrysenes	<1.6	U	4.80	1.60
Benzo(b)fluoranthene	<2.4	U	7.15	2.38
Benzo(k,j)fluoranthene	<2.5	U	7.53	2.51
Benzo(a)fluoranthene	<2.5	U	7.53	2.51
Benzo(e)pyrene	<2.7	U	8.08	2.69
Benzo(a)pyrene	<1.9	U	5.74	1.91
Perylene	<0.6	U	1.90	0.635
Indeno(1,2,3-c,d)pyrene	<1.4	U	4.18	1.39
Dibenzo(a,h)anthracene	<1.1	U	3.41	1.14
C1-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
C2-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
C3-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
Benzo(g,h,i)perylene	<2.5	U	7.53	2.51
Total PAHs	0.0			

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4073A.D
Sample ID	Method Blank
Matrix	Water
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	03/18/2020
Extraction Batch	ENV4073
Date Acquired	20-Mar-2020 20:10
Method	SOP1006
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	3X MDL	Actual MDL
Individual Alkyl Isomers and Hopanes				
2-Methylnaphthalene	<1.1	U	3.31	1.10
1-Methylnaphthalene	<1.4	U	4.26	1.42
2,6-Dimethylnaphthalene	<0.7	U	2.09	0.696
1,6,7-Trimethylnaphthalene	<0.7	U	2.00	0.668
1-Methylfluorene	<1.5	U	4.41	1.47
4-Methyldibenzothiophene	<1	U	2.90	0.966
2/3-Methyldibenzothiophene	<1	U	2.90	0.966
1-Methyldibenzothiophene	<1	U	2.90	0.966
3-Methylphenanthrene	<0.9	U	2.82	0.939
2-Methylphenanthrene	<0.9	U	2.82	0.939
2-Methylanthracene	<0.9	U	2.82	0.939
4/9-Methylphenanthrene	<0.9	U	2.82	0.939
1-Methylphenanthrene	<0.9	U	2.82	0.939
3,6-Dimethylphenanthrene	<1.7	U	5.01	1.67
Retene	<1.6	U	4.78	1.59
2-Methylfluoranthene	<1.1	U	3.44	1.15
Benzo(b)fluorene	<1.4	U	4.12	1.37
C29-Hopane	<8.2	U	24.6	8.19
18a-Oleanane	<8.2	U	24.6	8.19
C30-Hopane	<8.2	U	24.6	8.19
C20-TAS	<2.6	U	7.80	2.60
C21-TAS	<2.6	U	7.80	2.60
C26(20S)-TAS	<2.6	U	7.80	2.60
C26(20R)/C27(20S)-TAS	<2.6	U	7.80	2.60
C28(20S)-TAS	<2.6	U	7.80	2.60
C27(20R)-TAS	<2.6	U	7.80	2.60
C28(20R)-TAS	<2.6	U	7.80	2.60

Surrogate Standards	
Naphthalene-d8	76
Acenaphthene-d10	79
Phenanthrene-d10	82
Chrysene-d12	83
Perylene-d12	91

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4074A.D
Sample ID	Method Blank
Matrix	Water
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	03/19/2020
Extraction Batch	ENV4074
Date Acquired	25-Mar-2020 22:51
Method	SOP1006
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	3X MDL	Actual MDL
cis/trans Decalin	<1.1	U	3.43	1.14
C1-Decalins	<2.3	U	6.85	2.28
C2-Decalins	<2.3	U	6.85	2.28
C3-Decalins	<2.3	U	6.85	2.28
C4-Decalins	<2.3	U	6.85	2.28
Naphthalene	<2.9	U	8.72	2.91
C1-Naphthalenes	<1.4	U	4.09	1.36
C2-Naphthalenes	<5.8	U	17.4	5.82
C3-Naphthalenes	<5.8	U	17.4	5.82
C4-Naphthalenes	<5.8	U	17.45	5.82
Benzothiophene	<1.3	U	3.86	1.29
C1-Benzothiophenes	<2.6	U	7.72	2.57
C2-Benzothiophenes	<2.6	U	7.72	2.57
C3-Benzothiophenes	<2.6	U	7.72	2.57
C4-Benzothiophenes	<2.6	U	7.72	2.57
Biphenyl	<5.1	U	15.3	5.09
Acenaphthylene	<1.2	U	3.52	1.17
Acenaphthene	<1.4	U	4.31	1.44
Dibenzofuran	<1.2	U	3.57	1.19
Fluorene	<0.8	U	2.44	0.813
C1-Fluorenes	<1.6	U	4.88	1.63
C2-Fluorenes	<1.6	U	4.88	1.63
C3-Fluorenes	<1.6	U	4.88	1.63
Carbazole	<0.8	U	2.50	0.833
Anthracene	1.62		2.30	0.767
Phenanthrene	1.84	J	6.79	2.26
C1-Phenanthrenes/Anthracenes	<0.7	U	2.10	0.701
C2-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
C3-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
C4-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
Dibenzothiophene	<0.8	U	2.47	0.824
C1-Dibenzothiophenes	<0.7	U	2.01	0.670
C2-Dibenzothiophenes	<1.3	U	4.02	1.34
C3-Dibenzothiophenes	<1.3	U	4.02	1.34
C4-Dibenzothiophenes	<1.3	U	4.02	1.34
Fluoranthene	<1.1	U	3.28	1.09
Pyrene	<1.4	U	4.12	1.37
C1-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C2-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C3-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C4-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
Naphthobenzothiophene	<1	U	3.10	1.03
C1-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C2-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C3-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C4-Naphthobenzothiophenes	<2.1	U	6.20	2.07
Benz(a)anthracene	<0.7	U	2.21	0.737
Chrysene/Triphenylene	<0.8	U	2.40	0.799
C1-Chrysenes	<1.6	U	4.80	1.60
C2-Chrysenes	<1.6	U	4.80	1.60
C3-Chrysenes	<1.6	U	4.80	1.60
C4-Chrysenes	<1.6	U	4.80	1.60
Benzo(b)fluoranthene	2.38		7.15	2.38
Benzo(k,j)fluoranthene	2.26	J	7.53	2.51
Benzo(a)fluoranthene	<2.5	U	7.53	2.51
Benzo(e)pyrene	2.86		8.08	2.69
Benzo(a)pyrene	2.04		5.74	1.91
Perylene	2.43	*	1.90	0.635
Indeno(1,2,3-c,d)pyrene	<1.4	U	4.18	1.39
Dibenzo(a,h)anthracene	<1.1	U	3.41	1.14
C1-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
C2-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
C3-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
Benzo(g,h,i)perylene	1.41	J	7.53	2.51
Total PAHs	16.8			

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4074A.D
Sample ID	Method Blank
Matrix	Water
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	03/19/2020
Extraction Batch	ENV4074
Date Acquired	25-Mar-2020 22:51
Method	SOP1006
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	3X MDL	Actual MDL
Individual Alkyl Isomers and Hopanes				
2-Methylnaphthalene	<1.1	U	3.31	1.10
1-Methylnaphthalene	<1.4	U	4.26	1.42
2,6-Dimethylnaphthalene	<0.7	U	2.09	0.696
1,6,7-Trimethylnaphthalene	<0.7	U	2.00	0.668
1-Methylfluorene	<1.5	U	4.41	1.47
4-Methyldibenzothiophene	<1	U	2.90	0.966
2/3-Methyldibenzothiophene	<1	U	2.90	0.966
1-Methyldibenzothiophene	<1	U	2.90	0.966
3-Methylphenanthrene	<0.9	U	2.82	0.939
2-Methylphenanthrene	<0.9	U	2.82	0.939
2-Methylanthracene	<0.9	U	2.82	0.939
4/9-Methylphenanthrene	<0.9	U	2.82	0.939
1-Methylphenanthrene	<0.9	U	2.82	0.939
3,6-Dimethylphenanthrene	<1.7	U	5.01	1.67
Retene	<1.6	U	4.78	1.59
2-Methylfluoranthene	<1.1	U	3.44	1.15
Benzo(b)fluorene	<1.4	U	4.12	1.37
C29-Hopane	<8.2	U	24.6	8.19
18a-Oleanane	<8.2	U	24.6	8.19
C30-Hopane	<8.2	U	24.6	8.19
C20-TAS	<2.6	U	7.80	2.60
C21-TAS	<2.6	U	7.80	2.60
C26(20S)-TAS	<2.6	U	7.80	2.60
C26(20R)/C27(20S)-TAS	<2.6	U	7.80	2.60
C28(20S)-TAS	<2.6	U	7.80	2.60
C27(20R)-TAS	<2.6	U	7.80	2.60
C28(20R)-TAS	<2.6	U	7.80	2.60

Surrogate Standards	
Naphthalene-d8	88
Acenaphthene-d10	89
Phenanthrene-d10	93
Chrysene-d12	91
Perylene-d12	91

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4075A.D
Sample ID	Method Blank
Matrix	Water
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	03/20/2020
Extraction Batch	ENV4075
Date Acquired	27-Mar-2020 4:23
Method	SOP1006
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	3X MDL	Actual MDL
cis/trans Decalin	<1.1	U	3.43	1.14
C1-Decalins	<2.3	U	6.85	2.28
C2-Decalins	<2.3	U	6.85	2.28
C3-Decalins	<2.3	U	6.85	2.28
C4-Decalins	<2.3	U	6.85	2.28
Naphthalene	<2.9	U	8.72	2.91
C1-Naphthalenes	<1.4	U	4.09	1.36
C2-Naphthalenes	<5.8	U	17.4	5.82
C3-Naphthalenes	<5.8	U	17.4	5.82
C4-Naphthalenes	<5.8	U	17.4	5.82
Benzothiophene	<1.3	U	3.86	1.29
C1-Benzothiophenes	<2.6	U	7.72	2.57
C2-Benzothiophenes	<2.6	U	7.72	2.57
C3-Benzothiophenes	<2.6	U	7.72	2.57
C4-Benzothiophenes	<2.6	U	7.72	2.57
Biphenyl	<5.1	U	15.3	5.09
Acenaphthylene	<1.2	U	3.52	1.17
Acenaphthene	<1.4	U	4.31	1.44
Dibenzofuran	<1.2	U	3.57	1.19
Fluorene	<0.8	U	2.44	0.813
C1-Fluorenes	<1.6	U	4.88	1.63
C2-Fluorenes	<1.6	U	4.88	1.63
C3-Fluorenes	<1.6	U	4.88	1.63
Carbazole	<0.8	U	2.50	0.833
Anthracene	<0.8	U	2.30	0.767
Phenanthrene	1.3	J	6.79	2.26
C1-Phenanthrenes/Anthracenes	<0.7	U	2.10	0.701
C2-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
C3-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
C4-Phenanthrenes/Anthracenes	<3	U	9.09	3.03
Dibenzothiophene	<0.8	U	2.47	0.824
C1-Dibenzothiophenes	<0.7	U	2.01	0.670
C2-Dibenzothiophenes	<1.3	U	4.02	1.34
C3-Dibenzothiophenes	<1.3	U	4.02	1.34
C4-Dibenzothiophenes	<1.3	U	4.02	1.34
Fluoranthene	<1.1	U	3.28	1.09
Pyrene	<1.4	U	4.12	1.37
C1-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C2-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C3-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
C4-Fluoranthenes/Pyrenes	<2.5	U	7.41	2.47
Naphthobenzothiophene	<1	U	3.10	1.03
C1-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C2-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C3-Naphthobenzothiophenes	<2.1	U	6.20	2.07
C4-Naphthobenzothiophenes	<2.1	U	6.20	2.07
Benz(a)anthracene	<0.7	U	2.21	0.737
Chrysene/Triphenylene	<0.8	U	2.40	0.799
C1-Chrysenes	<1.6	U	4.80	1.60
C2-Chrysenes	<1.6	U	4.80	1.60
C3-Chrysenes	<1.6	U	4.80	1.60
C4-Chrysenes	<1.6	U	4.80	1.60
Benzo(b)fluoranthene	<2.4	U	7.15	2.38
Benzo(k,j)fluoranthene	<2.5	U	7.53	2.51
Benzo(a)fluoranthene	<2.5	U	7.53	2.51
Benzo(e)pyrene	<2.7	U	8.08	2.69
Benzo(a)pyrene	<1.9	U	5.74	1.91
Perylene	<0.6	U	1.90	0.635
Indeno(1,2,3-c,d)pyrene	<1.4	U	4.18	1.39
Dibenzo(a,h)anthracene	<1.1	U	3.41	1.14
C1-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
C2-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
C3-Dibenzo(a,h)anthracenes	<2.3	U	6.82	2.27
Benzo(g,h,i)perylene	<2.5	U	7.53	2.51
Total PAHs	1.31			

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Method Blank Report

Laboratory ID	ENV4075A.D
Sample ID	Method Blank
Matrix	Water
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	03/20/2020
Extraction Batch	ENV4075
Date Acquired	27-Mar-2020 4:23
Method	SOP1006
Sample Volume (L)	1.00
Dilution	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	3X MDL	Actual MDL
Individual Alkyl Isomers and Hopanes				
2-Methylnaphthalene	<1.1	U	3.31	1.10
1-Methylnaphthalene	<1.4	U	4.26	1.42
2,6-Dimethylnaphthalene	<0.7	U	2.09	0.696
1,6,7-Trimethylnaphthalene	<0.7	U	2.00	0.668
1-Methylfluorene	<1.5	U	4.41	1.47
4-Methyldibenzothiophene	<1	U	2.90	0.966
2/3-Methyldibenzothiophene	<1	U	2.90	0.966
1-Methyldibenzothiophene	<1	U	2.90	0.966
3-Methylphenanthrene	<0.9	U	2.82	0.939
2-Methylphenanthrene	<0.9	U	2.82	0.939
2-Methylanthracene	<0.9	U	2.82	0.939
4/9-Methylphenanthrene	<0.9	U	2.82	0.939
1-Methylphenanthrene	<0.9	U	2.82	0.939
3,6-Dimethylphenanthrene	<1.7	U	5.01	1.67
Retene	<1.6	U	4.78	1.59
2-Methylfluoranthene	<1.1	U	3.44	1.15
Benzo(b)fluorene	<1.4	U	4.12	1.37
C29-Hopane	<8.2	U	24.6	8.19
18a-Oleanane	<8.2	U	24.6	8.19
C30-Hopane	<8.2	U	24.6	8.19
C20-TAS	<2.6	U	7.80	2.60
C21-TAS	<2.6	U	7.80	2.60
C26(20S)-TAS	<2.6	U	7.80	2.60
C26(20R)/C27(20S)-TAS	<2.6	U	7.80	2.60
C28(20S)-TAS	<2.6	U	7.80	2.60
C27(20R)-TAS	<2.6	U	7.80	2.60
C28(20R)-TAS	<2.6	U	7.80	2.60

Surrogate Standards	
Naphthalene-d8	87
Acenaphthene-d10	88
Phenanthrene-d10	89
Chrysene-d12	88
Perylene-d12	90

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4073B.D	ENV4073C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Species	NA	NA
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073
Date Acquired	20-Mar-2020 21:18	20-Mar-2020 22:26
Method	SOP1006	SOP1006
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	RPD (%)	Q	Amount (ng)
cis/trans Decalin	78.3		78		84.4		84		7		100
C1-Decalins	NA				NA						
C2-Decalins	NA				NA						
C3-Decalins	NA				NA						
C4-Decalins	NA				NA						
Naphthalene	91.4		91		96.4		96		5		100
C1-Naphthalenes	NA				NA						
C2-Naphthalenes	NA				NA						
C3-Naphthalenes	NA				NA						
C4-Naphthalenes	NA				NA						
Benzothiophene	91.3		91		92.0		92		1		100
C1-Benzothiophenes	NA				NA						
C2-Benzothiophenes	NA				NA						
C3-Benzothiophenes	NA				NA						
C4-Benzothiophenes	NA				NA						
Biphenyl	137		137		130		130		5		100
Acenaphthylene	96.6		97		97.2		97		1		100
Acenaphthene	98.3		98		97.1		97		1		100
Dibenzofuran	98.2		98		98.8		99		1		100
Fluorene	100		100		101		101		0		100
C1-Fluorenes	NA				NA						
C2-Fluorenes	NA				NA						
C3-Fluorenes	NA				NA						
Carbazole	91.4		91		86.0		86		6		100
Anthracene	96.9		97		96.3		96		1		100
Phenanthrene	99.6		100		98.8		99		1		100
C1-Phenanthrenes/Anthracenes	NA				NA						
C2-Phenanthrenes/Anthracenes	NA				NA						
C3-Phenanthrenes/Anthracenes	NA				NA						
C4-Phenanthrenes/Anthracenes	NA				NA						
Dibenzothiophene	103		103		105		105		1		100
C1-Dibenzothiophenes	NA				NA						
C2-Dibenzothiophenes	NA				NA						
C3-Dibenzothiophenes	NA				NA						
C4-Dibenzothiophenes	NA				NA						
Fluoranthene	104		104		103		103		1		100
Pyrene	103		103		103		103		0		100
C1-Fluoranthenes/Pyrenes	NA				NA						
C2-Fluoranthenes/Pyrenes	NA				NA						
C3-Fluoranthenes/Pyrenes	NA				NA						
C4-Fluoranthenes/Pyrenes	NA				NA						
Naphthobenzothiophene	105		105		110		110		5		100
C1-Naphthobenzothiophenes	NA				NA						
C2-Naphthobenzothiophenes	NA				NA						
C3-Naphthobenzothiophenes	NA				NA						
C4-Naphthobenzothiophenes	NA				NA						
Benz(a)anthracene	103		103		109		109		6		100
Chrysene/Triphenylene	101		101		105		105		5		100
C1-Chrysenes	NA				NA						
C2-Chrysenes	NA				NA						
C3-Chrysenes	NA				NA						
C4-Chrysenes	NA				NA						
Benzo(b)fluoranthene	116		116		109		109		6		100
Benzo(k,j)fluoranthene	116		116		103		103		11		100
Benzo(a)fluoranthene	NA				NA						
Benzo(e)pyrene	108		108		107		107		1		100
Benzo(a)pyrene	103		103		102		102		1		100
Perylene	120		120		119		119		1		100
Indeno(1,2,3-c,d)pyrene	91.5		91		90.4		90		1		100
Dibenzo(a,h)anthracene	86.0		86		87.2		87		1		100
C1-Dibenzo(a,h)anthracenes	NA				NA						
C2-Dibenzo(a,h)anthracenes	NA				NA						
C3-Dibenzo(a,h)anthracenes	NA				NA						
Benzo(g,h,i)perylene	90.6		91		90.4		90		0		100
Average Recovery (%)			101				101				

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4073B.D	ENV4073C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Species	NA	NA
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/18/2020	03/18/2020
Extraction Batch	ENV4073	ENV4073
Date Acquired	20-Mar-2020 21:18	20-Mar-2020 22:26
Method	SOP1006	SOP1006
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	RPD (%)	Q	Amount (ng)
Individual Alkyl Isomers and Hopanes											
2-Methylnaphthalene	88.8		89		89.1		89		0		100
1-Methylnaphthalene	88.3		88		89.4		89		1		100
2,6-Dimethylnaphthalene	94.0		94		96.3		96		2		100
1,6,7-Trimethylnaphthalene	98.7		99		98.3		98		0		100
1-Methylfluorene	105		105		105		105		0		100
4-Methyldibenzothiophene	116		116		112		112		4		100
2/3-Methyldibenzothiophene	NA				NA						
1-Methyldibenzothiophene	NA				NA						
3-Methylphenanthrene	NA				NA						
2-Methylphenanthrene	NA				NA						
2-Methylanthracene	NA				NA						
4/9-Methylphenanthrene	NA				NA						
1-Methylphenanthrene	102		102		102		102		0		100
3,6-Dimethylphenanthrene	103		103		108		108		5		100
Retene	108		108		107		107		1		100
2-Methylfluoranthene	105		105		104		104		1		100
Benzo(b)fluorene	111		111		110		110		1		100
C29-Hopane	NA				NA						
18a-Oleanane	NA				NA						
C30-Hopane	97.7		98		101		101		4		100
C20-TAS	NA				NA						
C21-TAS	NA				NA						
C26(20S)-TAS	NA				NA						
C26(20R)/C27(20S)-TAS	NA				NA						
C28(20S)-TAS	NA				NA						
C27(20R)-TAS	NA				NA						
C28(20R)-TAS	NA				NA						

Surrogate Standards		
Naphthalene-d8	74	81
Acenaphthene-d10	80	83
Phenanthrene-d10	82	85
Chrysene-d12	86	93
Perylene-d12	83	86

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4074B.D	ENV4074C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Species	NA	NA
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074
Date Acquired	25-Mar-2020 23:59	26-Mar-2020 1:07
Method	SOP1006	SOP1006
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	RPD (%)	Q	Amount (ng)
cis/trans Decalin	80.3		80		83.0		83		3		100
C1-Decalins	NA				NA						
C2-Decalins	NA				NA						
C3-Decalins	NA				NA						
C4-Decalins	NA				NA						
Naphthalene	87.1		87		90.7		91		4		100
C1-Naphthalenes	NA				NA						
C2-Naphthalenes	NA				NA						
C3-Naphthalenes	NA				NA						
C4-Naphthalenes	NA				NA						
Benzothiophene	86.4		86		89.8		90		4		100
C1-Benzothiophenes	NA				NA						
C2-Benzothiophenes	NA				NA						
C3-Benzothiophenes	NA				NA						
C4-Benzothiophenes	NA				NA						
Biphenyl	118		118		122		122		3		100
Acenaphthylene	87.5		88		90.3		90		3		100
Acenaphthene	87.9		88		89.9		90		2		100
Dibenzofuran	89.5		89		90.8		91		1		100
Fluorene	89		89		91.3		91		2		100
C1-Fluorenes	NA				NA						
C2-Fluorenes	NA				NA						
C3-Fluorenes	NA				NA						
Carbazole	81.1		81		83.9		84		3		100
Anthracene	95.6		96		94.9		95		1		100
Phenanthrene	97.7		98		96.5		96		1		100
C1-Phenanthrenes/Anthracenes	NA				NA						
C2-Phenanthrenes/Anthracenes	NA				NA						
C3-Phenanthrenes/Anthracenes	NA				NA						
C4-Phenanthrenes/Anthracenes	NA				NA						
Dibenzothiophene	102		102		105		105		3		100
C1-Dibenzothiophenes	NA				NA						
C2-Dibenzothiophenes	NA				NA						
C3-Dibenzothiophenes	NA				NA						
C4-Dibenzothiophenes	NA				NA						
Fluoranthene	95.2		95		100		100		5		100
Pyrene	92.1		92		93.2		93		1		100
C1-Fluoranthenes/Pyrenes	NA				NA						
C2-Fluoranthenes/Pyrenes	NA				NA						
C3-Fluoranthenes/Pyrenes	NA				NA						
C4-Fluoranthenes/Pyrenes	NA				NA						
Naphthobenzothiophene	94.9		95		90.8		91		4		100
C1-Naphthobenzothiophenes	NA				NA						
C2-Naphthobenzothiophenes	NA				NA						
C3-Naphthobenzothiophenes	NA				NA						
C4-Naphthobenzothiophenes	NA				NA						
Benz(a)anthracene	96.9		97		95.6		96		1		100
Chrysene/Triphenylene	95.7		96		94.1		94		2		100
C1-Chrysenes	NA				NA						
C2-Chrysenes	NA				NA						
C3-Chrysenes	NA				NA						
C4-Chrysenes	NA				NA						
Benzo(b)fluoranthene	95.3		95		95.7		96		0		100
Benzo(k,j)fluoranthene	92.0		92		96.8		97		5		100
Benzo(a)fluoranthene	NA				NA						
Benzo(e)pyrene	98.1		98		100		100		2		100
Benzo(a)pyrene	91.0		91		92.6		93		2		100
Perylene	110		110		119		119		7		100
Indeno(1,2,3-c,d)pyrene	92.7		93		96.0		96		4		100
Dibenzo(a,h)anthracene	83.4		83		87.6		88		5		100
C1-Dibenzo(a,h)anthracenes	NA				NA						
C2-Dibenzo(a,h)anthracenes	NA				NA						
C3-Dibenzo(a,h)anthracenes	NA				NA						
Benzo(g,h,i)perylene	90.8		91		98.7		99		8		100
Average Recovery (%)			93				95				

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4074B.D	ENV4074C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Species	NA	NA
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/19/2020	03/19/2020
Extraction Batch	ENV4074	ENV4074
Date Acquired	25-Mar-2020 23:59	26-Mar-2020 1:07
Method	SOP1006	SOP1006
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	RPD (%)	Q	Amount (ng)
Individual Alkyl Isomers and Hopanes											
2-Methylnaphthalene	85.2		85		86.9		87		2		100
1-Methylnaphthalene	83.5		83		87.9		88		5		100
2,6-Dimethylnaphthalene	84.3		84		83.4		83		1		100
1,6,7-Trimethylnaphthalene	88.9		89		93.0		93		5		100
1-Methylfluorene	88.8		89		93.4		93		5		100
4-Methyldibenzothiophene	109		109		108		108		1		100
2/3-Methyldibenzothiophene	NA				NA						
1-Methyldibenzothiophene	NA				NA						
3-Methylphenanthrene	NA				NA						
2-Methylphenanthrene	NA				NA						
2-Methylanthracene	NA				NA						
4/9-Methylphenanthrene	NA				NA						
1-Methylphenanthrene	96.5		96		99.6		100		3		100
3,6-Dimethylphenanthrene	99.4		99		91.0		91		9		100
Retene	91.2		91		97.0		97		6		100
2-Methylfluoranthene	91.3		91		98.2		98		7		100
Benzo(b)fluorene	93.3		93		96.0		96		3		100
C29-Hopane	NA				NA						
18a-Oleanane	NA				NA						
C30-Hopane	99.7		100		105		105		6		100
C20-TAS	NA				NA						
C21-TAS	NA				NA						
C26(20S)-TAS	NA				NA						
C26(20R)/C27(20S)-TAS	NA				NA						
C28(20S)-TAS	NA				NA						
C27(20R)-TAS	NA				NA						
C28(20R)-TAS	NA				NA						

Surrogate Standards		
Naphthalene-d8	82	84
Acenaphthene-d10	83	85
Phenanthrene-d10	94	92
Chrysene-d12	92	87
Perylene-d12	84	92

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4075B.D	ENV4075C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Species	NA	NA
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075
Date Acquired	27-Mar-2020 5:31	27-Mar-2020 6:39
Method	SOP1006	SOP1006
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	RPD (%)	Q	Amount (ng)
cis/trans Decalin	108		108		106		106		2		100
C1-Decalins	NA				NA						
C2-Decalins	NA				NA						
C3-Decalins	NA				NA						
C4-Decalins	NA				NA						
Naphthalene	93.2		93		95.4		95		2		100
C1-Naphthalenes	NA				NA						
C2-Naphthalenes	NA				NA						
C3-Naphthalenes	NA				NA						
C4-Naphthalenes	NA				NA						
Benzothiophene	92.3		92		94.5		95		2		100
C1-Benzothiophenes	NA				NA						
C2-Benzothiophenes	NA				NA						
C3-Benzothiophenes	NA				NA						
C4-Benzothiophenes	NA				NA						
Biphenyl	127		127		129		129		1		100
Acenaphthylene	92.1		92		94.2		94		2		100
Acenaphthene	93.7		94		95.8		96		2		100
Dibenzofuran	95.5		96		97.5		98		2		100
Fluorene	94.7		95		97.1		97		3		100
C1-Fluorenes	NA				NA						
C2-Fluorenes	NA				NA						
C3-Fluorenes	NA				NA						
Carbazole	81.6		82		83.7		84		3		100
Anthracene	93.9		94		94.9		95		1		100
Phenanthrene	96.5		97		98.1		98		2		100
C1-Phenanthrenes/Anthracenes	NA				NA						
C2-Phenanthrenes/Anthracenes	NA				NA						
C3-Phenanthrenes/Anthracenes	NA				NA						
C4-Phenanthrenes/Anthracenes	NA				NA						
Dibenzothiophene	103		103		106		106		4		100
C1-Dibenzothiophenes	NA				NA						
C2-Dibenzothiophenes	NA				NA						
C3-Dibenzothiophenes	NA				NA						
C4-Dibenzothiophenes	NA				NA						
Fluoranthene	98.7		99		101		101		2		100
Pyrene	96.7		97		98.0		98		1		100
C1-Fluoranthenes/Pyrenes	NA				NA						
C2-Fluoranthenes/Pyrenes	NA				NA						
C3-Fluoranthenes/Pyrenes	NA				NA						
C4-Fluoranthenes/Pyrenes	NA				NA						
Naphthobenzothiophene	96.3		96		97.6		98		1		100
C1-Naphthobenzothiophenes	NA				NA						
C2-Naphthobenzothiophenes	NA				NA						
C3-Naphthobenzothiophenes	NA				NA						
C4-Naphthobenzothiophenes	NA				NA						
Benz(a)anthracene	94.6		95		95.9		96		1		100
Chrysene/Triphenylene	93.2		93		95.8		96		3		100
C1-Chrysenes	NA				NA						
C2-Chrysenes	NA				NA						
C3-Chrysenes	NA				NA						
C4-Chrysenes	NA				NA						
Benzo(b)fluoranthene	96.0		96		99.0		99		3		100
Benzo(k,j)fluoranthene	96.6		97		100		100		3		100
Benzo(a)fluoranthene	NA				NA						
Benzo(e)pyrene	101		101		104		104		3		100
Benzo(a)pyrene	94.2		94		95.8		96		2		100
Perylene	116		116		120		120		4		100
Indeno(1,2,3-c,d)pyrene	92.1		92		99.8		100		8		100
Dibenzo(a,h)anthracene	84.6		85		89.1		89		5		100
C1-Dibenzo(a,h)anthracenes	NA				NA						
C2-Dibenzo(a,h)anthracenes	NA				NA						
C3-Dibenzo(a,h)anthracenes	NA				NA						
Benzo(g,h,i)perylene	94.4		94		96.1		96		2		100
Average Recovery (%)			97				99				

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Blank Spike Report

Laboratory ID	ENV4075B.D	ENV4075C.D
Sample ID	Blank Spike	Blank Spike Duplicate
Matrix	Water	Water
Species	NA	NA
Collection Date	NA	NA
Received Date	NA	NA
Extraction Date	03/20/2020	03/20/2020
Extraction Batch	ENV4075	ENV4075
Date Acquired	27-Mar-2020 5:31	27-Mar-2020 6:39
Method	SOP1006	SOP1006
Sample Volume (L)	1.00	1.00
Dilution	1X	1X

Target Compounds	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	Su. Corrected Conc. (ng/L)	Q	Recovery (%)	Q	RPD (%)	Q	Amount (ng)
Individual Alkyl Isomers and Hopanes											
2-Methylnaphthalene	91.2		91		92.5		93		1		100
1-Methylnaphthalene	90.9		91		93.1		93		2		100
2,6-Dimethylnaphthalene	89.8		90		91.0		91		1		100
1,6,7-Trimethylnaphthalene	95.0		95		96.7		97		2		100
1-Methylfluorene	95.8		96		98.2		98		2		100
4-Methyldibenzothiophene	109		109		110		110		1		100
2/3-Methyldibenzothiophene	NA				NA						
1-Methyldibenzothiophene	NA				NA						
3-Methylphenanthrene	NA				NA						
2-Methylphenanthrene	NA				NA						
2-Methylanthracene	NA				NA						
4/9-Methylphenanthrene	NA				NA						
1-Methylphenanthrene	99.4		99		102		102		2		100
3,6-Dimethylphenanthrene	98.3		98		100		100		2		100
Retene	97.0		97		100		100		3		100
2-Methylfluoranthene	97.1		97		99		99		2		100
Benzo(b)fluorene	96.8		97		100		100		3		100
C29-Hopane	NA				NA						
18a-Oleanane	NA				NA						
C30-Hopane	106		106		111		111		4		100
C20-TAS	NA				NA						
C21-TAS	NA				NA						
C26(20S)-TAS	NA				NA						
C26(20R)/C27(20S)-TAS	NA				NA						
C28(20S)-TAS	NA				NA						
C27(20R)-TAS	NA				NA						
C28(20R)-TAS	NA				NA						

Surrogate Standards		
Naphthalene-d8	77	88
Acenaphthene-d10	79	90
Phenanthrene-d10	83	93
Chrysene-d12	80	90
Perylene-d12	78	89

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70376N.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4073
Date Acquired	20-Mar-2020 19:02
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	Q1	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
cis/trans Decalin	687						
C1-Decalins	1053						
C2-Decalins	925						
C3-Decalins	958						
C4-Decalins	584						
Naphthalene	796			7	855±46	647	1081
C1-Naphthalenes	1638						
C2-Naphthalenes	2058						
C3-Naphthalenes	1527						
C4-Naphthalenes	797						
Benzothiophene	15.8						
C1-Benzothiophenes	37.3						
C2-Benzothiophenes	47.9						
C3-Benzothiophenes	49.5						
C4-Benzothiophenes	27.4						
Biphenyl	197						
Acenaphthylene	8.13	J					
Acenaphthene	14.3						
Dibenzofuran	31.3						
Fluorene	152						
C1-Fluorenes	358						
C2-Fluorenes	470						
C3-Fluorenes	326						
Carbazole	10.11						
Anthracene	3.46	J		1	3.42±0.59	2.26	4.81
Phenanthrene	288			11	258±27	185	342
C1-Phenanthrenes/Anthracenes	702						
C2-Phenanthrenes/Anthracenes	791						
C3-Phenanthrenes/Anthracenes	510						
C4-Phenanthrenes/Anthracenes	253						
Dibenzothiophene	53.2			3	51.8±2.1	39.8	64.7
C1-Dibenzothiophenes	163						
C2-Dibenzothiophenes	204						
C3-Dibenzothiophenes	128						
C4-Dibenzothiophenes	74.5						
Fluoranthene	4.25	J		3	4.36±0.4	3.17	5.71
Pyrene	13.8			7	14.81±0.39	11.5	18.2
C1-Fluoranthenes/Pyrenes	76.1						
C2-Fluoranthenes/Pyrenes	95.3						
C3-Fluoranthenes/Pyrenes	152						
C4-Fluoranthenes/Pyrenes	81.7						
Naphthobenzothiophene	30.1						
C1-Naphthobenzothiophenes	77.4						
C2-Naphthobenzothiophenes	106						
C3-Naphthobenzothiophenes	71.3						
C4-Naphthobenzothiophenes	26.4						
Benz(a)anthracene	7.19	J		2	7.03±0.85	4.94	9.46
Chrysene/Triphenylene	61.6			40	41±11.9	23.3	63.5
C1-Chrysenes	138						
C2-Chrysenes	161						
C3-Chrysenes	120						
C4-Chrysenes	57.8						
Benzo(b)fluoranthene	5.74	J		2	5.62±0.34	4.22	7.15
Benzo(k,j)fluoranthene	1.33	J					
Benzo(a)fluoranthene	<10	U					
Benzo(e)pyrene	13.2			20	10.78±0.6	8.14	13.7
Benzo(a)pyrene	1.57	J					
Perylene	1.05	J					
Indeno(1,2,3-c,d)pyrene	0.440	J					
Dibenzo(a,h)anthracene	0.597	J		4	0.574±0.091	0.386	0.798
C1-Dibenzo(a,h)anthracenes	<10	U					
C2-Dibenzo(a,h)anthracenes	<10	U					
C3-Dibenzo(a,h)anthracenes	<10	U					
Benzo(g,h,i)perylene	1.79	J		17	2.11±0.26	1.48	2.84
Total PAHs	17240						

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70376N.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4073
Date Acquired	20-Mar-2020 19:02
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
Individual Alkyl Isomers and Hopanes						
2-Methylnaphthalene	1566		4	1630±50	1264	2016
1-Methylnaphthalene	1071		6	1140±20	896	1392
2,6-Dimethylnaphthalene	1034					
1,6,7-Trimethylnaphthalene	303					
1-Methylfluorene	264					
4-Methyldibenzothiophene	124					
2/3-Methyldibenzothiophene	60.1					
1-Methyldibenzothiophene	35.1					
3-Methylphenanthrene	206		0	206±32	139	286
2-Methylphenanthrene	223		3	230±14	173	293
2-Methylanthracene	17.6					
4/9-Methylphenanthrene	284		20	232±19	170	301
1-Methylphenanthrene	191		12	169±10	127	215
3,6-Dimethylphenanthrene	70.9					
Retene	22.5					
2-Methylfluoranthene	4.64	J				
Benzo(b)fluorene	10.3					
C29-Hopane	19.4					
18a-Oleanane	<10	U				
C30-Hopane	48.0					
C20-TAS	37.6					
C21-TAS	33.2					
C26(20S)-TAS	24.0					
C26(20R)/C27(20S)-TAS	69.4					
C28(20S)-TAS	54.5					
C27(20R)-TAS	43.9					
C28(20R)-TAS	38.9					

Surrogate Standards	
Naphthalene-d8	84
Acenaphthene-d10	92
Phenanthrene-d10	87
Chrysene-d12	96
Perylene-d12	92

Peak Resolution (m/z 192)	90%
4/9-Methylphenanthrene from	131
1-Methylyphenanthrene	145

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70378K.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4074
Date Acquired	25-Mar-2020 21:43
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	Q1	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
cis/trans Decalin	776						
C1-Decalins	1005						
C2-Decalins	993						
C3-Decalins	928						
C4-Decalins	604						
Naphthalene	819			4	855±46	647	1081
C1-Naphthalenes	1701						
C2-Naphthalenes	2109						
C3-Naphthalenes	1498						
C4-Naphthalenes	688						
Benzothiophene	12.8						
C1-Benzothiophenes	38.1						
C2-Benzothiophenes	31.2						
C3-Benzothiophenes	44.7						
C4-Benzothiophenes	27.3						
Biphenyl	188						
Acenaphthylene	7.39	J					
Acenaphthene	10.2						
Dibenzofuran	27.4						
Fluorene	134						
C1-Fluorenes	319						
C2-Fluorenes	374						
C3-Fluorenes	244						
Carbazole	8.27	J					
Anthracene	3.05	J		12	3.42±0.59	2.26	4.81
Phenanthrene	289			11	258±27	185	342
C1-Phenanthrenes/Anthracenes	647						
C2-Phenanthrenes/Anthracenes	818						
C3-Phenanthrenes/Anthracenes	507						
C4-Phenanthrenes/Anthracenes	211						
Dibenzothiophene	55.0			6	51.8±2.1	39.8	64.7
C1-Dibenzothiophenes	155						
C2-Dibenzothiophenes	195						
C3-Dibenzothiophenes	131						
C4-Dibenzothiophenes	57.0						
Fluoranthene	4.41	J		1	4.36±0.4	3.17	5.71
Pyrene	13.2			12	14.81±0.39	11.5	18.2
C1-Fluoranthenes/Pyrenes	71.1						
C2-Fluoranthenes/Pyrenes	111.8						
C3-Fluoranthenes/Pyrenes	119						
C4-Fluoranthenes/Pyrenes	57.3						
Naphthobenzothiophene	26.6						
C1-Naphthobenzothiophenes	61.9						
C2-Naphthobenzothiophenes	83.4						
C3-Naphthobenzothiophenes	58.8						
C4-Naphthobenzothiophenes	23.0						
Benz(a)anthracene	5.86	J		18	7.03±0.85	4.94	9.46
Chrysene/Triphenylene	54.5			28	41±11.9	23.3	63.5
C1-Chrysenes	113						
C2-Chrysenes	122						
C3-Chrysenes	102						
C4-Chrysenes	76.2						
Benzo(b)fluoranthene	5.28	J		6	5.62±0.34	4.22	7.15
Benzo(k,j)fluoranthene	1.67	J					
Benzo(a)fluoranthene	<10	U					
Benzo(e)pyrene	13.5			23	10.78±0.6	8.14	13.7
Benzo(a)pyrene	1.73	J					
Perylene	1.04	J					
Indeno(1,2,3-c,d)pyrene	0.503	J					
Dibenzo(a,h)anthracene	0.525	J		9	0.574±0.091	0.386	0.798
C1-Dibenzo(a,h)anthracenes	<10	U					
C2-Dibenzo(a,h)anthracenes	<10	U					
C3-Dibenzo(a,h)anthracenes	<10	U					
Benzo(g,h,i)perylene	2.44	J		14	2.11±0.26	1.48	2.84
Total PAHs	16788						

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70378K.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4074
Date Acquired	25-Mar-2020 21:43
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
Individual Alkyl Isomers and Hopanes						
2-Methylnaphthalene	1516		7	1630±50	1264	2016
1-Methylnaphthalene	1049		8	1140±20	896	1392
2,6-Dimethylnaphthalene	925					
1,6,7-Trimethylnaphthalene	281					
1-Methylfluorene	227					
4-Methyldibenzothiophene	116					
2/3-Methyldibenzothiophene	59.8					
1-Methyldibenzothiophene	33.1					
3-Methylphenanthrene	192		7	206±32	139	286
2-Methylphenanthrene	211		9	230±14	173	293
2-Methylanthracene	16.3					
4/9-Methylphenanthrene	259		11	232±19	170	301
1-Methylphenanthrene	179		6	169±10	127	215
3,6-Dimethylphenanthrene	66.2					
Retene	21.0					
2-Methylfluoranthene	3.90	J				
Benzo(b)fluorene	10.4					
C29-Hopane	20.5					
18a-Oleanane	<10	U				
C30-Hopane	49.7					
C20-TAS	34.7					
C21-TAS	30.3					
C26(20S)-TAS	21.5					
C26(20R)/C27(20S)-TAS	60.3					
C28(20S)-TAS	48.7					
C27(20R)-TAS	37.4					
C28(20R)-TAS	33.5					

Surrogate Standards	
Naphthalene-d8	90
Acenaphthene-d10	99
Phenanthrene-d10	100
Chrysene-d12	98
Perylene-d12	96

Peak Resolution (m/z 192)	92%
4/9-Methylphenanthrene from	129
1-Methylyphenanthrene	140

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70378O.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4075
Date Acquired	27-Mar-2020 3:15
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	Q1	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
cis/trans Decalin	790						
C1-Decalins	1014						
C2-Decalins	968						
C3-Decalins	977						
C4-Decalins	606						
Naphthalene	841			2	855±46	647	1081
C1-Naphthalenes	1746						
C2-Naphthalenes	2208						
C3-Naphthalenes	1552						
C4-Naphthalenes	816						
Benzothiophene	12.7						
C1-Benzothiophenes	30.8						
C2-Benzothiophenes	40.8						
C3-Benzothiophenes	41.0						
C4-Benzothiophenes	24.0						
Biphenyl	195						
Acenaphthylene	8.16	J					
Acenaphthene	9.9	J					
Dibenzofuran	29.3						
Fluorene	137						
C1-Fluorenes	312						
C2-Fluorenes	384						
C3-Fluorenes	220						
Carbazole	8.18	J					
Anthracene	4.68	J		31	3.42±0.59	2.26	4.81
Phenanthrene	282			9	258±27	185	342
C1-Phenanthrenes/Anthracenes	679						
C2-Phenanthrenes/Anthracenes	809						
C3-Phenanthrenes/Anthracenes	494						
C4-Phenanthrenes/Anthracenes	264						
Dibenzothiophene	53.5			3	51.8±2.1	39.8	64.7
C1-Dibenzothiophenes	156						
C2-Dibenzothiophenes	194						
C3-Dibenzothiophenes	136						
C4-Dibenzothiophenes	55.8						
Fluoranthene	3.76	J		15	4.36±0.4	3.17	5.71
Pyrene	12.9			13	14.81±0.39	11.5	18.2
C1-Fluoranthenes/Pyrenes	76.0						
C2-Fluoranthenes/Pyrenes	97.1						
C3-Fluoranthenes/Pyrenes	126						
C4-Fluoranthenes/Pyrenes	58.2						
Naphthobenzothiophene	28.1						
C1-Naphthobenzothiophenes	63.9						
C2-Naphthobenzothiophenes	88						
C3-Naphthobenzothiophenes	63.8						
C4-Naphthobenzothiophenes	25.2						
Benz(a)anthracene	5.64	J		22	7.03±0.85	4.94	9.46
Chrysene/Triphenylene	50.4			21	41±11.9	23.3	63.5
C1-Chrysenes	117						
C2-Chrysenes	128						
C3-Chrysenes	116						
C4-Chrysenes	62.0						
Benzo(b)fluoranthene	5.37	J		5	5.62±0.34	4.22	7.15
Benzo(k,j)fluoranthene	0.81	J					
Benzo(a)fluoranthene	<10	U					
Benzo(e)pyrene	11.8			9	10.78±0.6	8.14	13.7
Benzo(a)pyrene	1.43	J					
Perylene	0.99	J					
Indeno(1,2,3-c,d)pyrene	0.502	J					
Dibenzo(a,h)anthracene	0.501	J		14	0.574±0.091	0.386	0.798
C1-Dibenzo(a,h)anthracenes	<10	U					
C2-Dibenzo(a,h)anthracenes	<10	U					
C3-Dibenzo(a,h)anthracenes	<10	U					
Benzo(g,h,i)perylene	2.42	J		14	2.11±0.26	1.48	2.84
Total PAHs	17245						

CSA - 3532 Guyana
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

Laboratory ID	MS70378O.D
Sample ID	PAH-WKSRM2779-4.0-014
Matrix	Product
Collection Date	NA
Received Date	NA
Extraction Date	NA
Extraction Batch	ENV4075
Date Acquired	27-Mar-2020 3:15
Method	SOP1006
Sample Weight (mg)	4.10

Target Compounds	Su. Corrected Conc. (ng/mg)	Q	RPD (%)	SRM 2779 Certified Conc. (ug/g)	-20% Certified Conc. (ug/g)	+20% Certified Conc. (ug/g)
Individual Alkyl Isomers and Hopanes						
2-Methylnaphthalene	1565		4	1630±50	1264	2016
1-Methylnaphthalene	1068		7	1140±20	896	1392
2,6-Dimethylnaphthalene	993					
1,6,7-Trimethylnaphthalene	291					
1-Methylfluorene	238					
4-Methyldibenzothiophene	117					
2/3-Methyldibenzothiophene	58.0					
1-Methyldibenzothiophene	35.0					
3-Methylphenanthrene	201		2	206±32	139	286
2-Methylphenanthrene	221		4	230±14	173	293
2-Methylanthracene	16.1					
4/9-Methylphenanthrene	271		16	232±19	170	301
1-Methylphenanthrene	190		12	169±10	127	215
3,6-Dimethylphenanthrene	69.3					
Retene	20.9					
2-Methylfluoranthene	3.12	J				
Benzo(b)fluorene	9.4	J				
C29-Hopane	24.1					
18a-Oleanane	<10	U				
C30-Hopane	56.3					
C20-TAS	37.9					
C21-TAS	34.5					
C26(20S)-TAS	23.5					
C26(20R)/C27(20S)-TAS	68.8					
C28(20S)-TAS	52.8					
C27(20R)-TAS	42.2					
C28(20R)-TAS	38.1					

Surrogate Standards	
Naphthalene-d8	88
Acenaphthene-d10	96
Phenanthrene-d10	95
Chrysene-d12	90
Perylene-d12	94

Peak Resolution (m/z 192)	92%
4/9-Methylphenanthrene from	130
1-Methylyphenanthrene	142

Polycyclic Aromatic Hydrocarbon Total Ion Chromatograms

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5190.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 20 Mar 2020  23:34     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sw_s|hc|01
Misc Info  :
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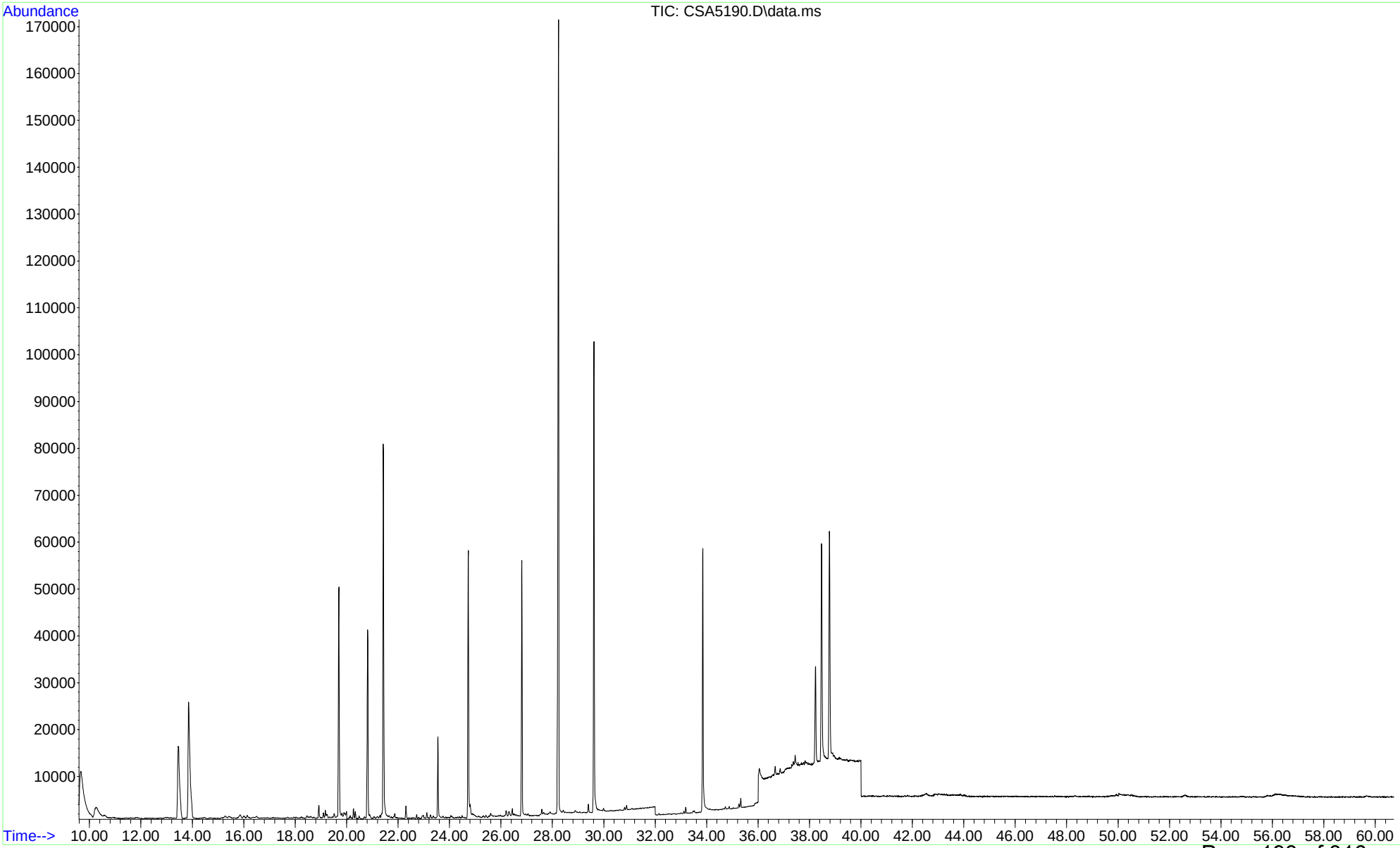
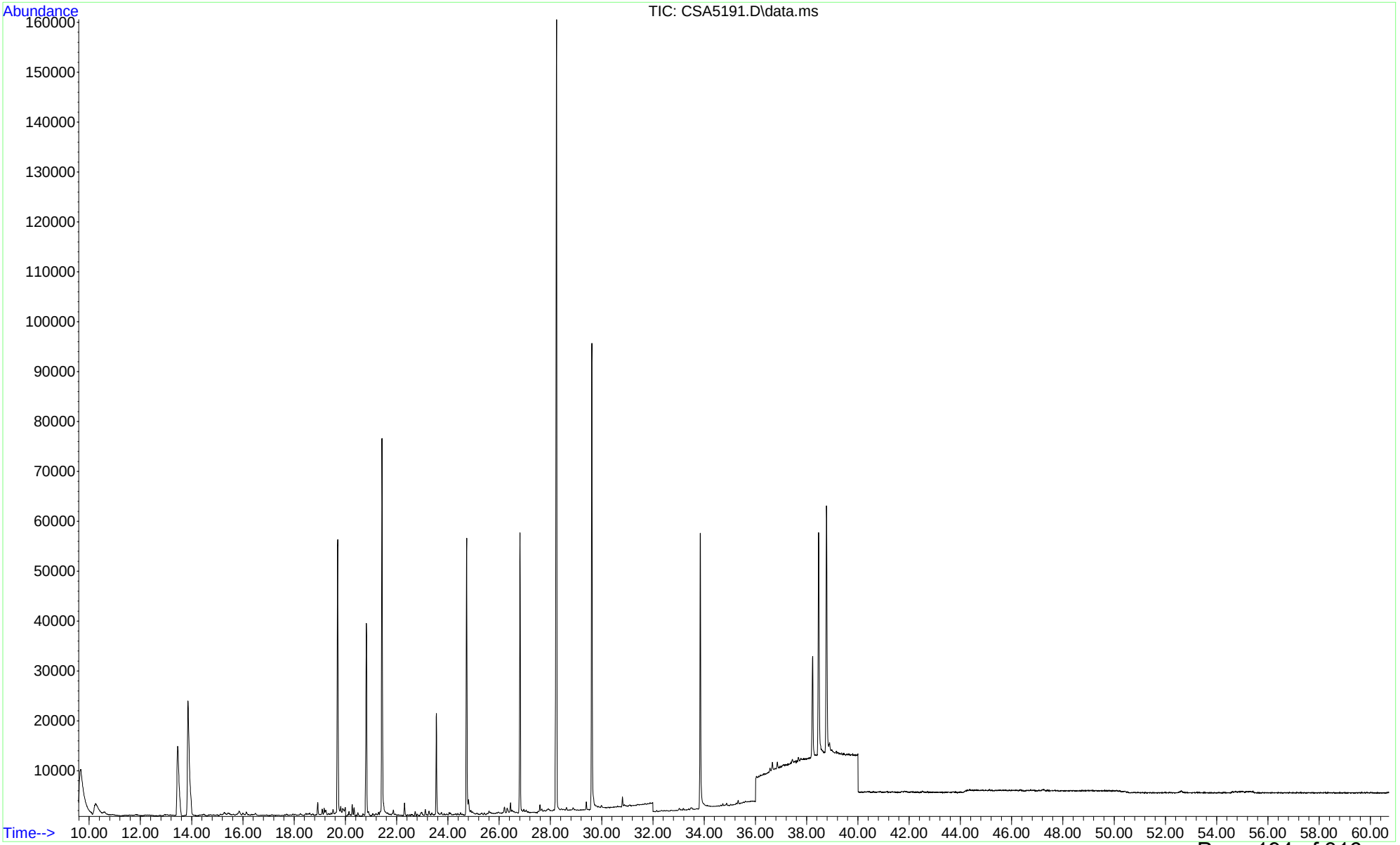


File :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
... ata\CSA5191.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 21 Mar 2020 00:42 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sw_s|hc|02
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5192.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   1:50     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sw_m|hc|01
Misc Info  :
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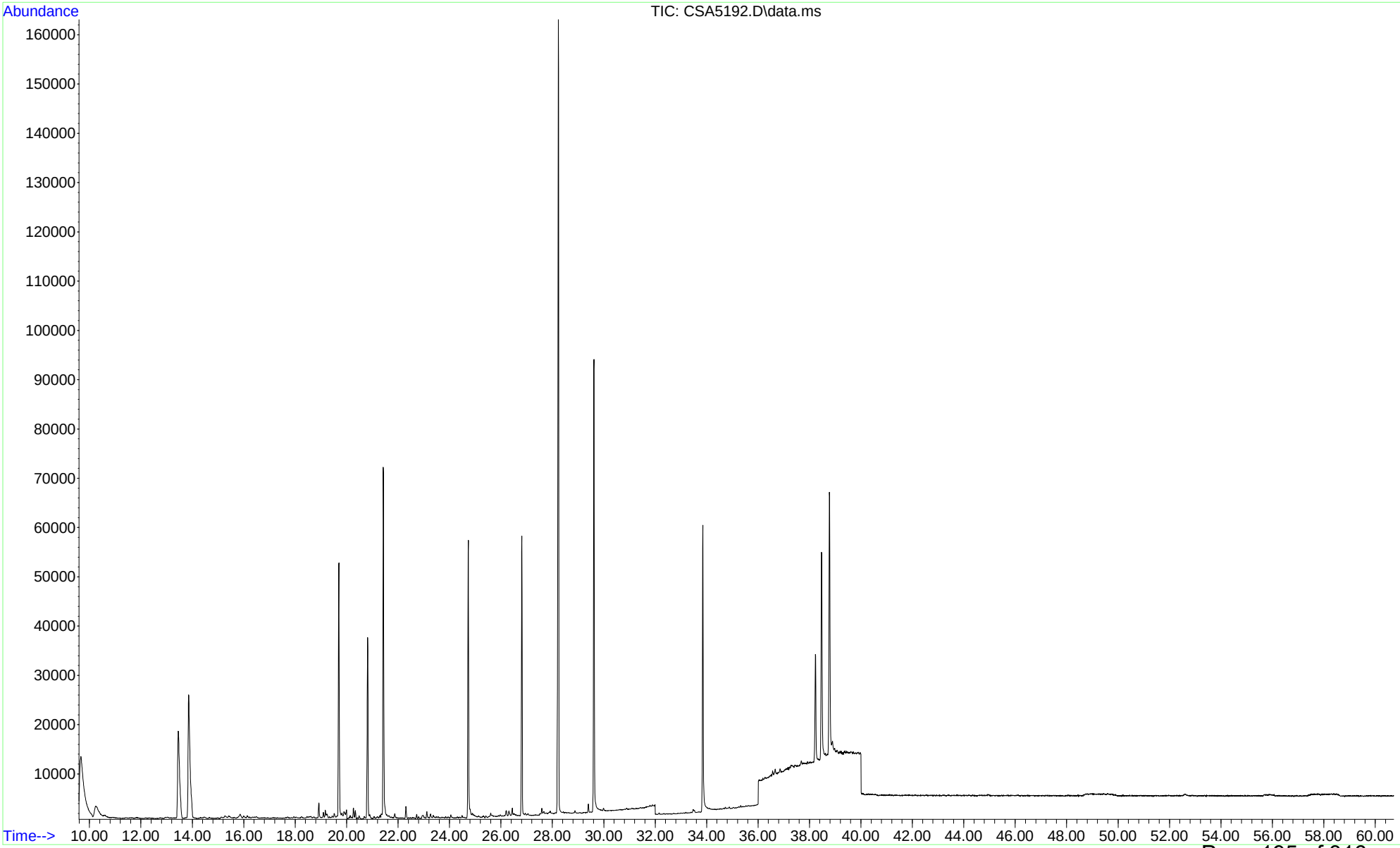

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5193.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   2:58     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sw_m|hc|02
Misc Info  :
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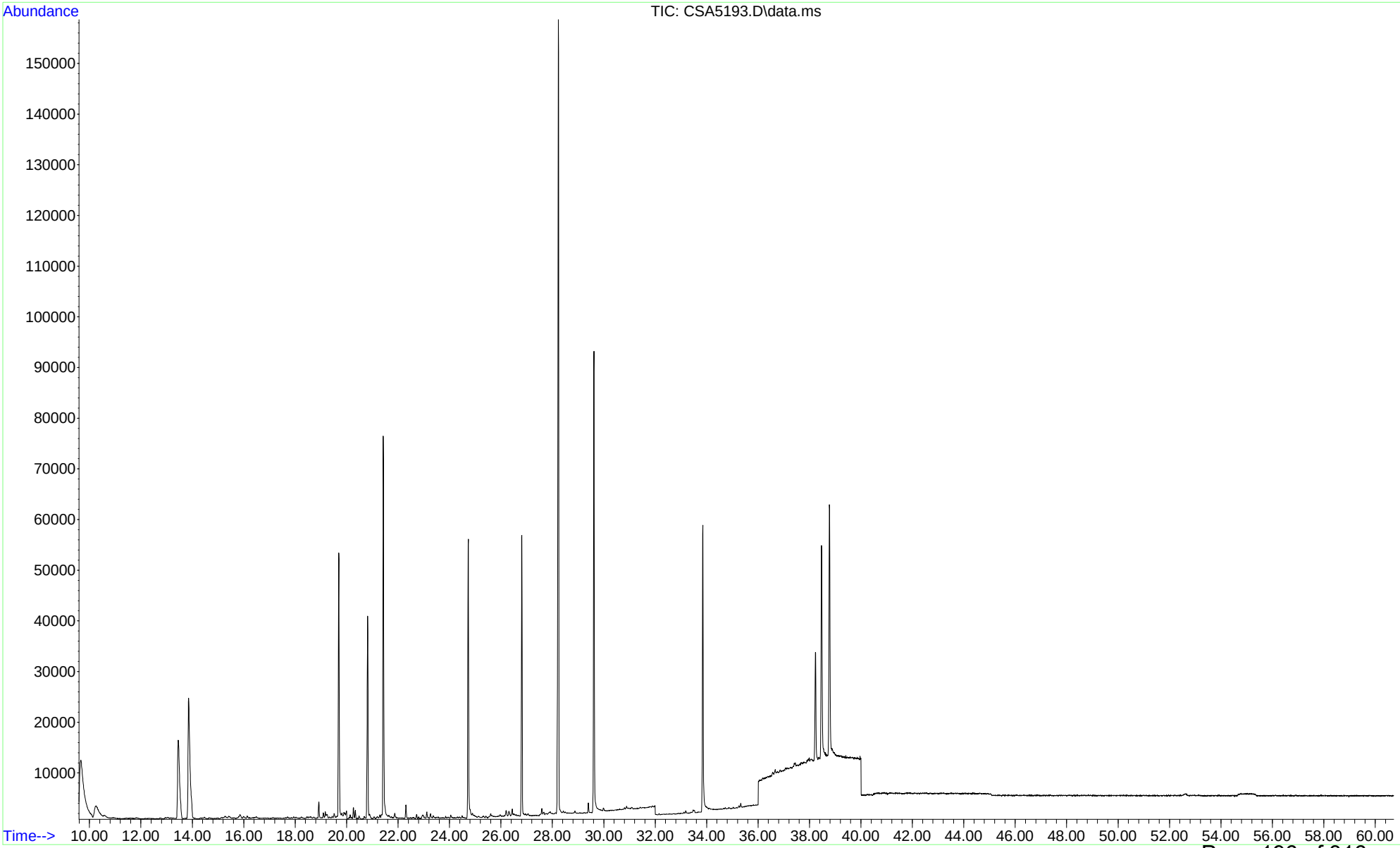

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5194.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   5:15     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sw_b|hc|01
Misc Info  :
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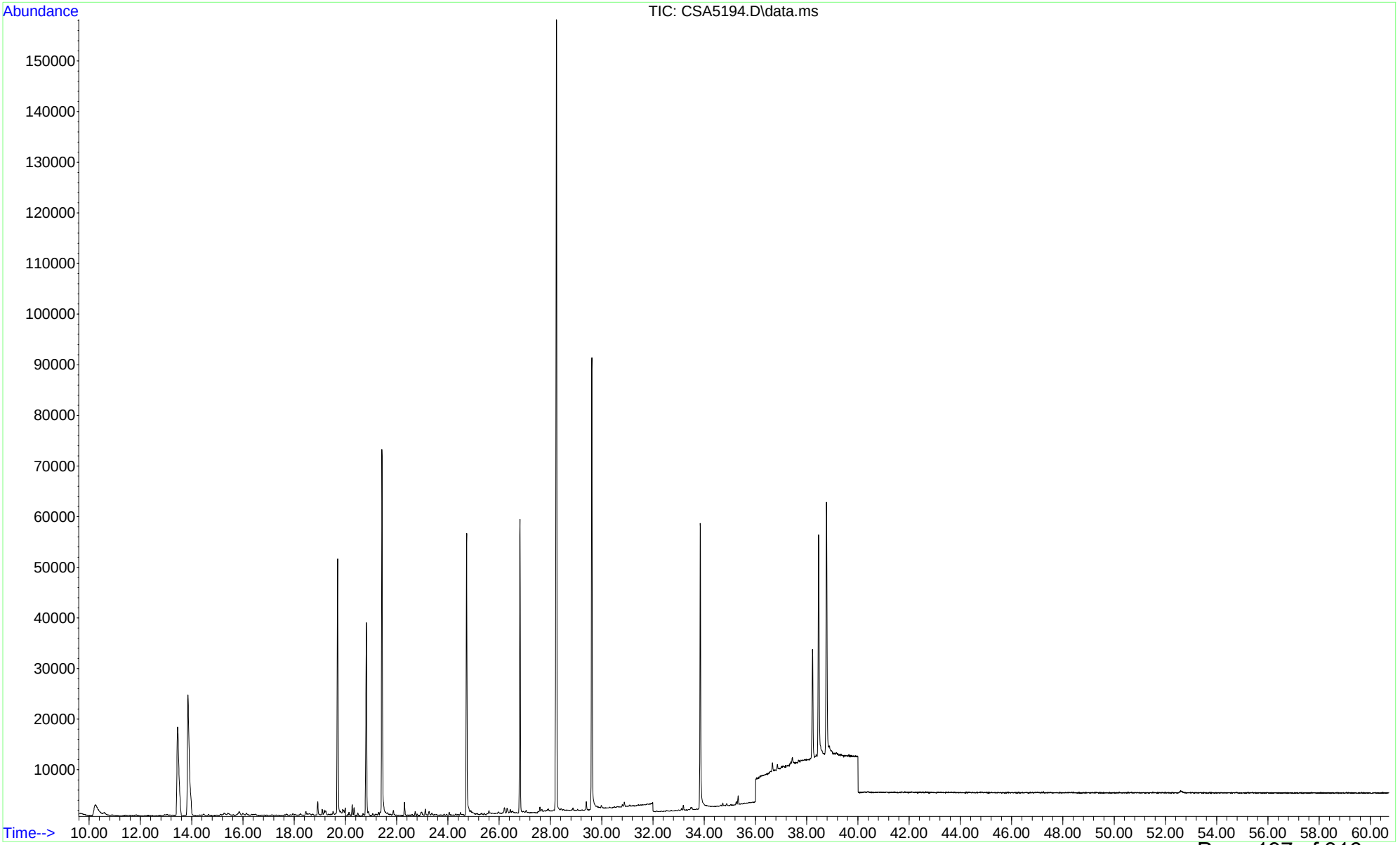

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5195.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   6:23     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-8|sw_b|hc|02
Misc Info  :
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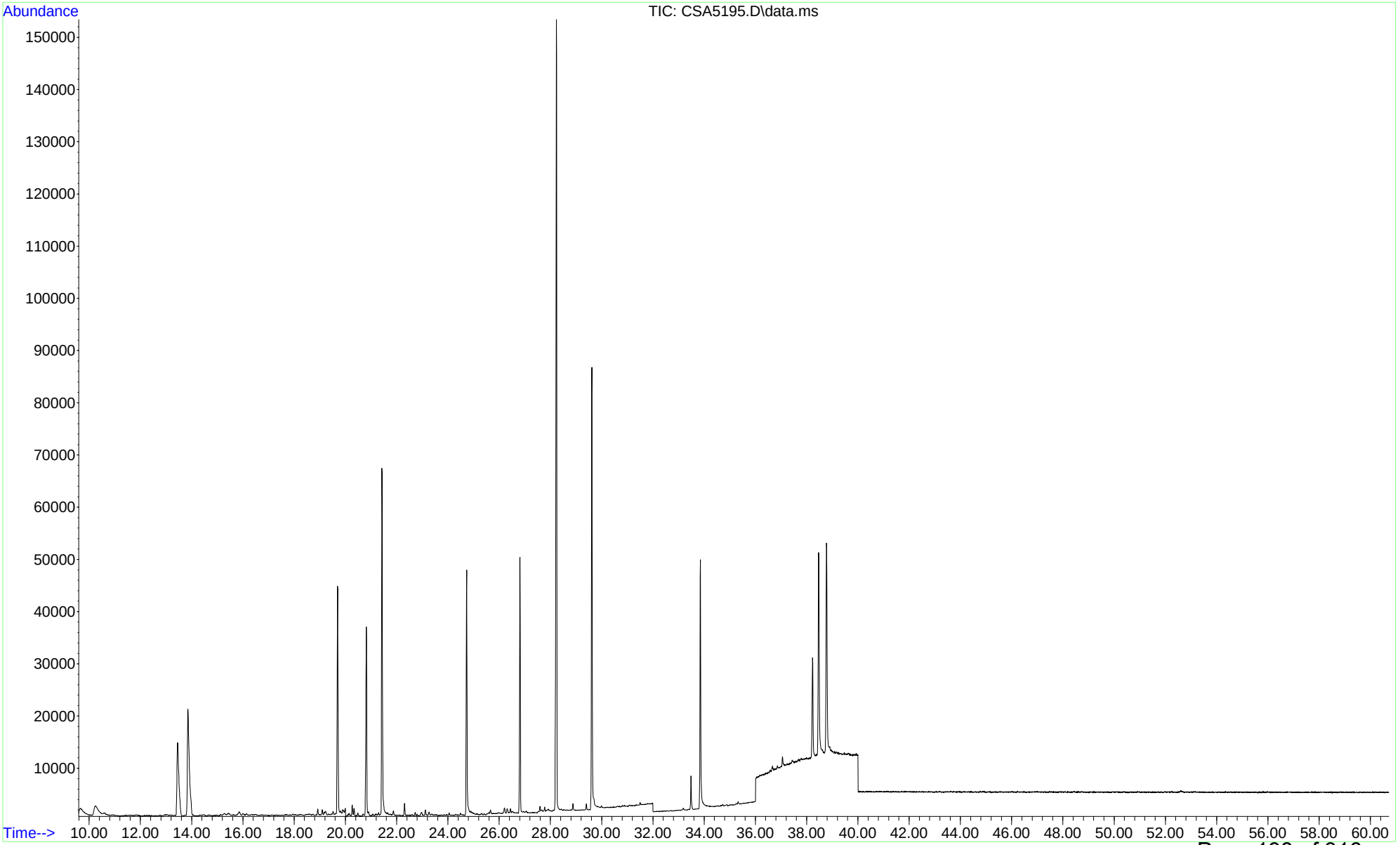

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5196.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   7:31     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sw_s|hc|01
Misc Info  :
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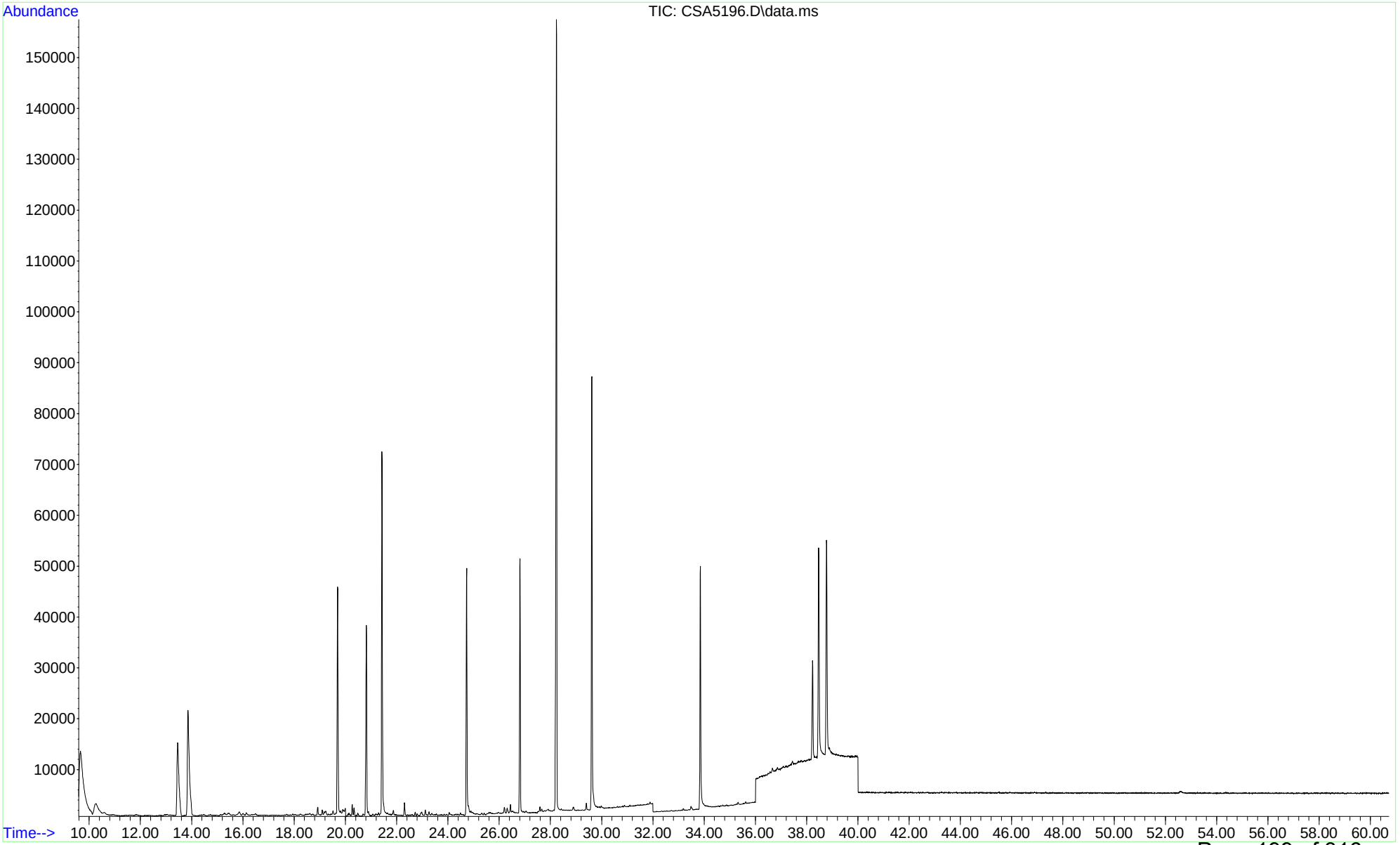

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5197.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   8:39     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sw_s|hc|02
Misc Info  :
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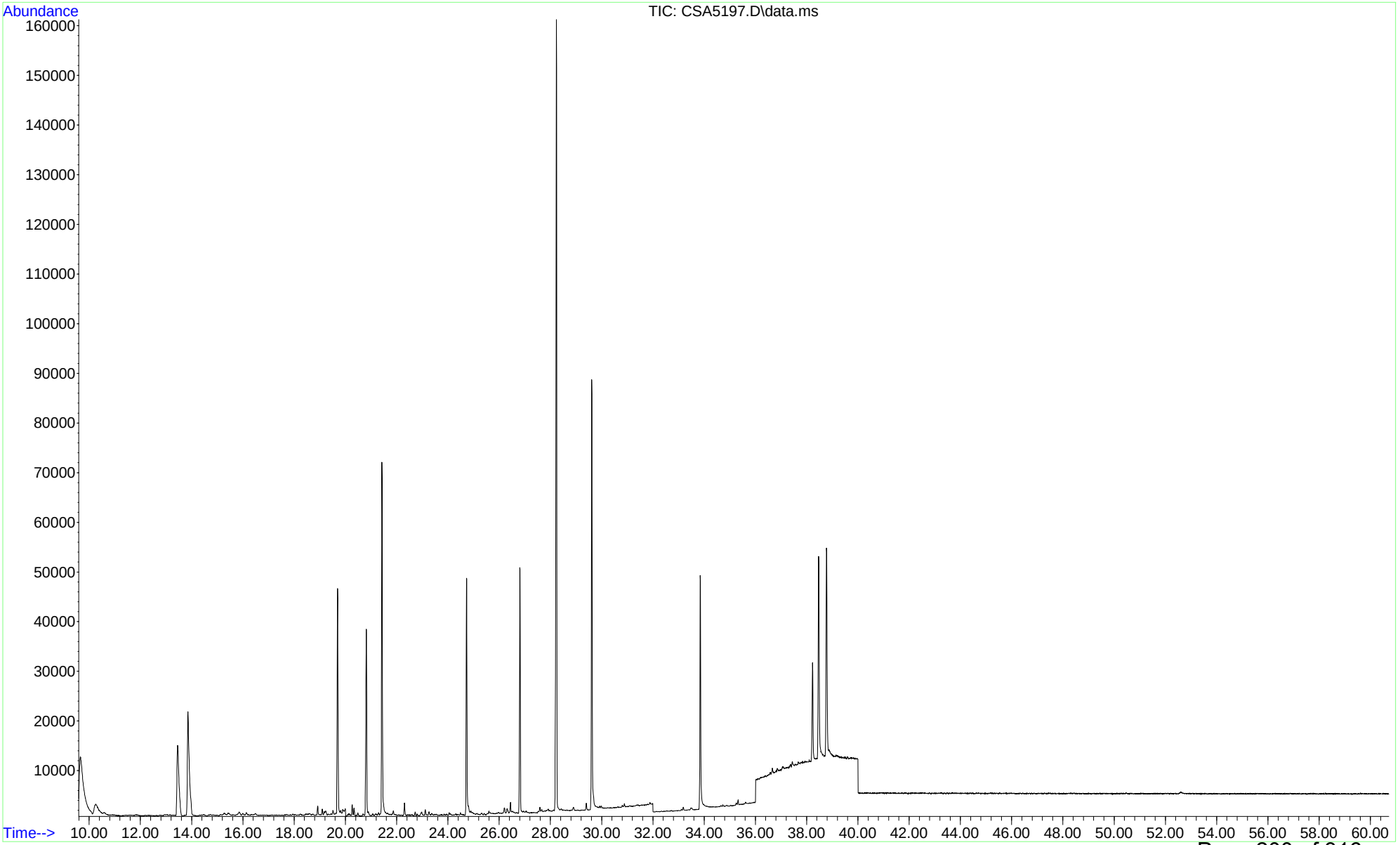

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5198.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020   9:47     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sw_m|hc|01
Misc Info  :
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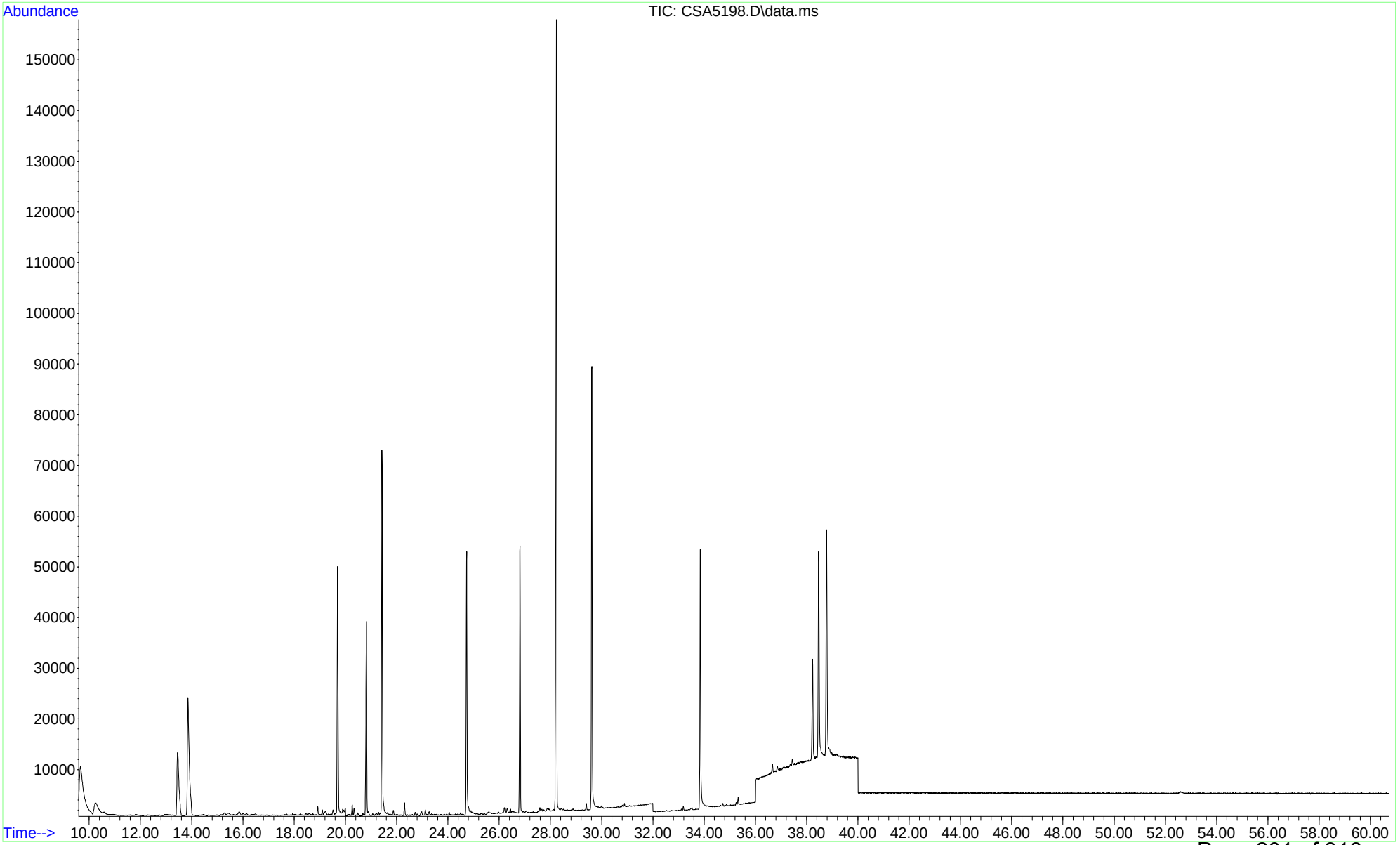

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5199.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  10:55     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sw_m|hc|02
Misc Info  :
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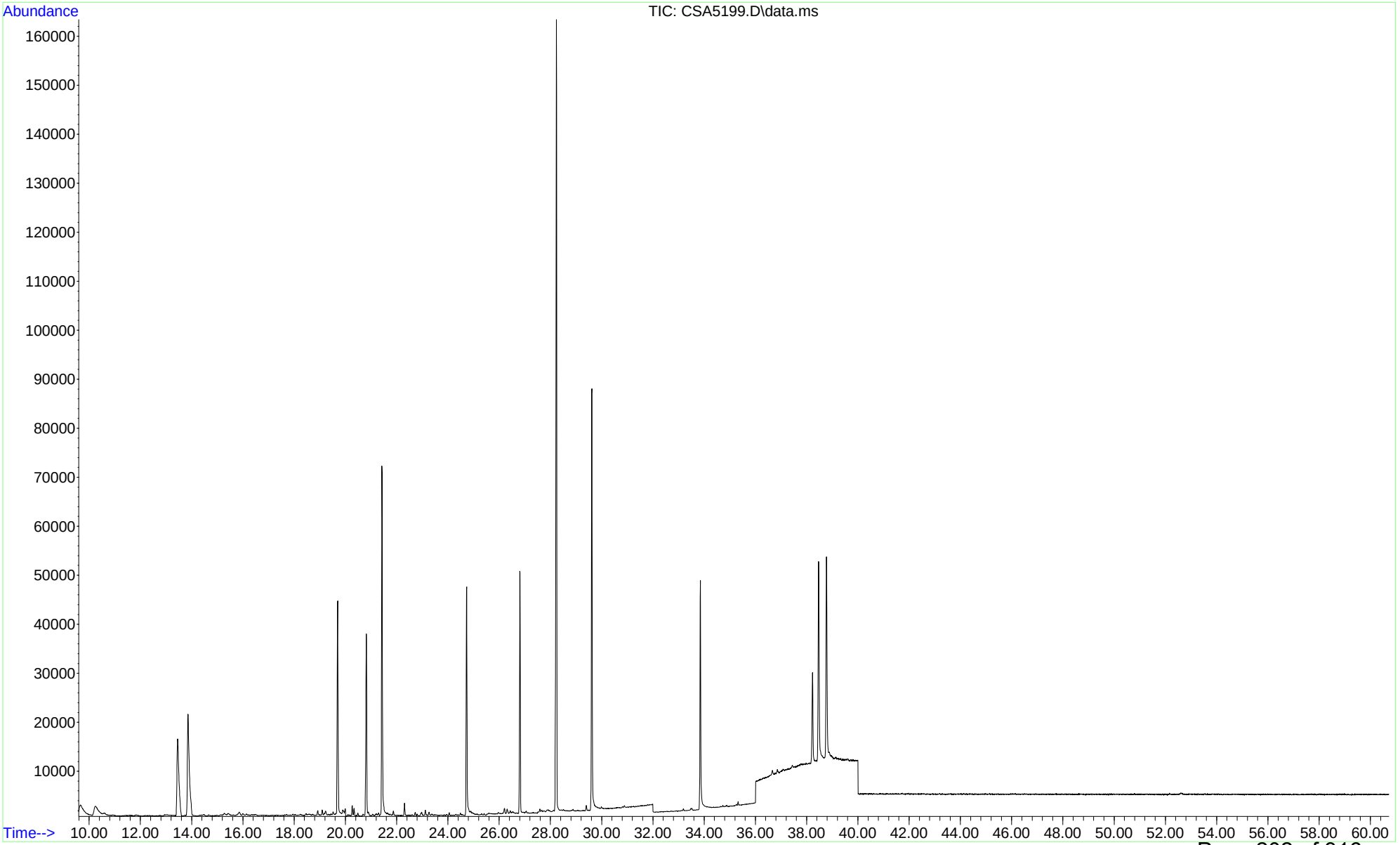
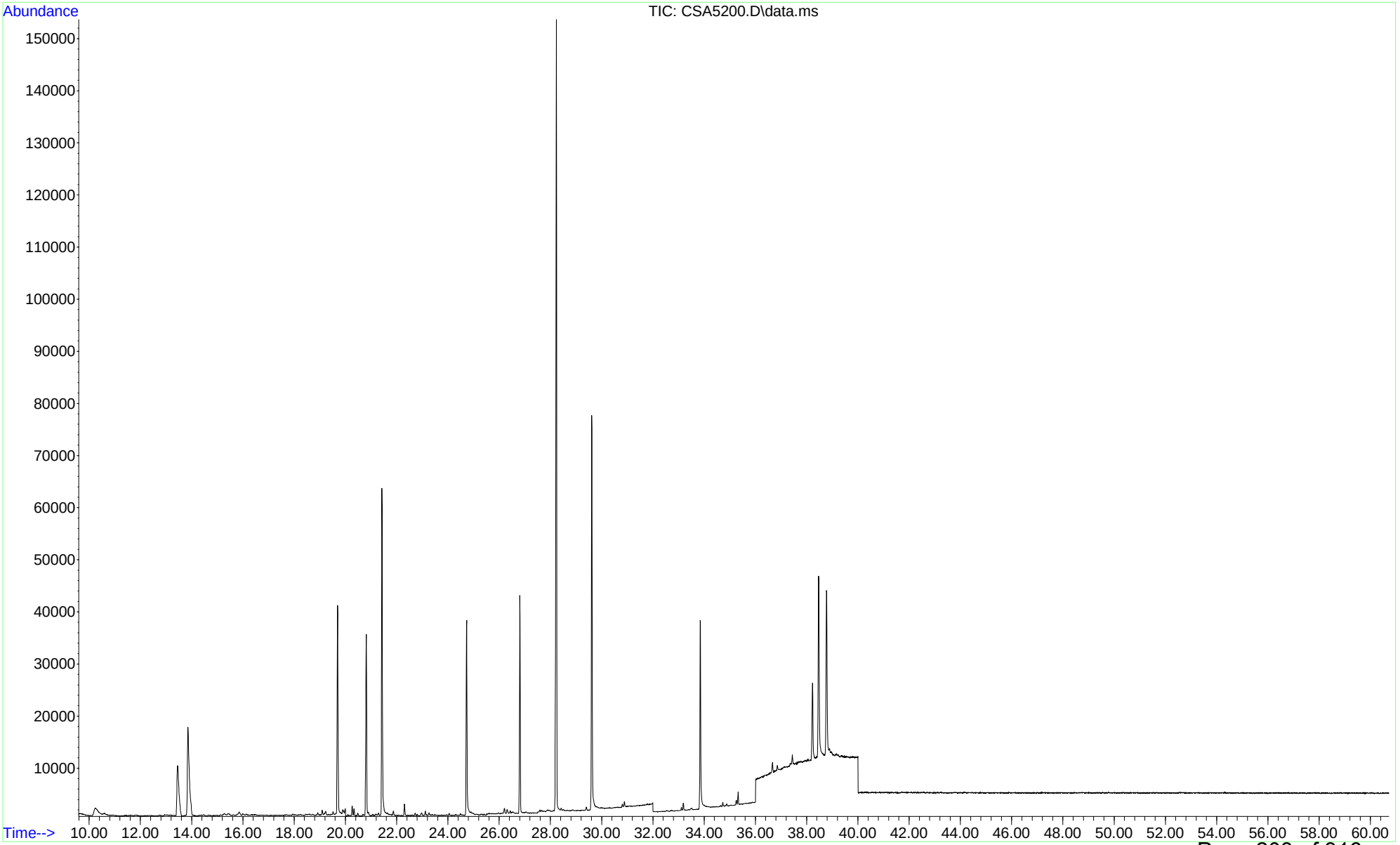


File :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
... ata\CSA5200.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 21 Mar 2020 12:03 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sw_b|hc|01
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5201.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  13:11     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-4|sw_b|hc|02
Misc Info  :
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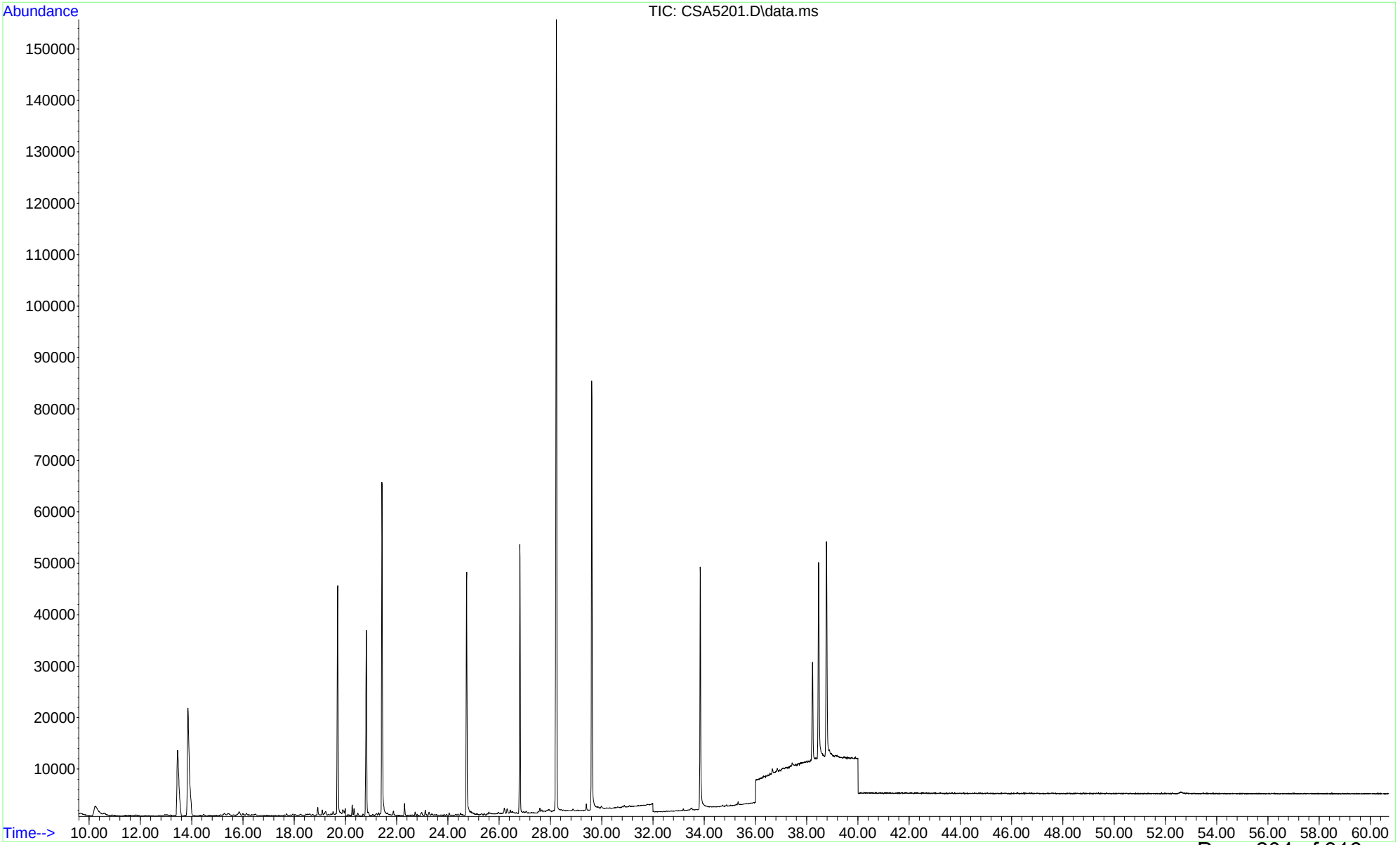

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5202.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  15:28     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sw_s|hc|01
Misc Info  :
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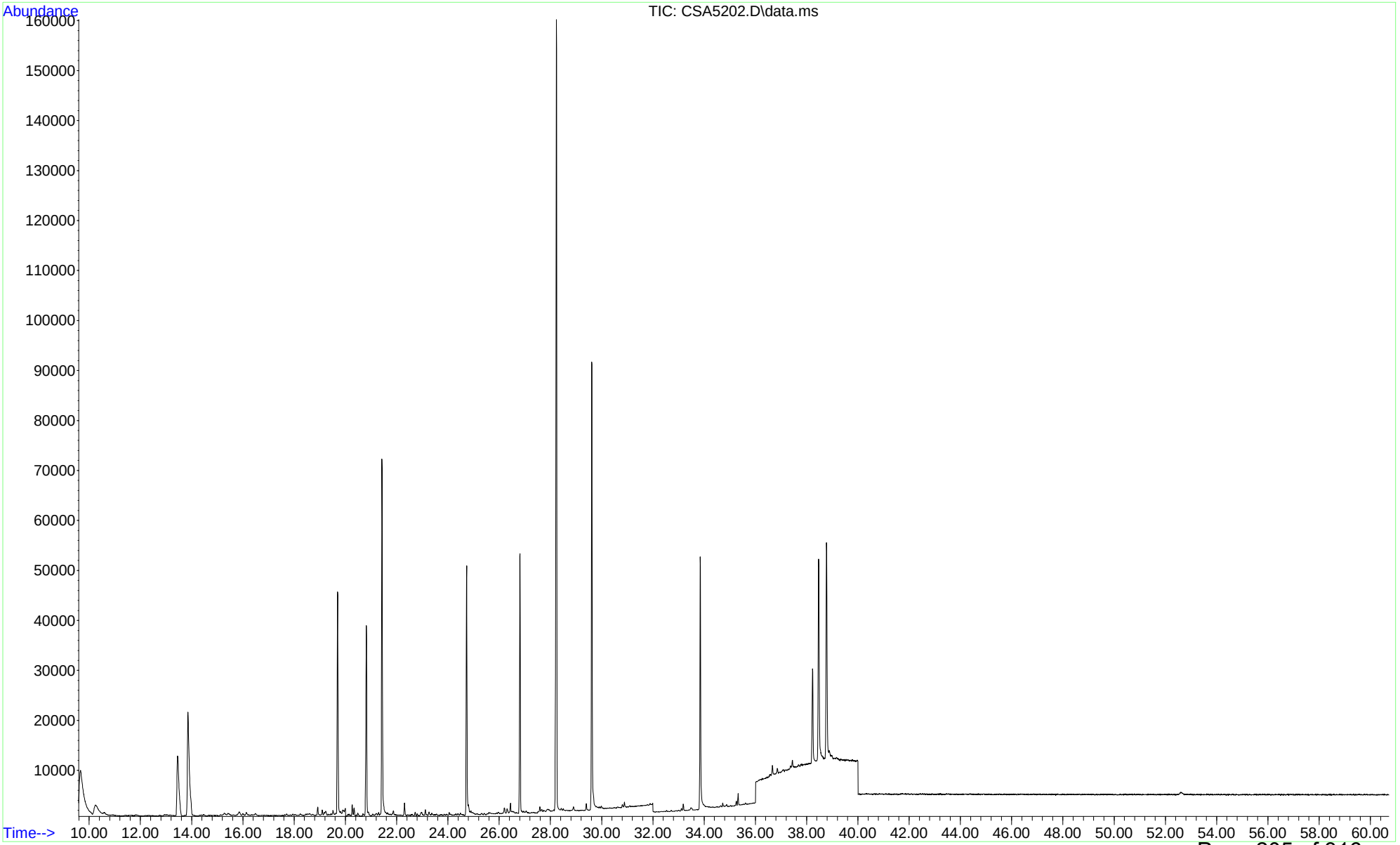

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5203.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  16:36     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sw_s|hc|02
Misc Info  :
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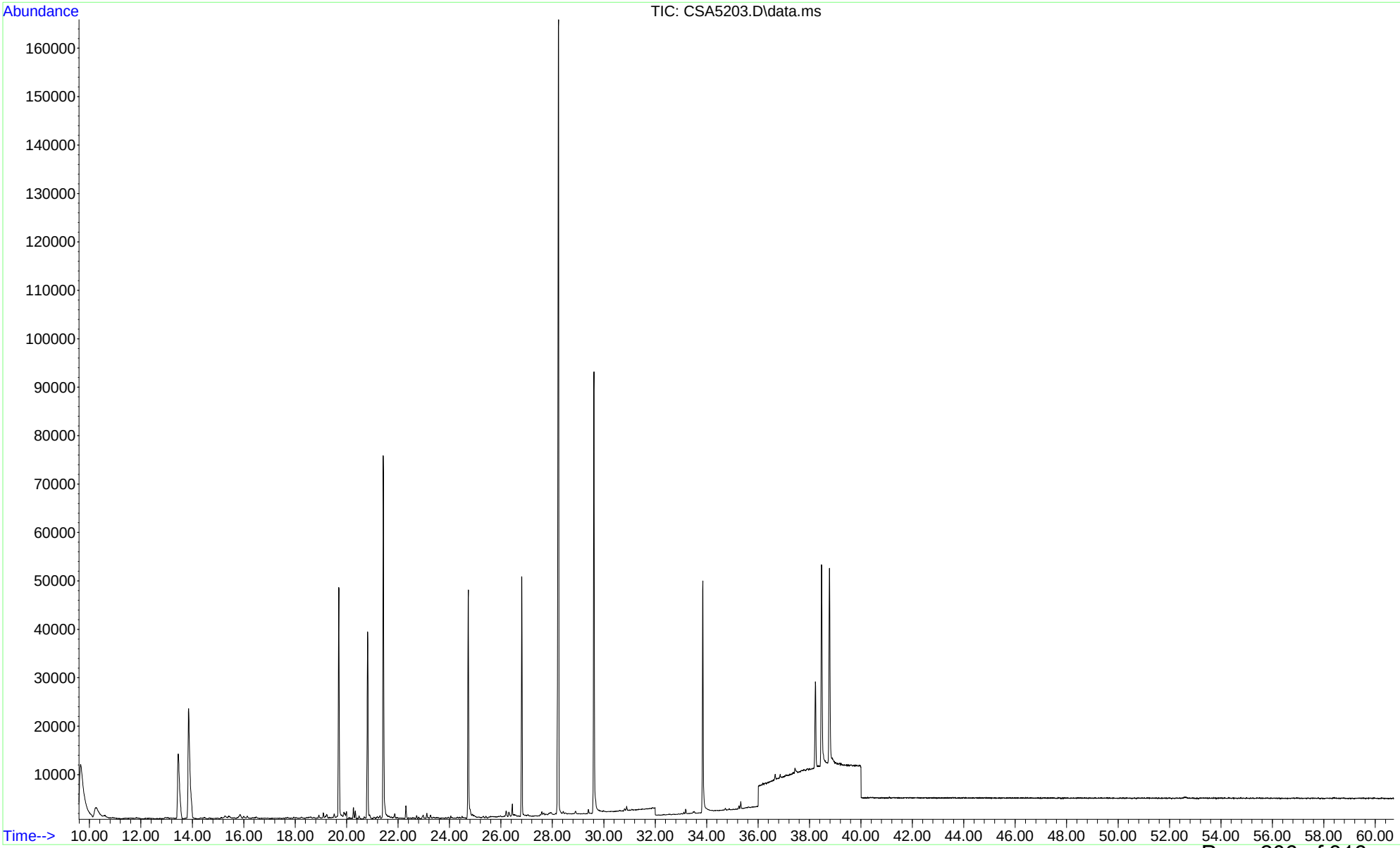

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5204.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  17:44     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sw_m|hc|01
Misc Info  :
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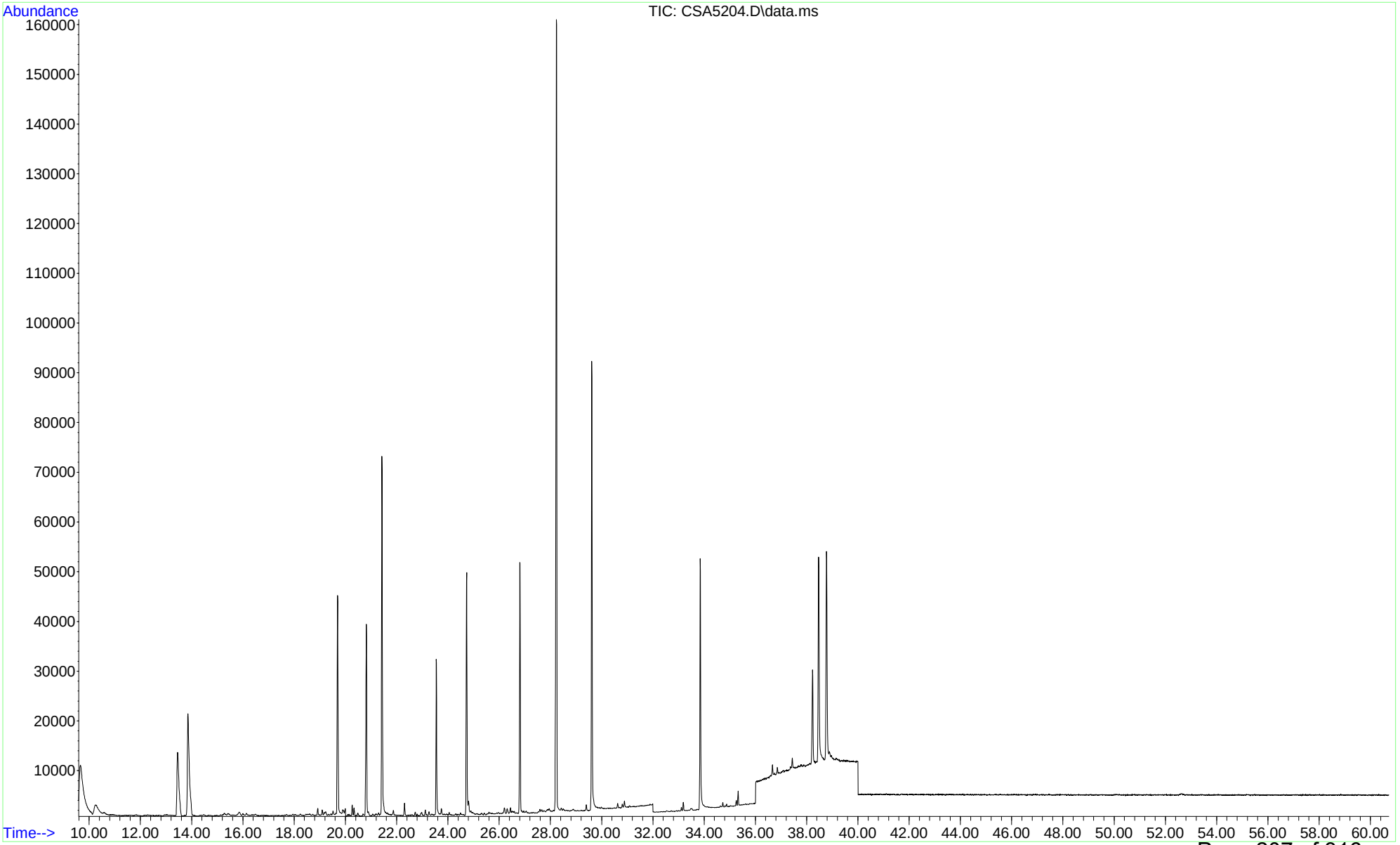

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5205.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  18:52     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sw_m|hc|02
Misc Info  :
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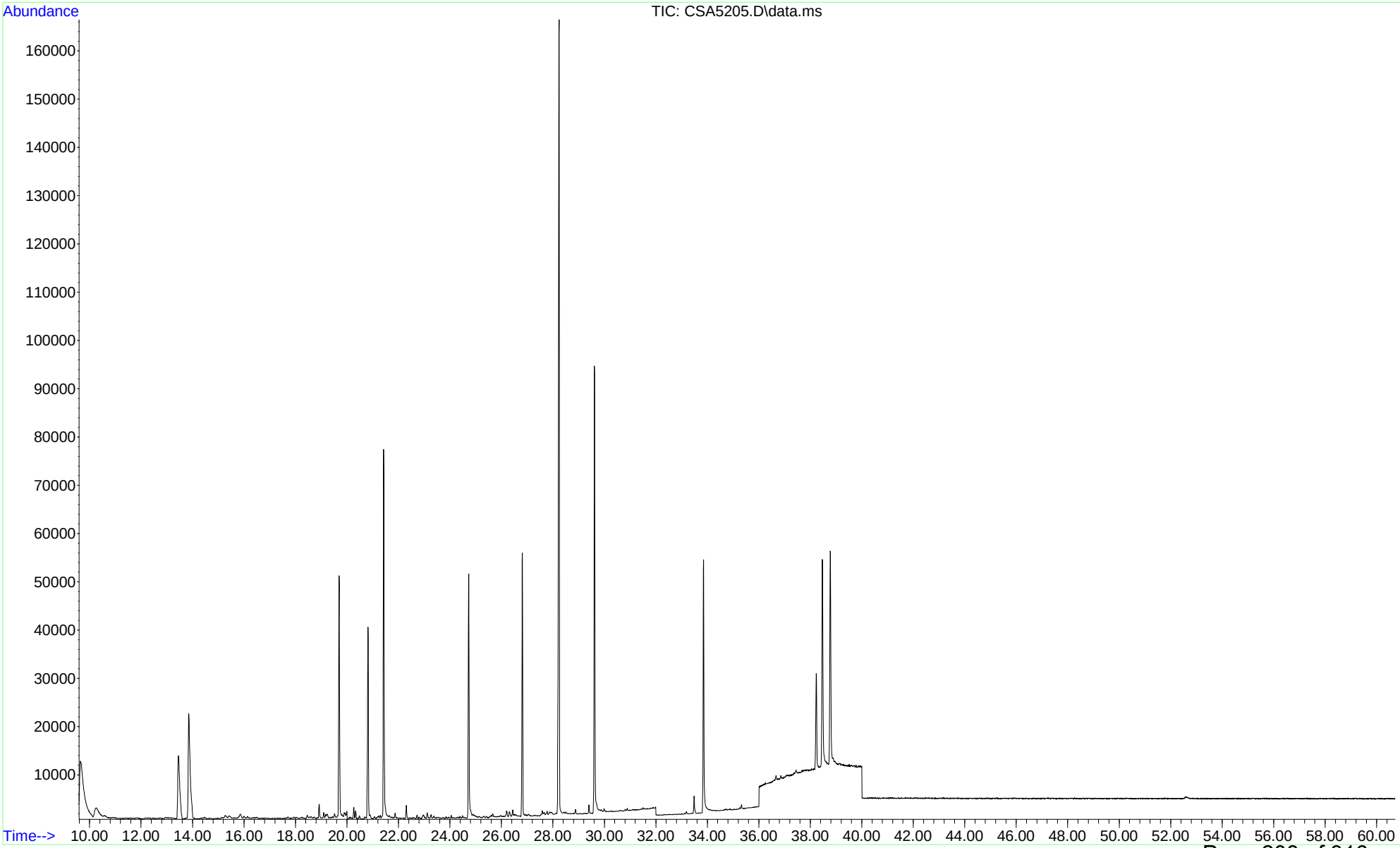
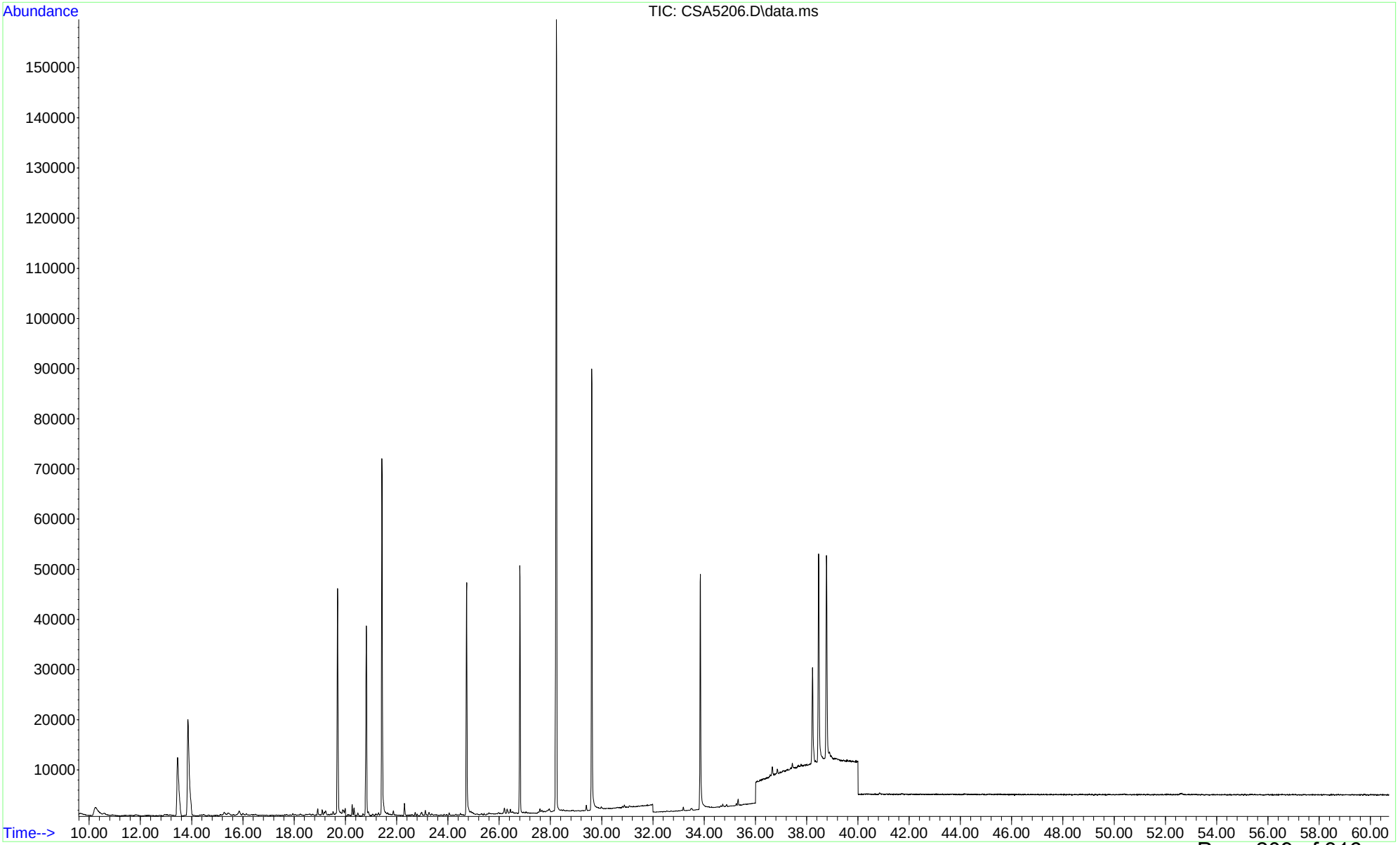
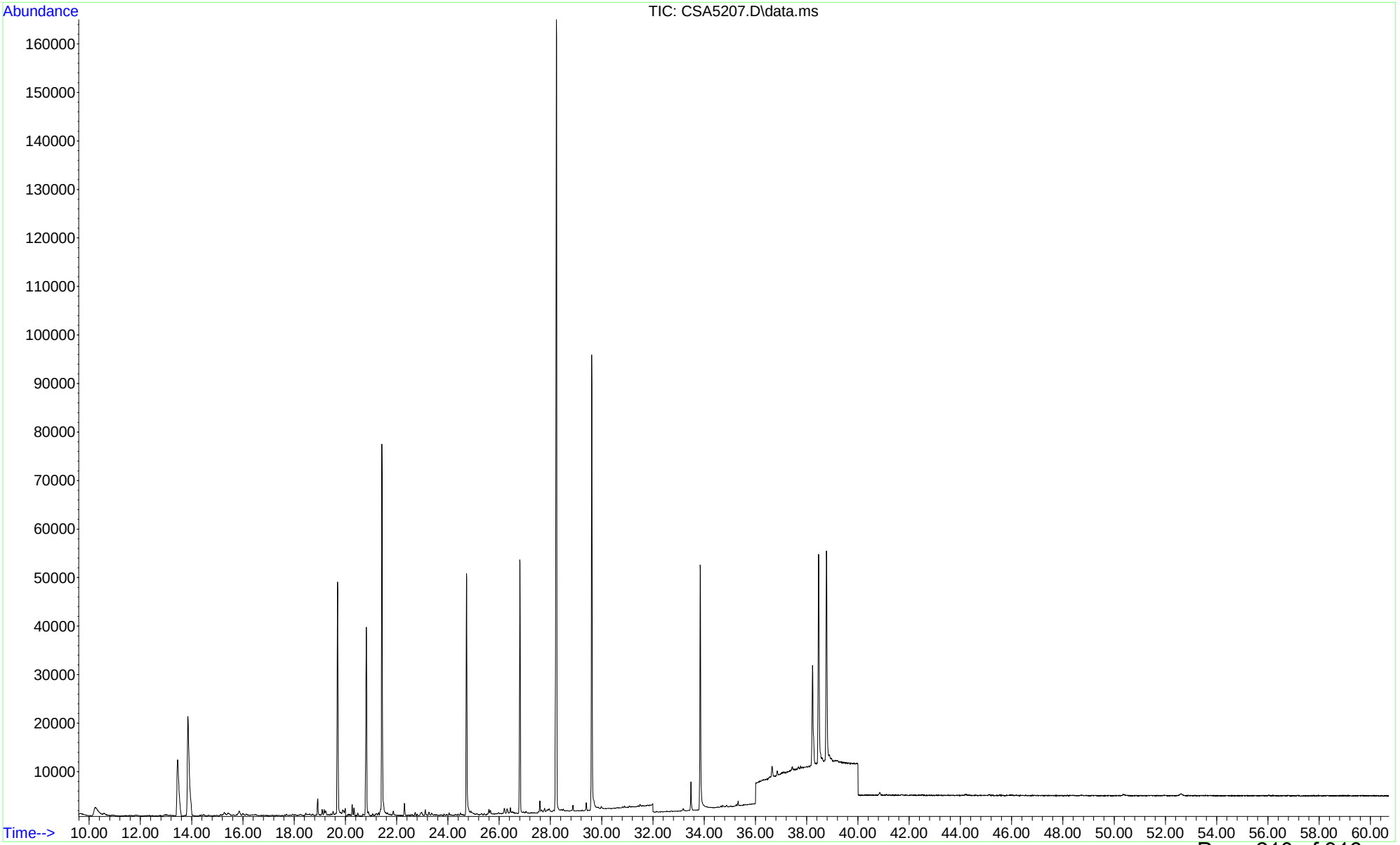


File :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
... ata\CSA5206.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 21 Mar 2020 20:00 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sw_b|hc|01
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5207.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  21:08     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-6|sw_b|hc|02
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5208.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  22:16     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sw_s|hc|01
Misc Info  :
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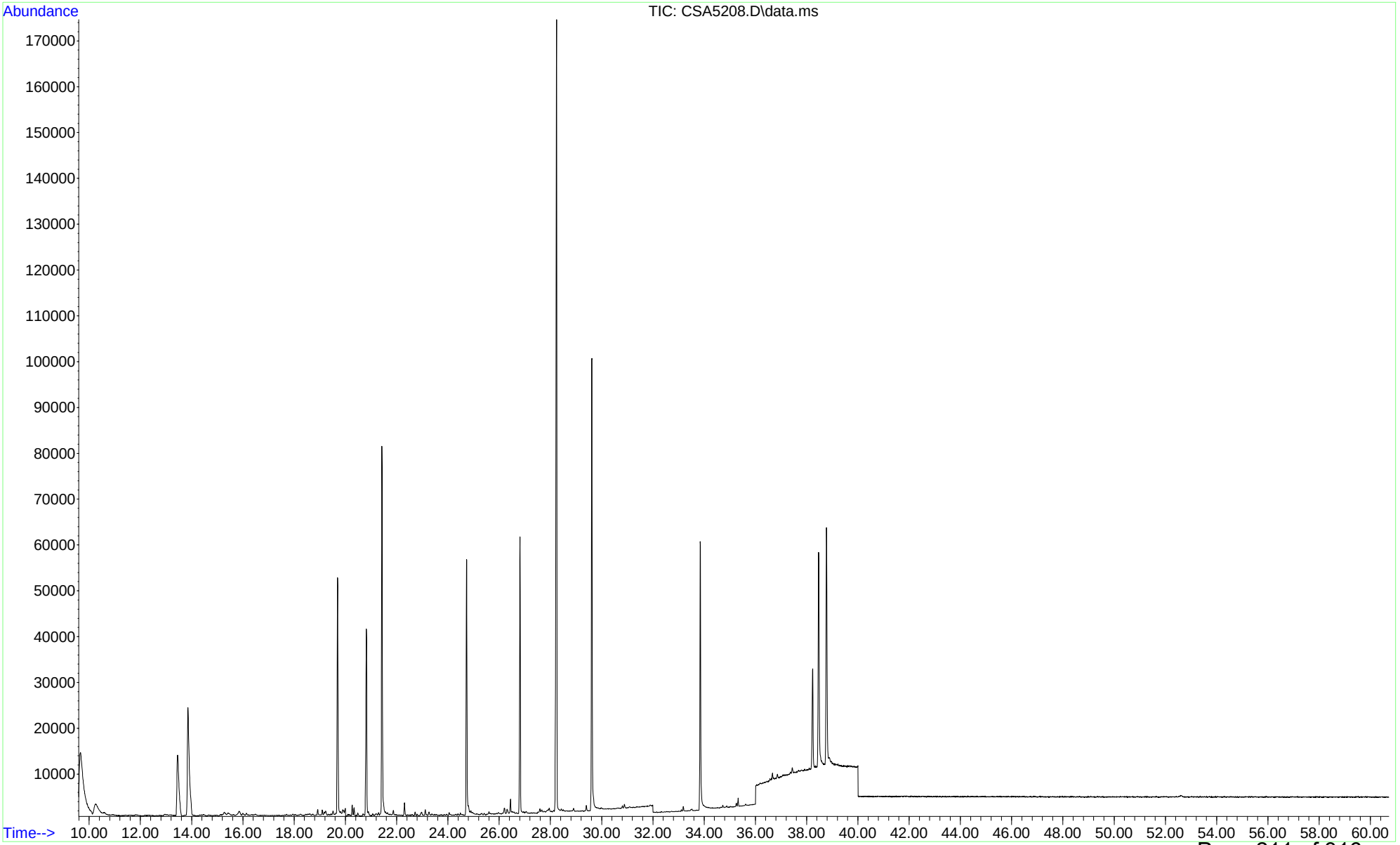
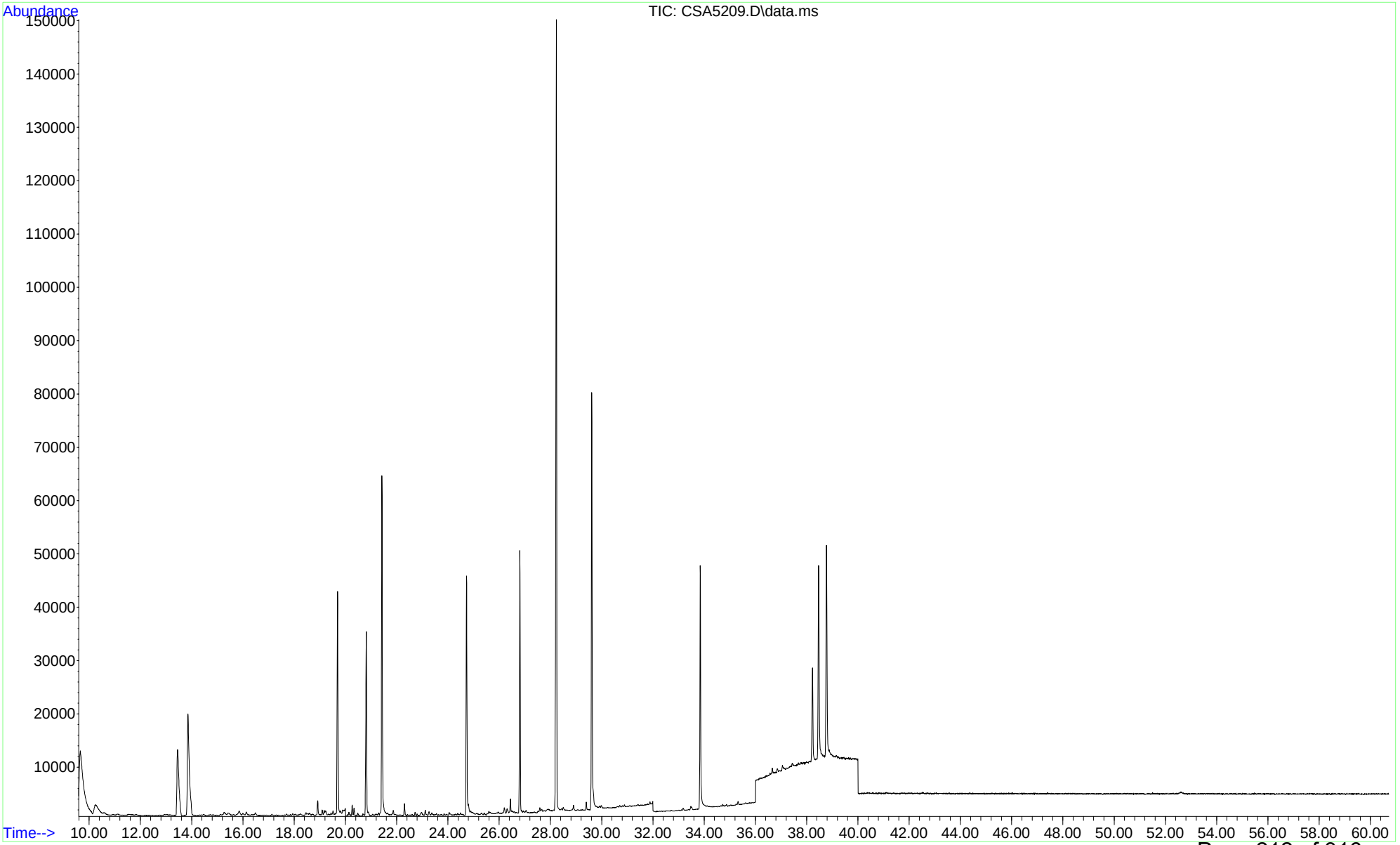
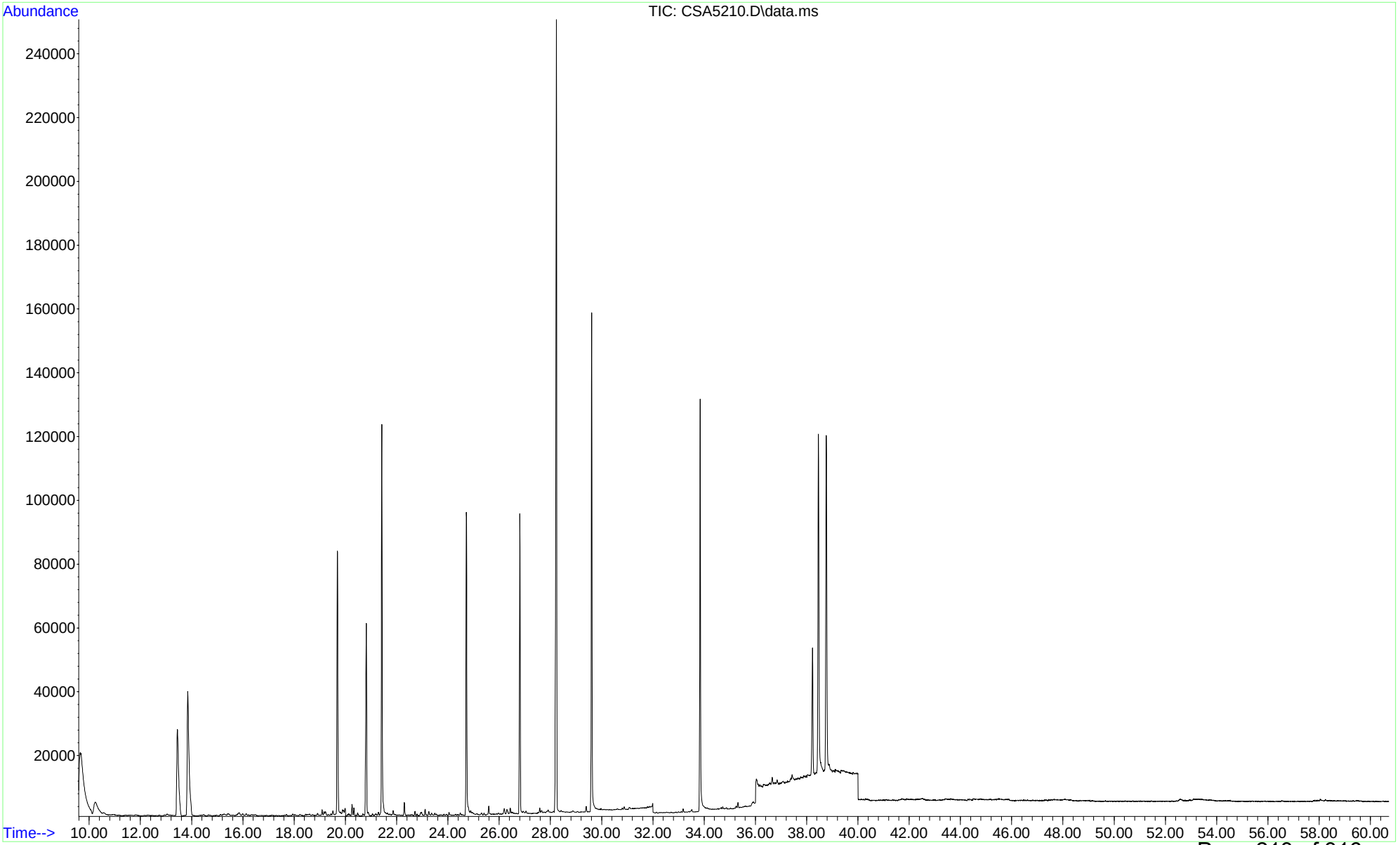


```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4073\ENV4073-MS70376PAH Raw D
...         ata\CSA5209.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 21 Mar 2020  23:24     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sw_s|hc|02
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5210.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020   2:16     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sw_m|hc|01
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5211.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020   3:24     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sw_m|hc|02
Misc Info  :
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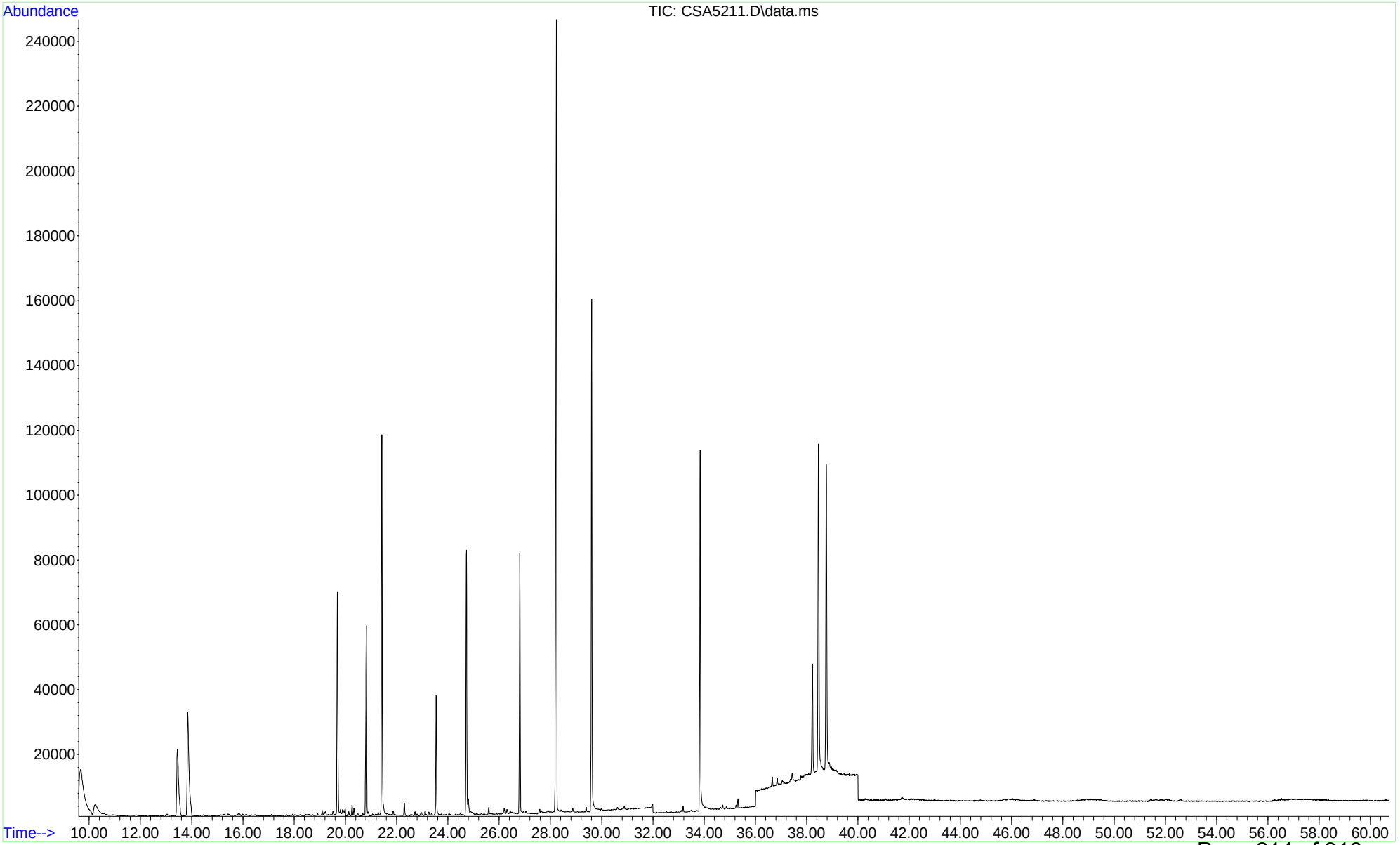

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5212.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020   4:32     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sw_b|hc|01
Misc Info  :
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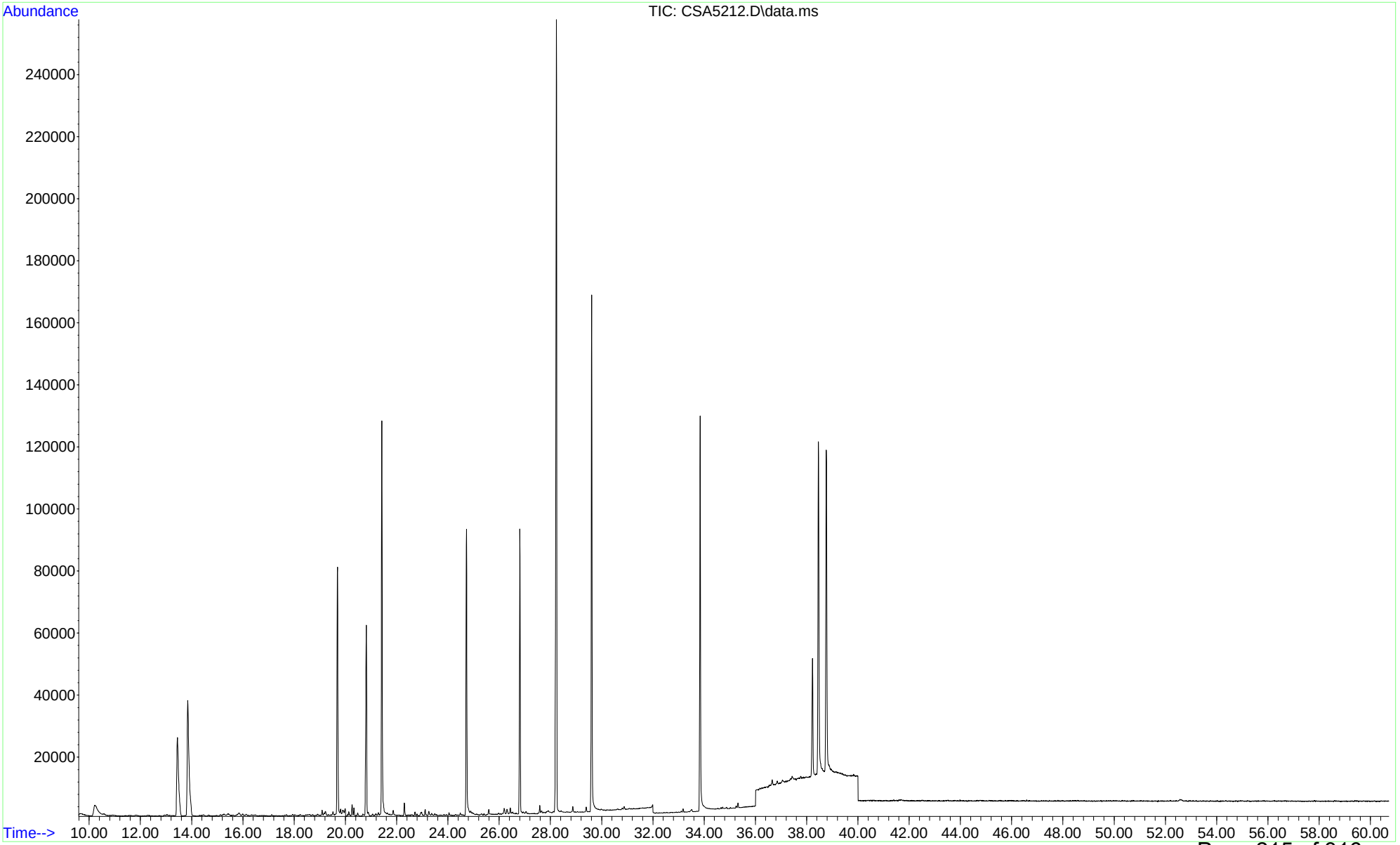

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5213.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020   5:40     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-1|sw_b|hc|02
Misc Info  :
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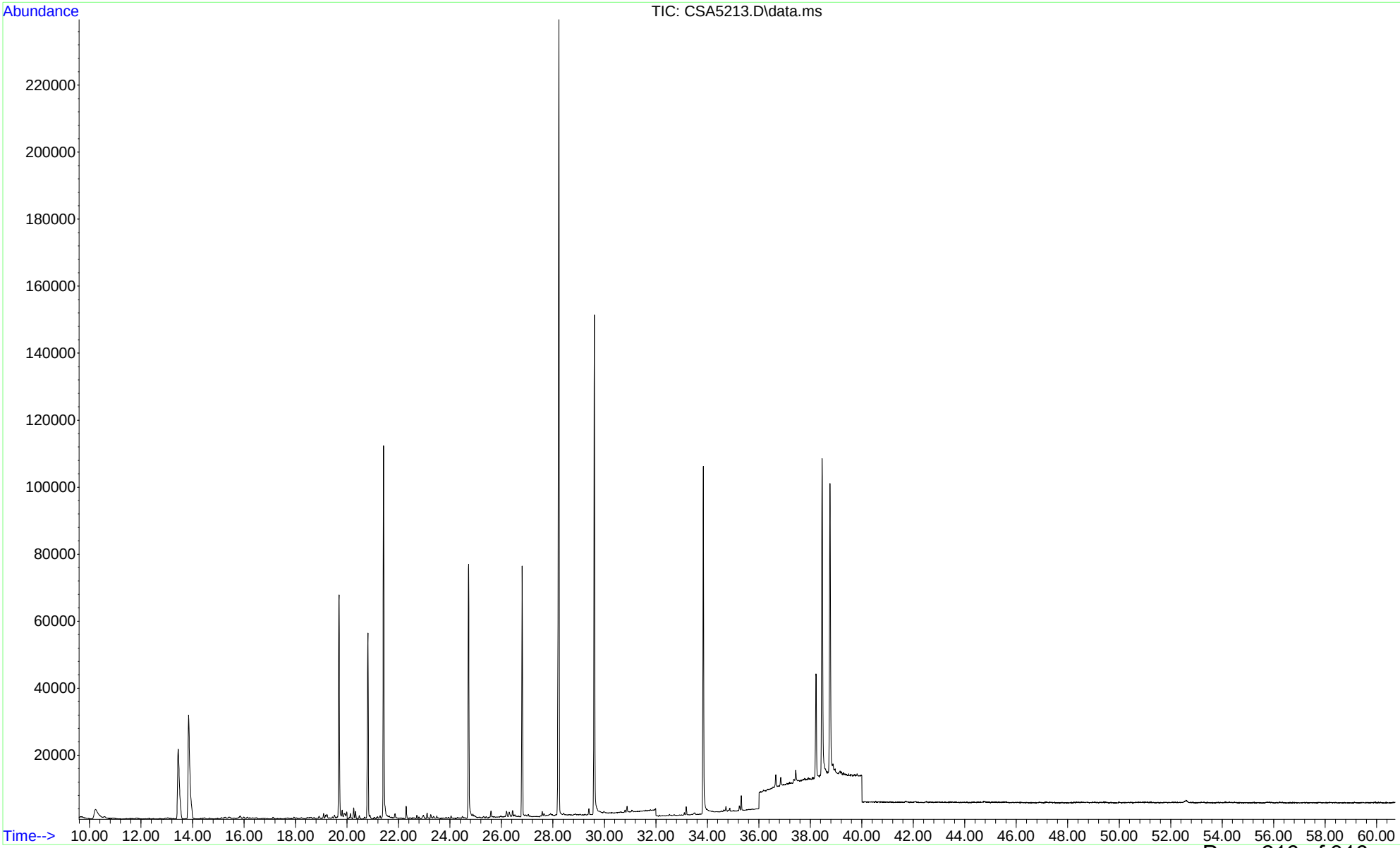
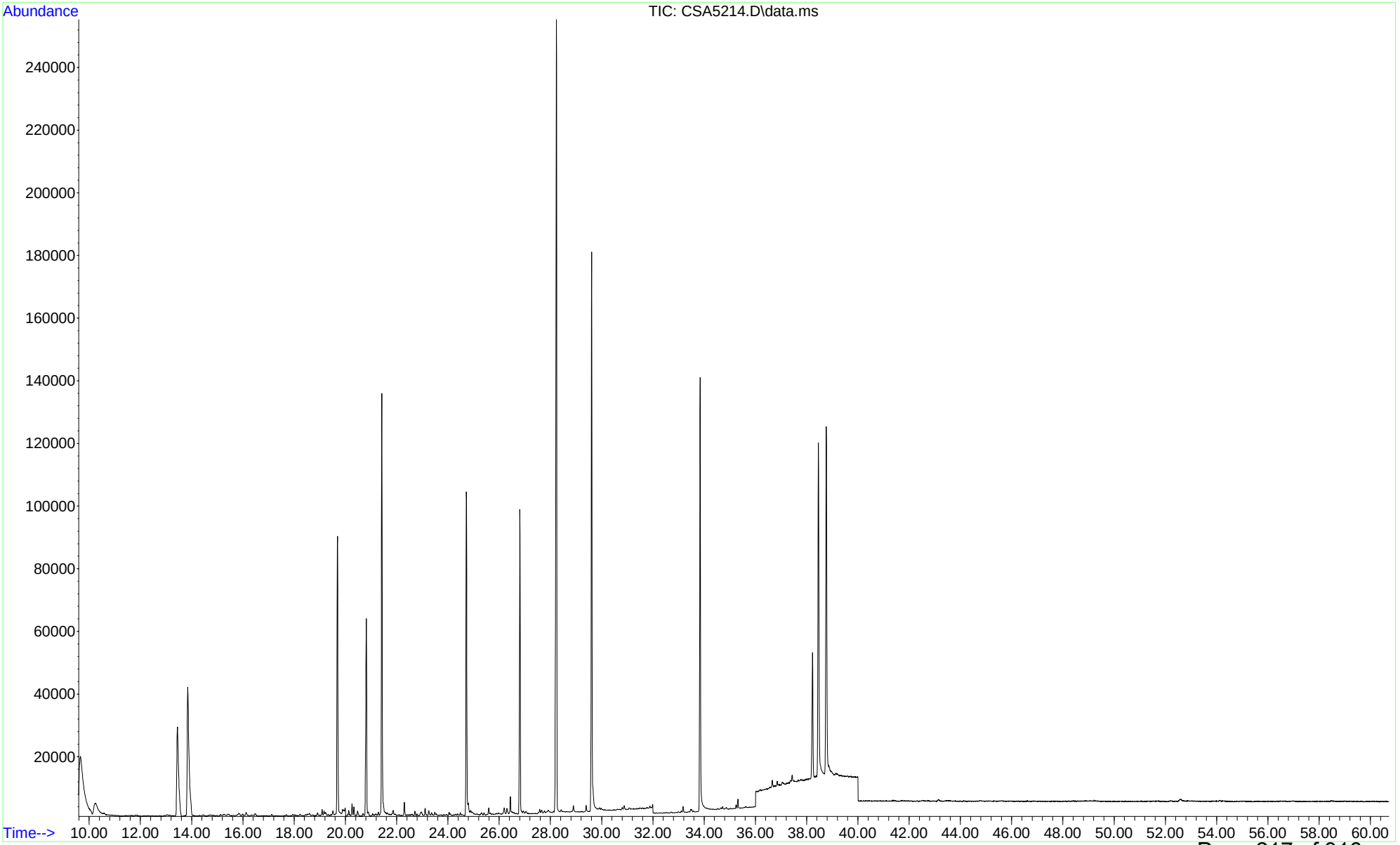


File :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
... ata\CSA5214.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 26 Mar 2020 7:56 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sw_s|hc|01
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5215.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020   9:05     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sw_s|hc|02
Misc Info  :
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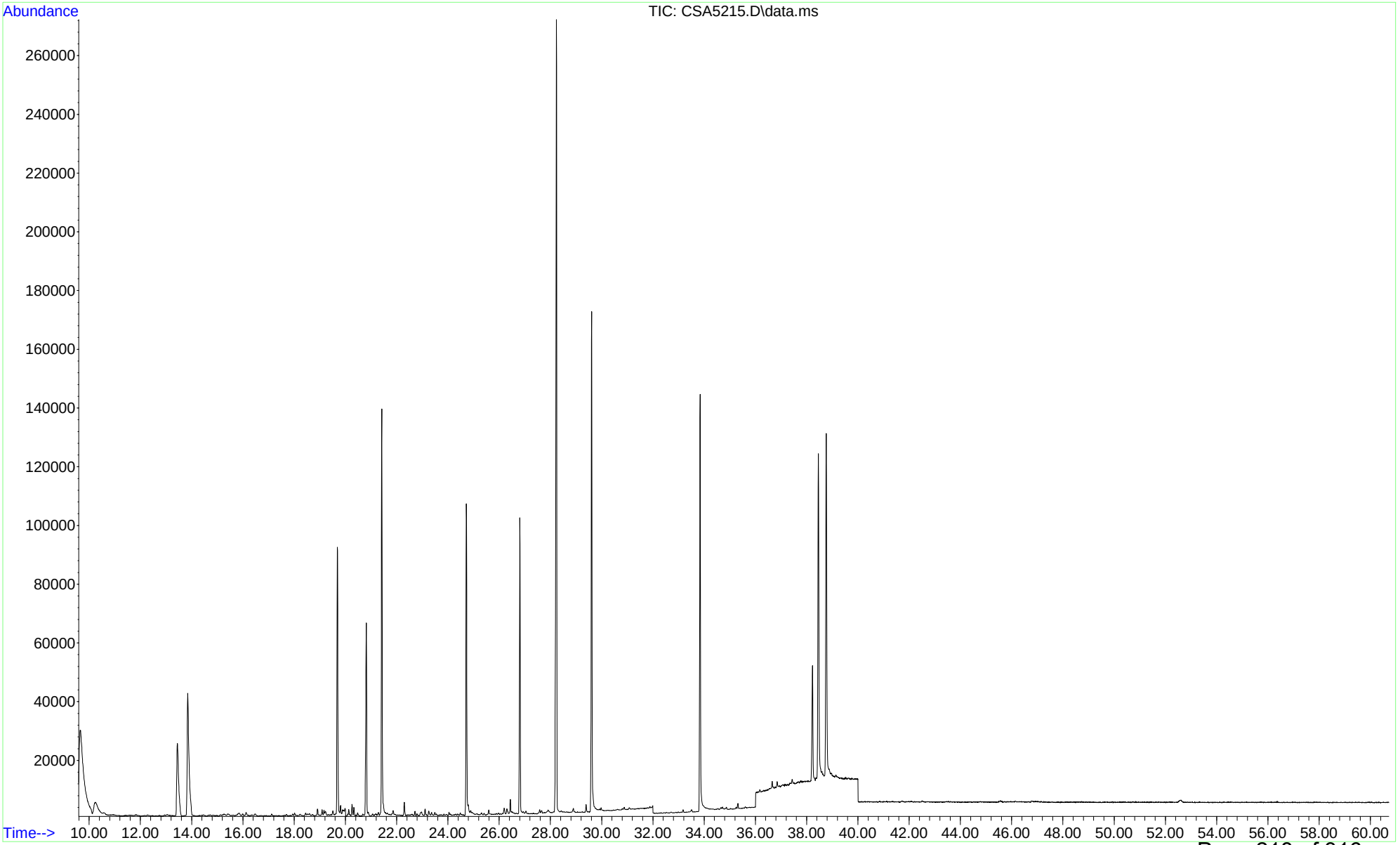
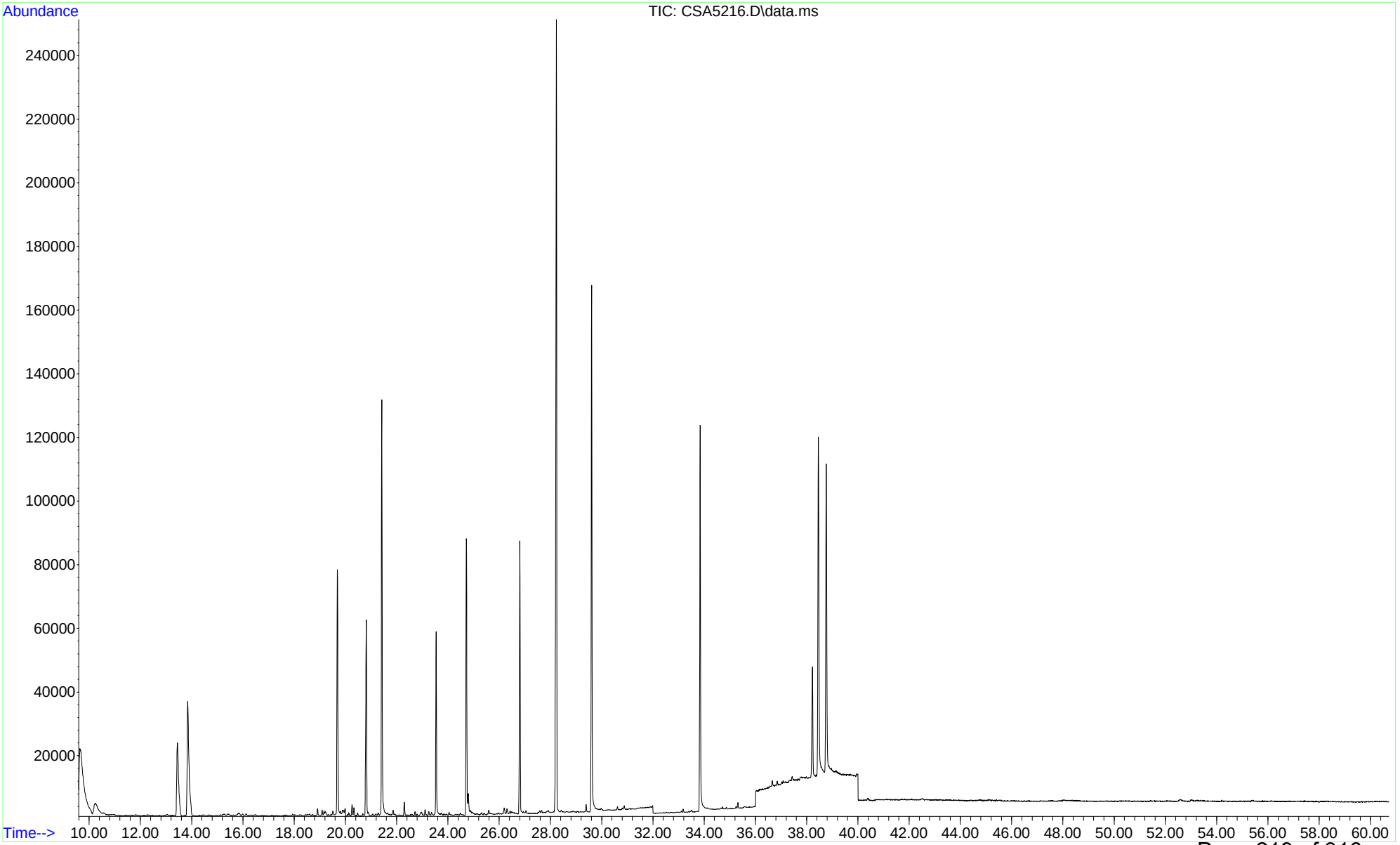


```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5216.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  10:13     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sw_m|hc|01
Misc Info  :
```



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5217.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  11:21     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sw_m|hc|02
Misc Info  :
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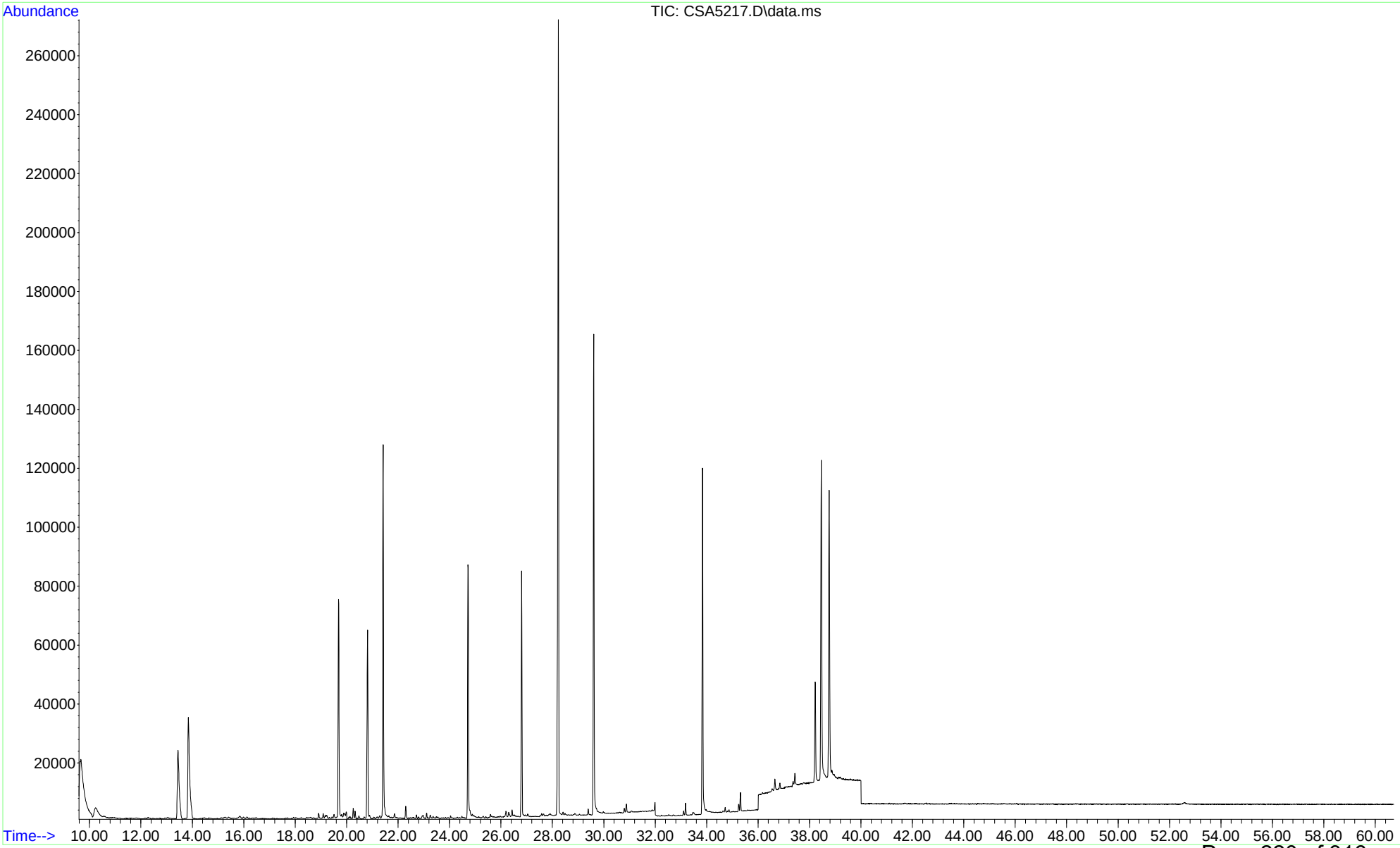

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5218.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  12:29     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sw_b|hc|01
Misc Info  :
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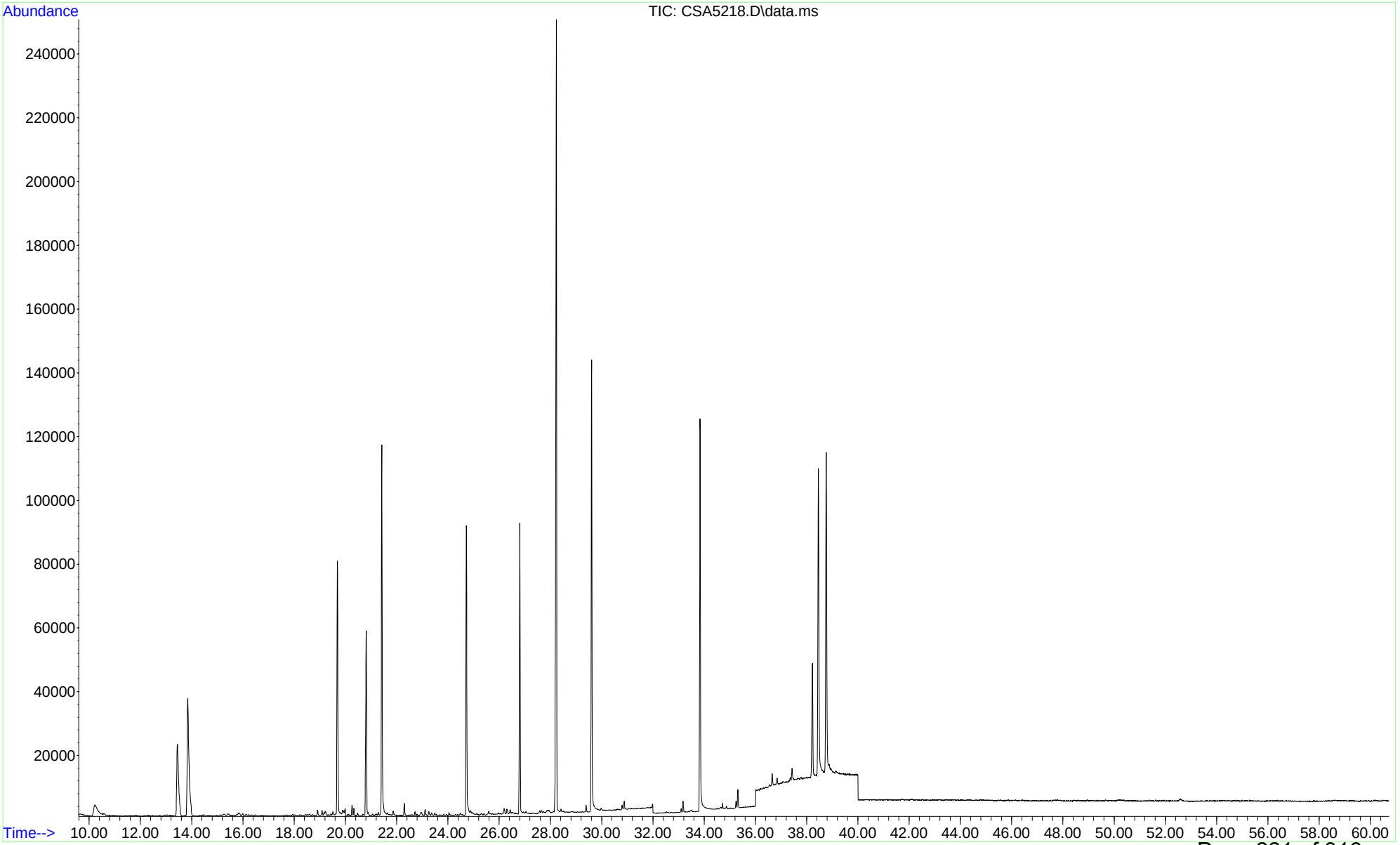
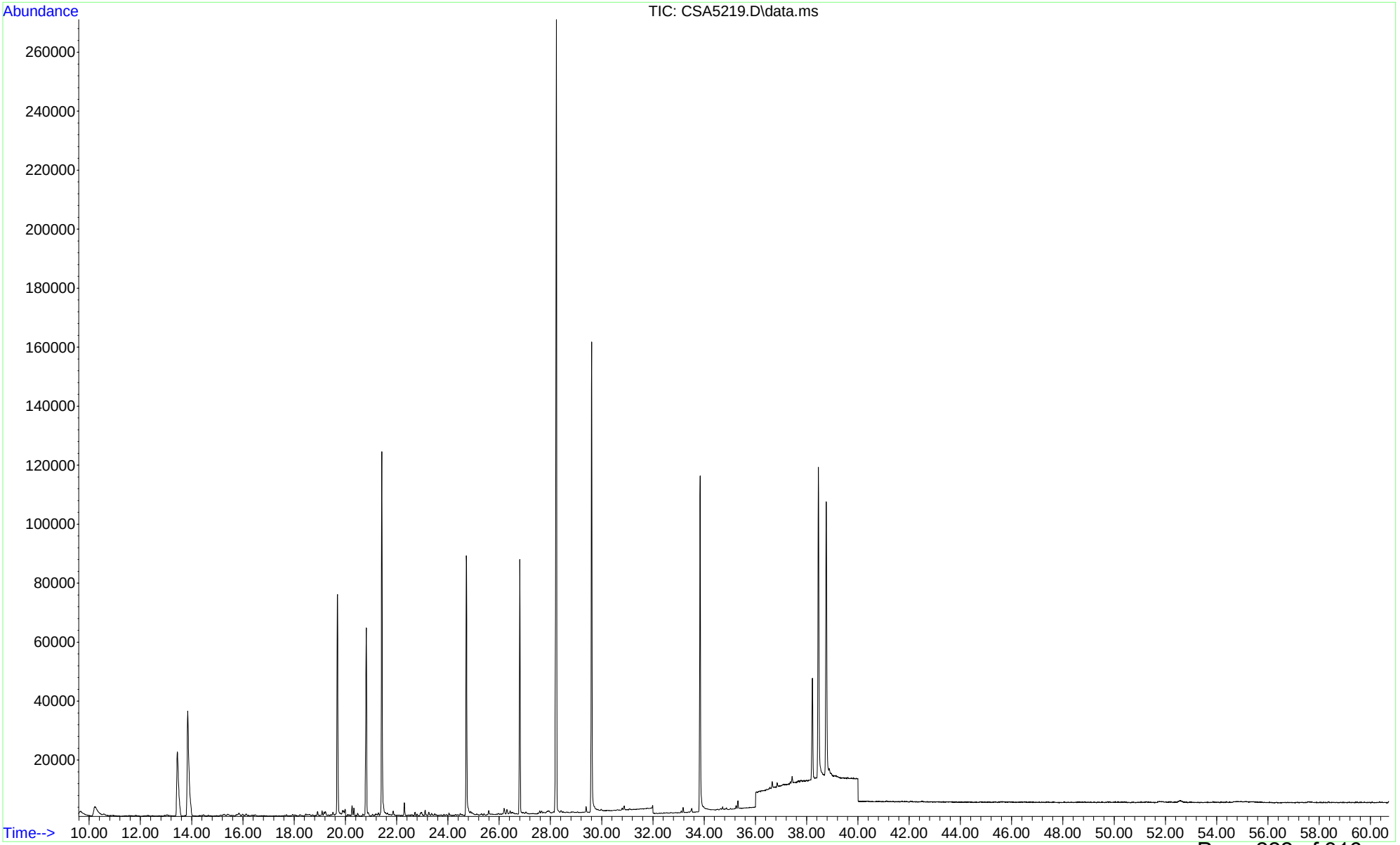


File :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
... ata\CSA5219.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 26 Mar 2020 13:37 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-2|sw_b|hc|02
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5220.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  14:46     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sw_s|hc|01
Misc Info  :
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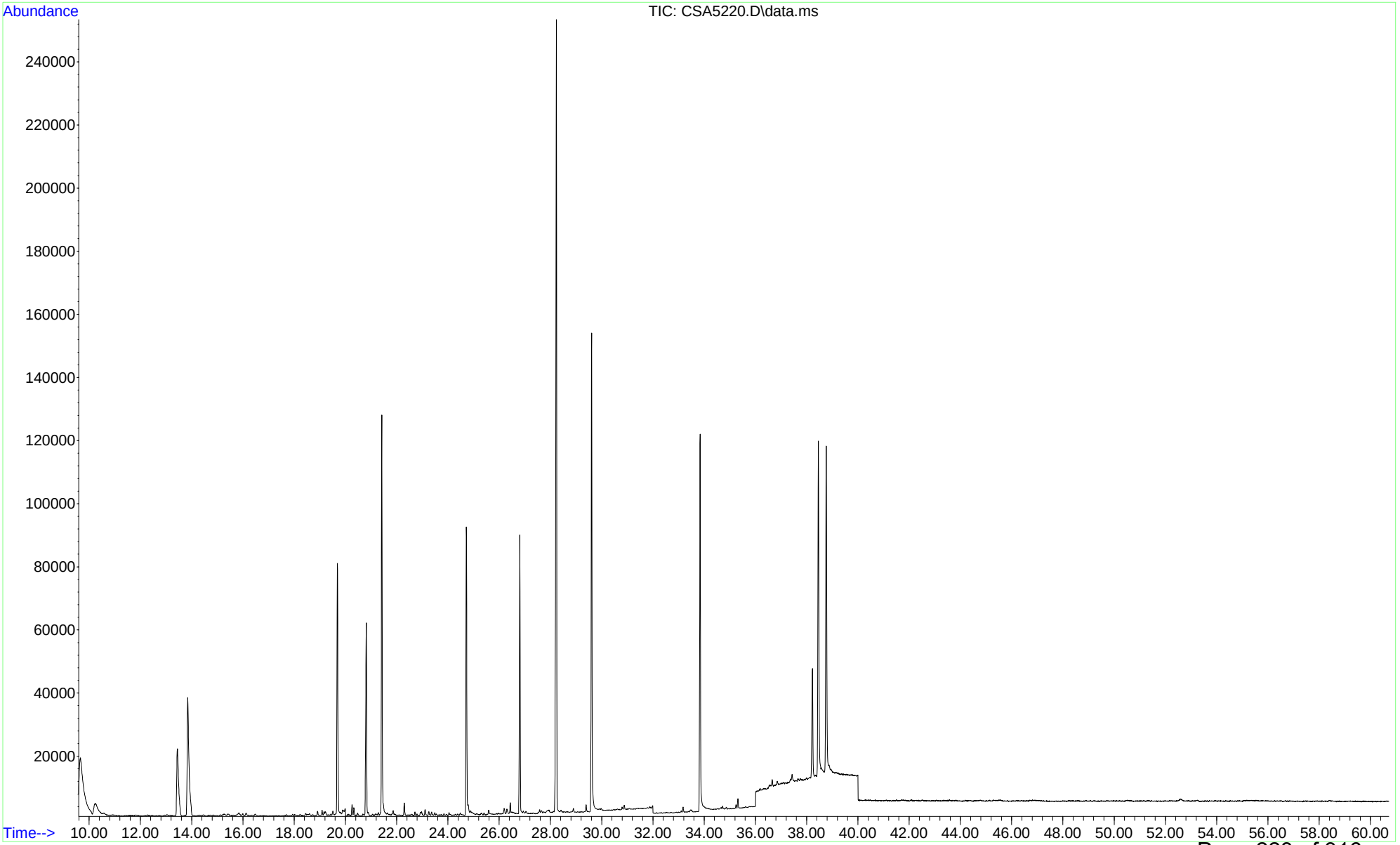

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5221.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  15:54     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sw_s|hc|02
Misc Info  :
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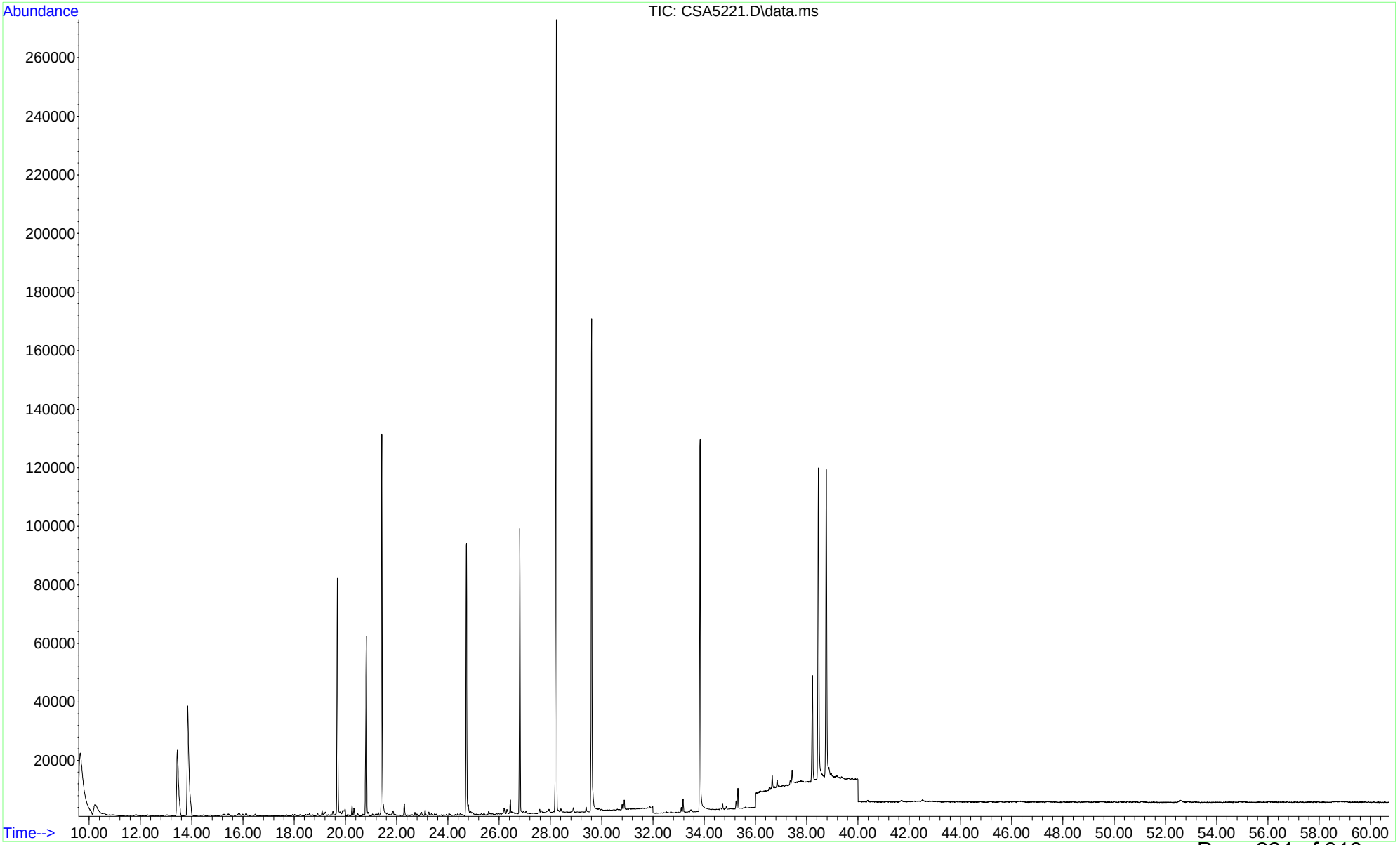
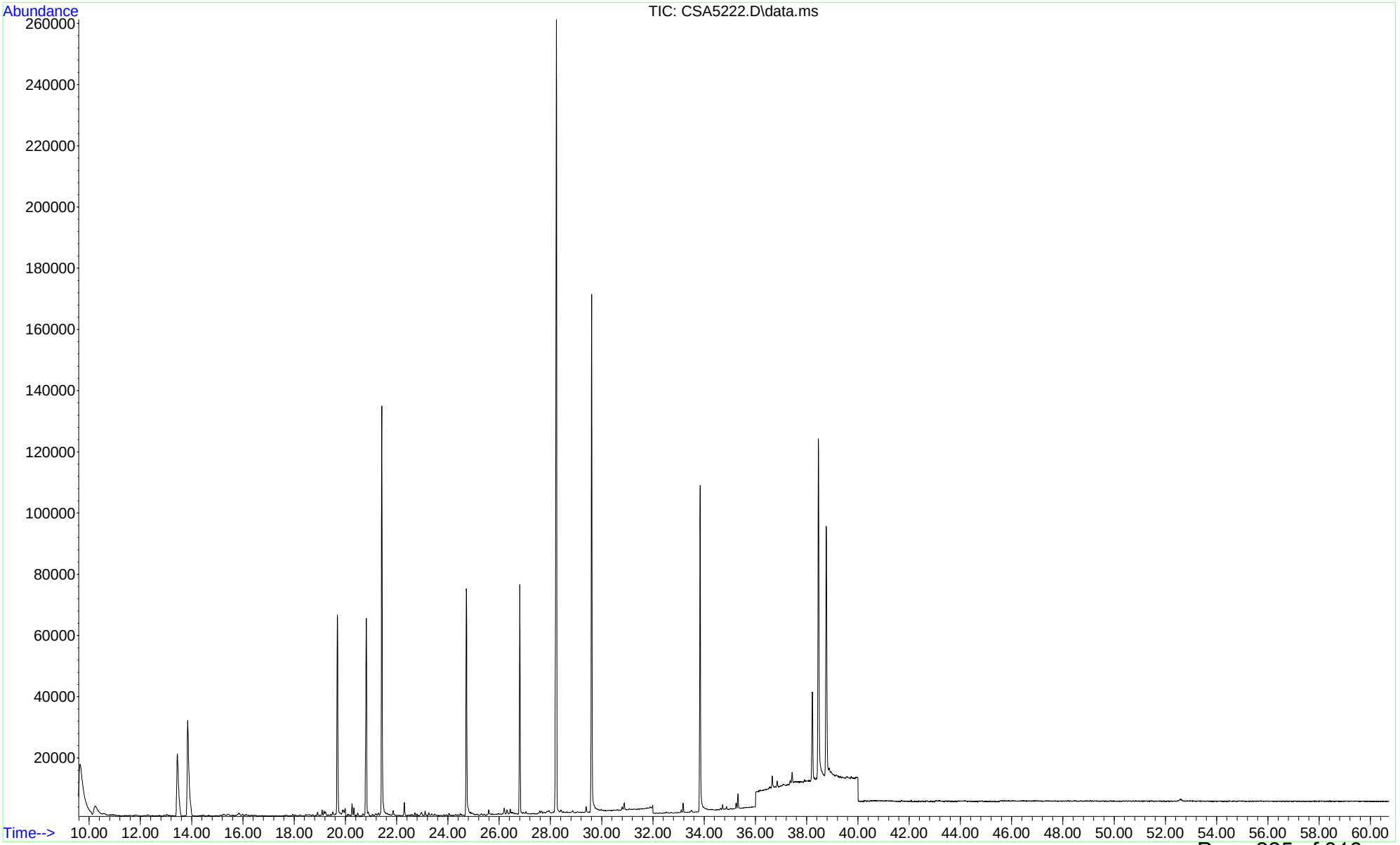


File :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
... ata\CSA5222.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 26 Mar 2020 18:10 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sw_m|hc|01
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5223.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  19:18     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sw_m|hc|02
Misc Info  :
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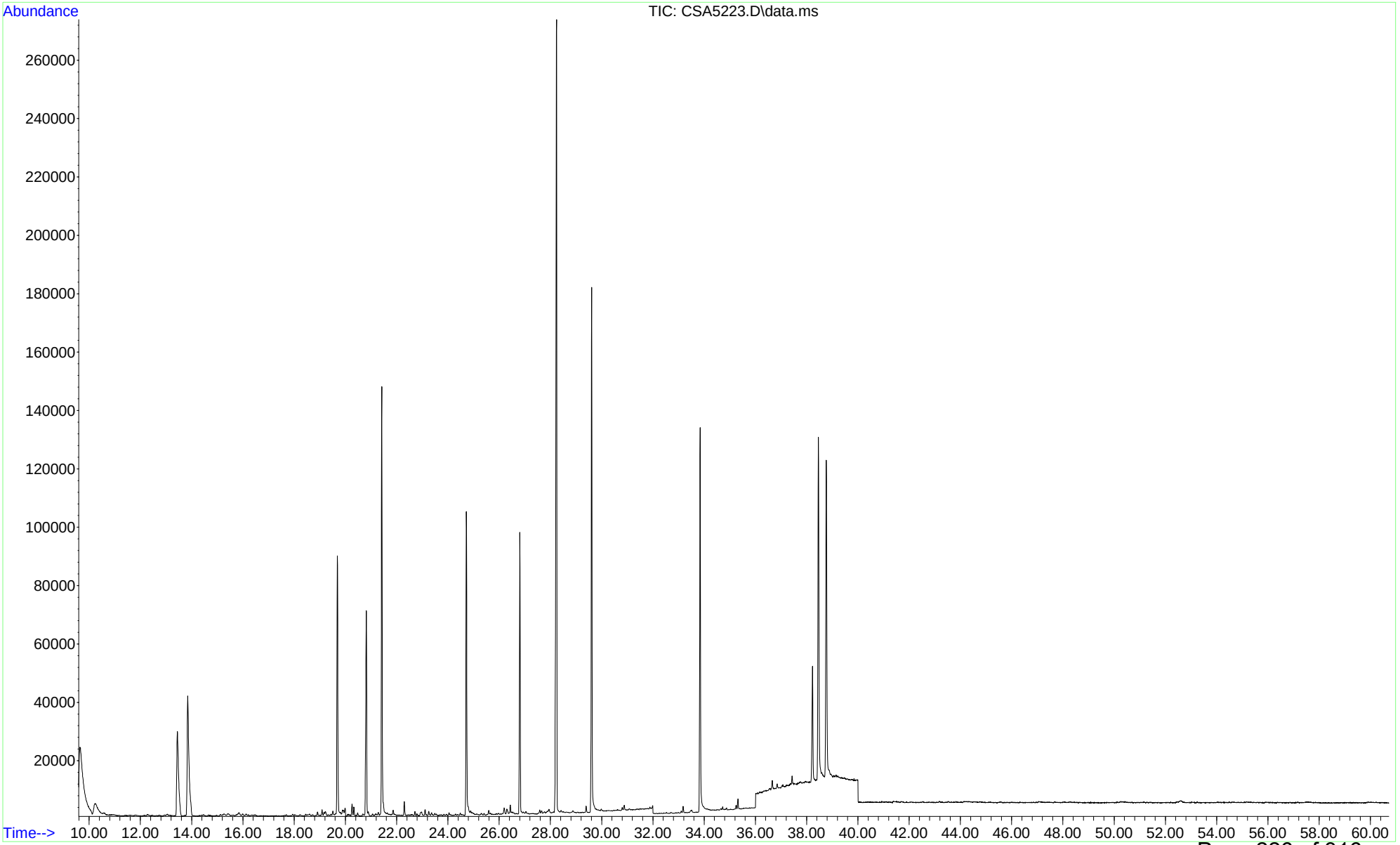

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5224.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 26 Mar 2020  20:26     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sw_b|hc|01
Misc Info  :
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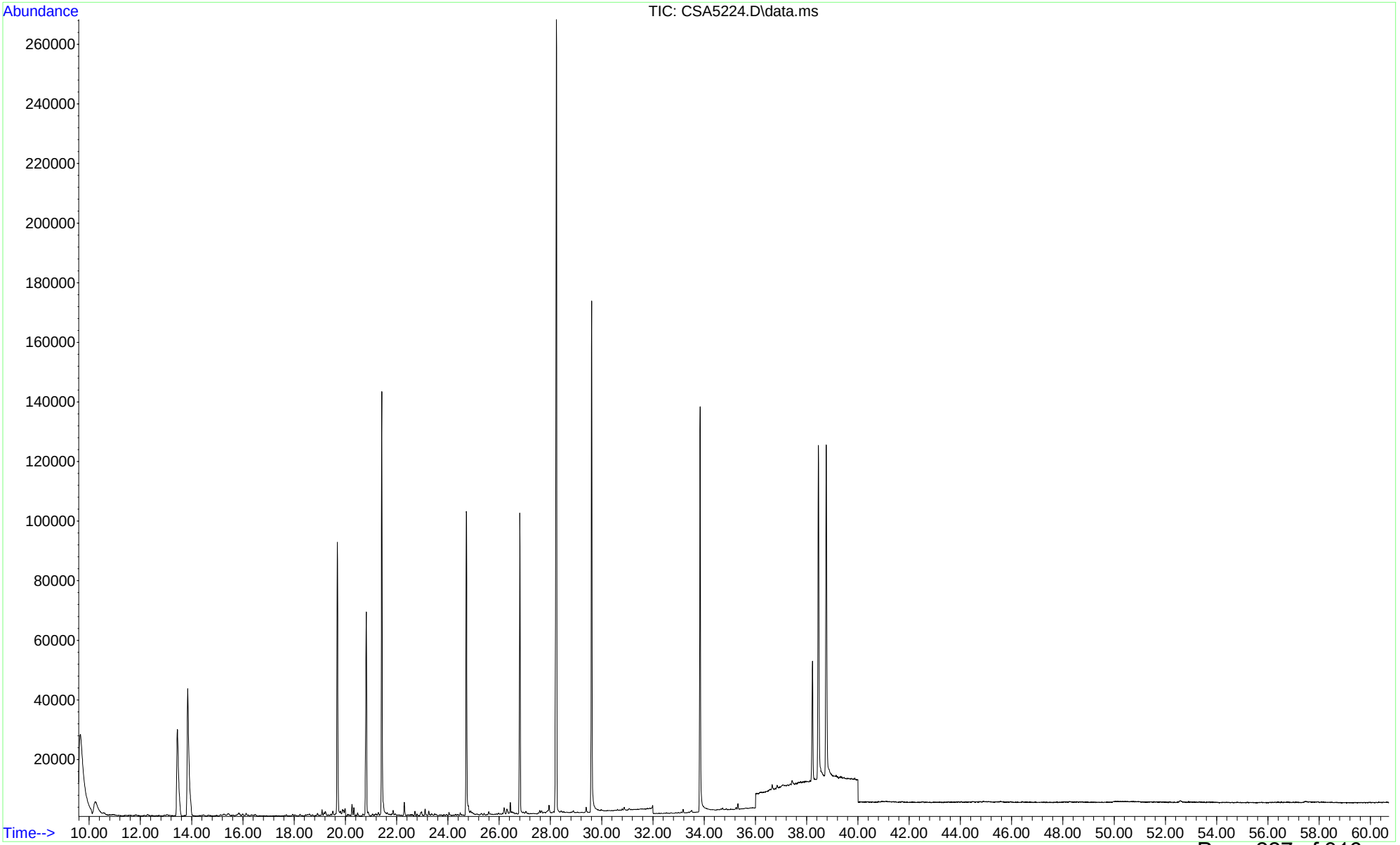
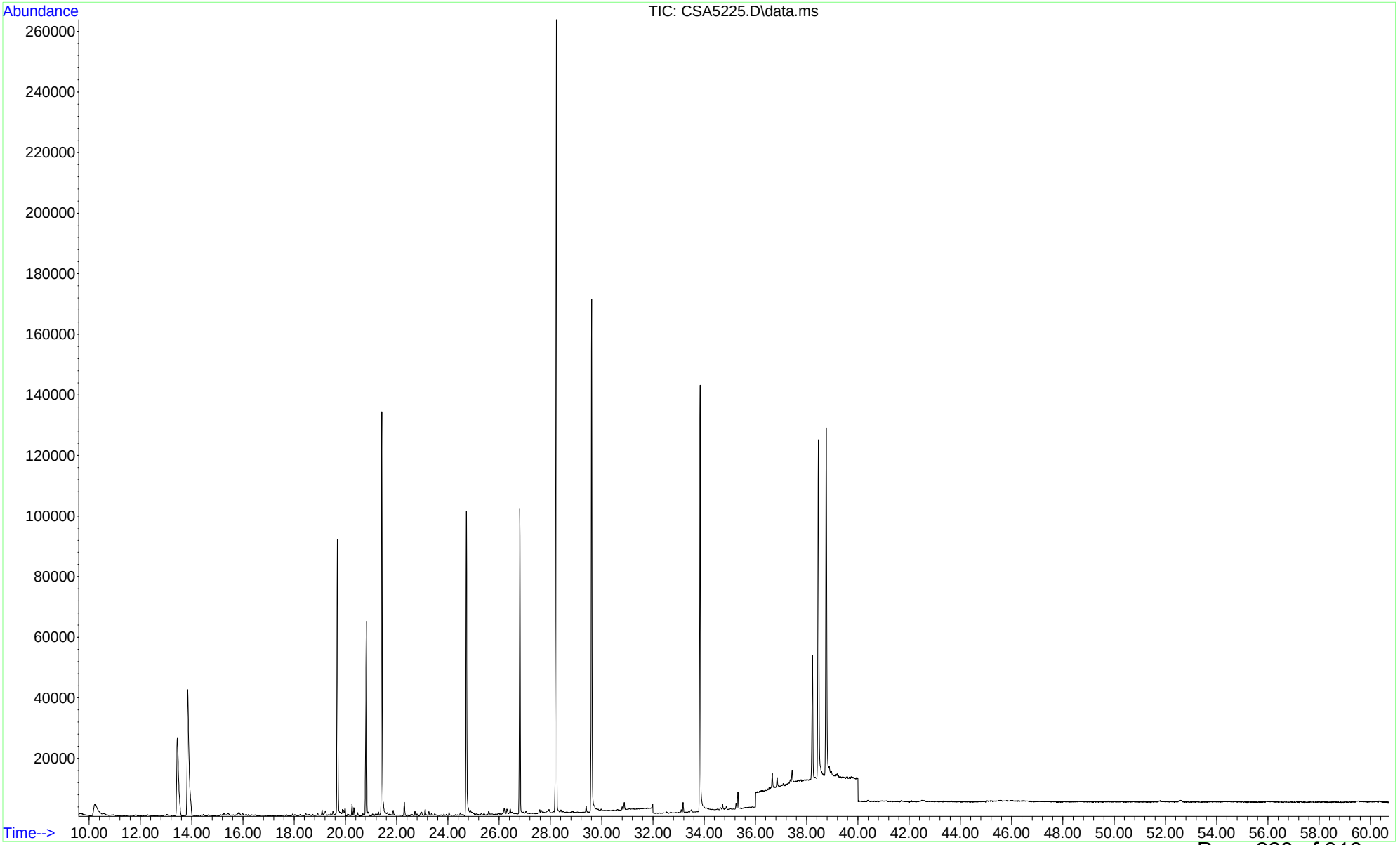
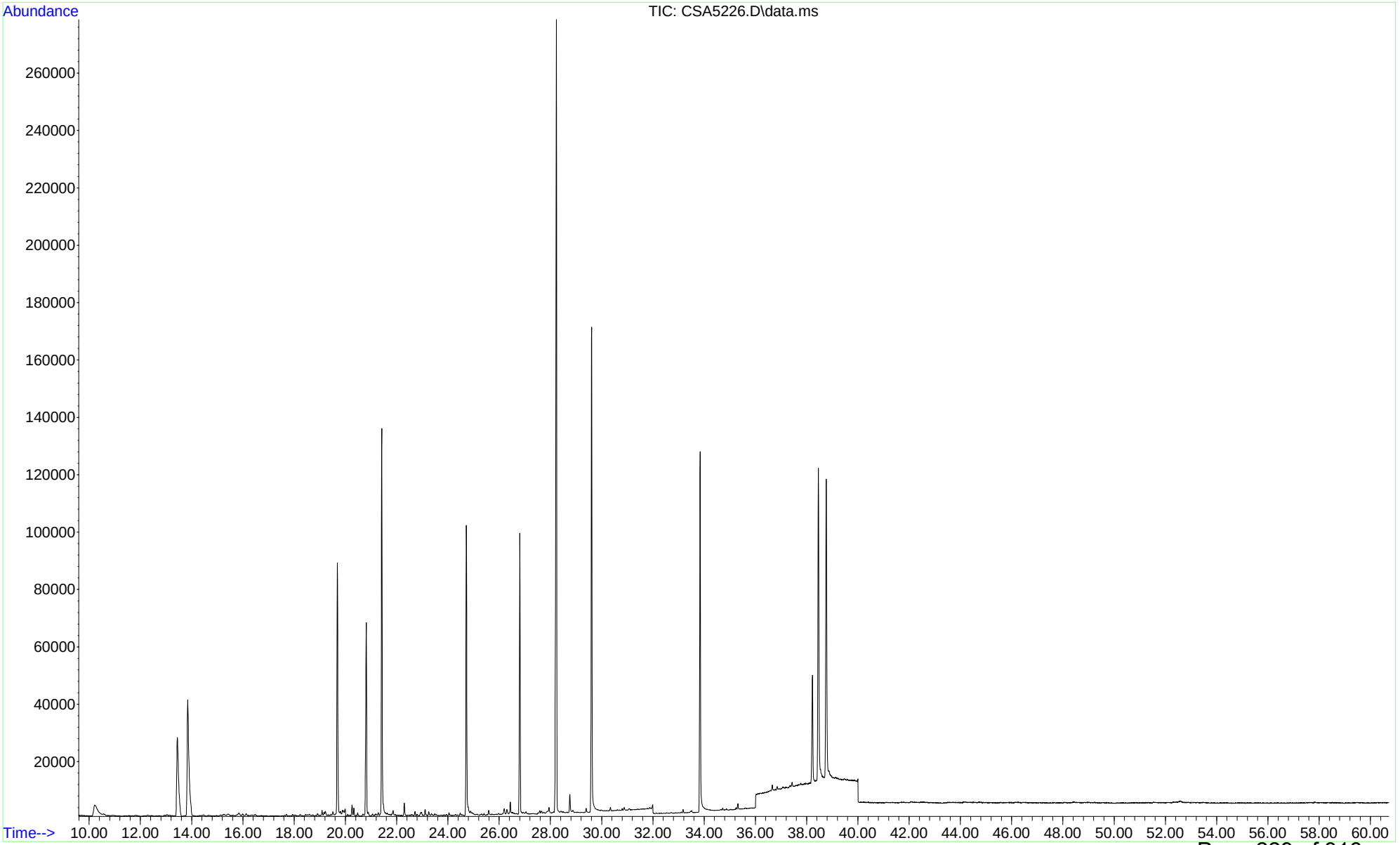


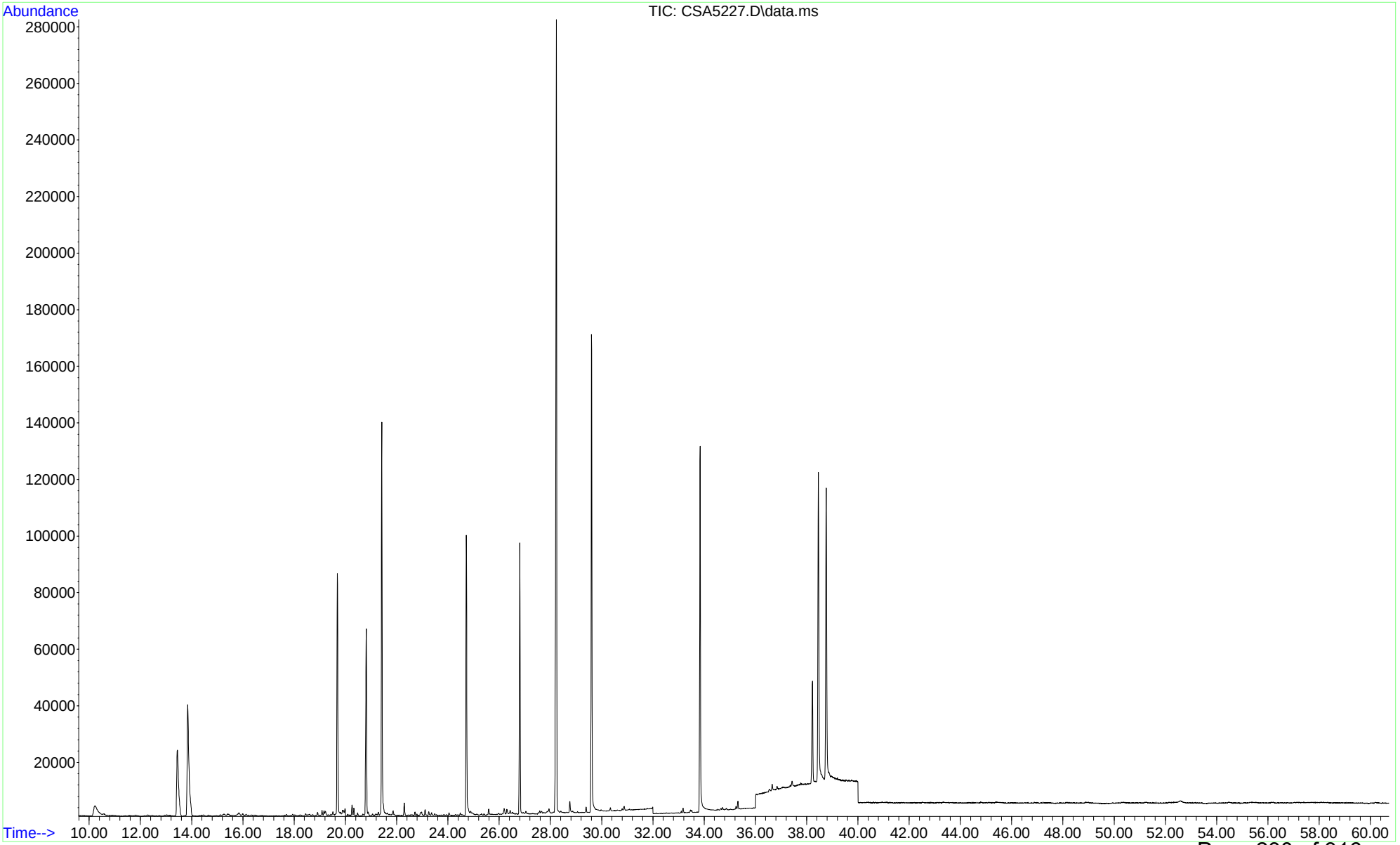
File :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
... ata\CSA5225.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 26 Mar 2020 21:34 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-3|sw_b|hc|02
Misc Info :



File :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
... ata\CSA5226.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 26 Mar 2020 22:42 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|EB|diw|hc|01
Misc Info :



File :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
... ata\CSA5227.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 26 Mar 2020 23:50 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|FB|diw|hc|01
Misc Info :



```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4074\ENV4074-MS70378PAH Raw D
...         ata\CSA5228.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  00:58     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|DI|diw|hc|01
Misc Info  :
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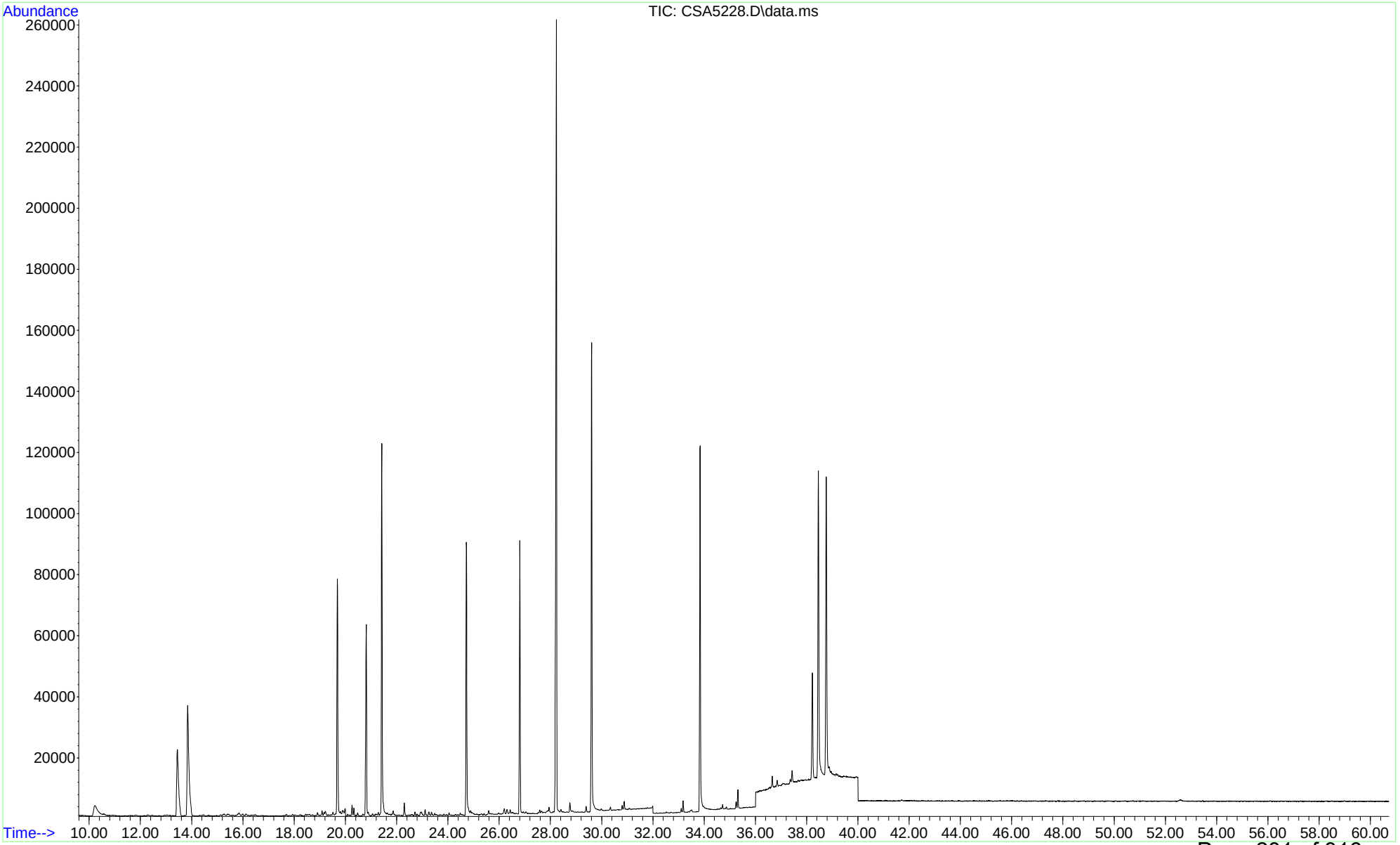

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5229.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020   7:47     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|CH2Cl2|hc|01
Misc Info  :
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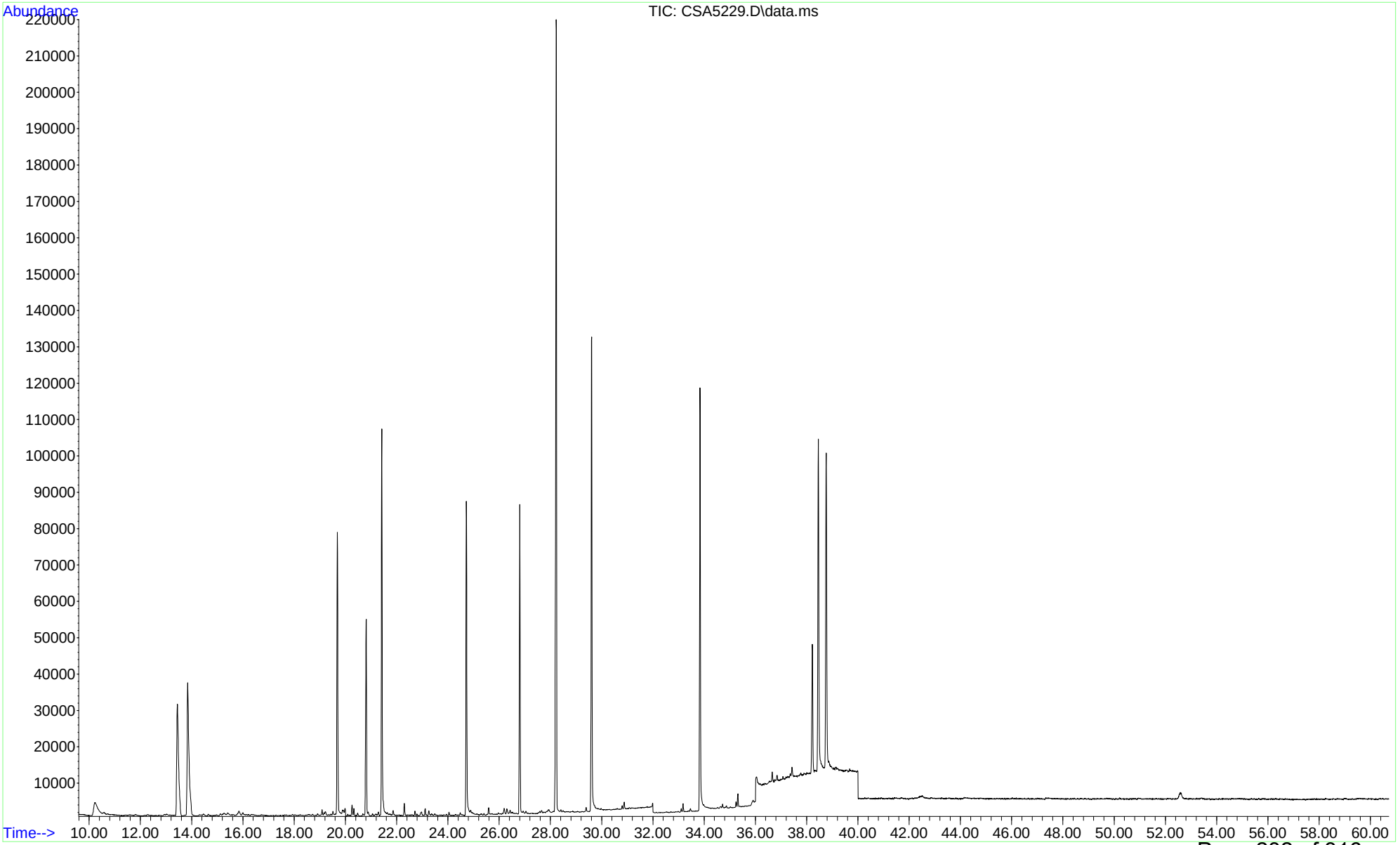
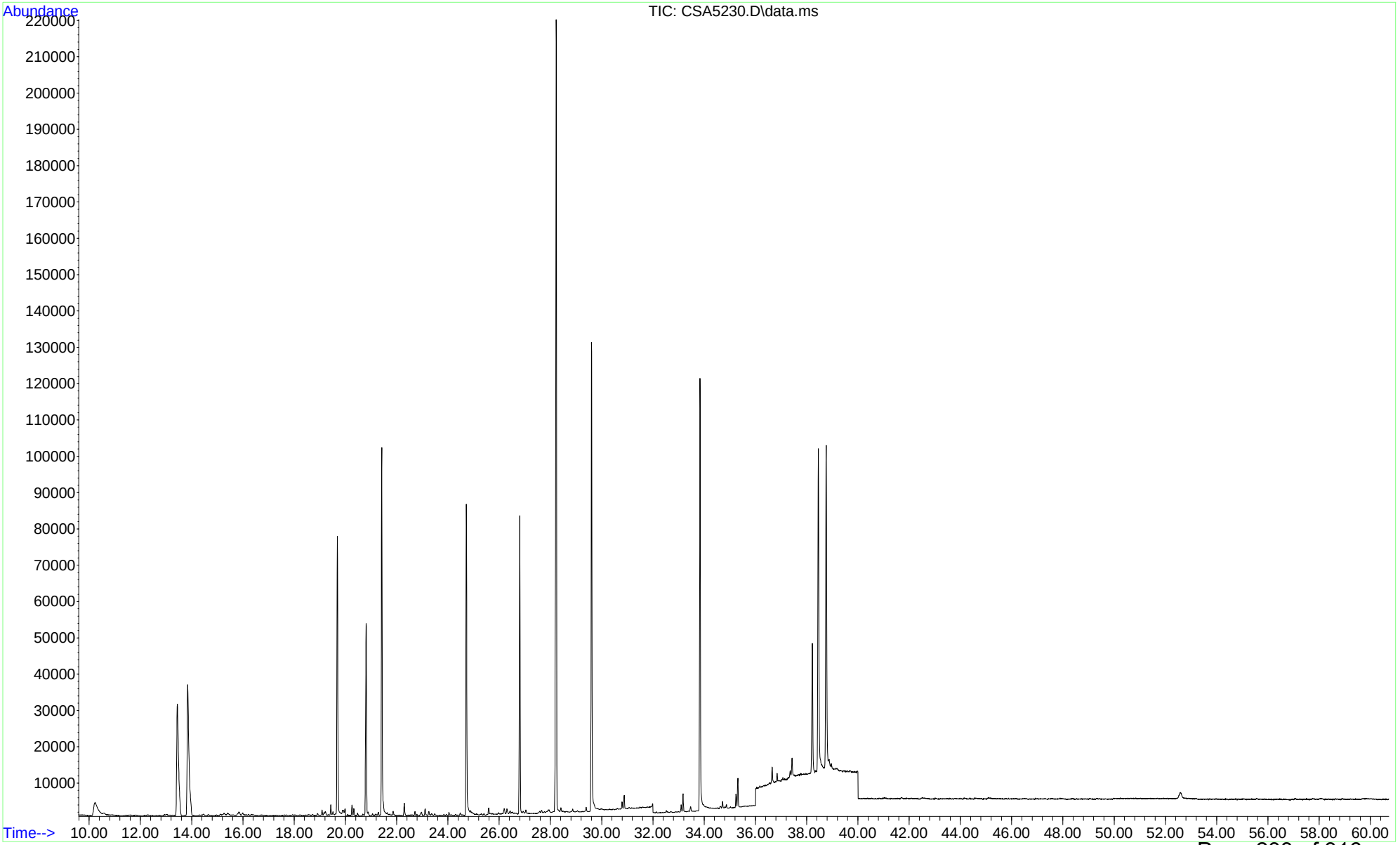


File :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
... ata\CSA5230.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 27 Mar 2020 8:55 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|DI|hc|01
Misc Info :



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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5247.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  10:03     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sw_s|hc|01
Misc Info  :
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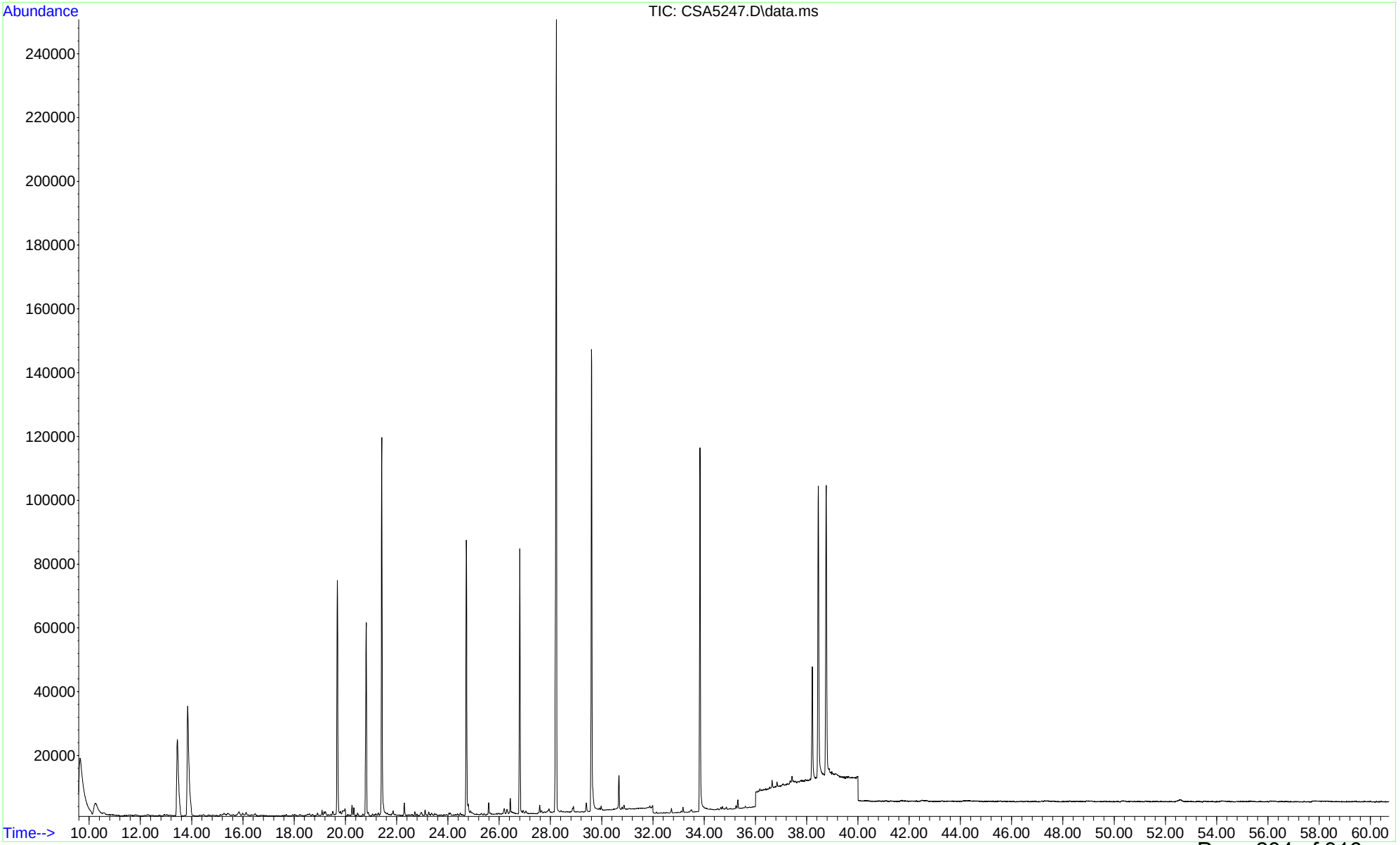

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5248.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  11:11     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sw_s|hc|02
Misc Info  :
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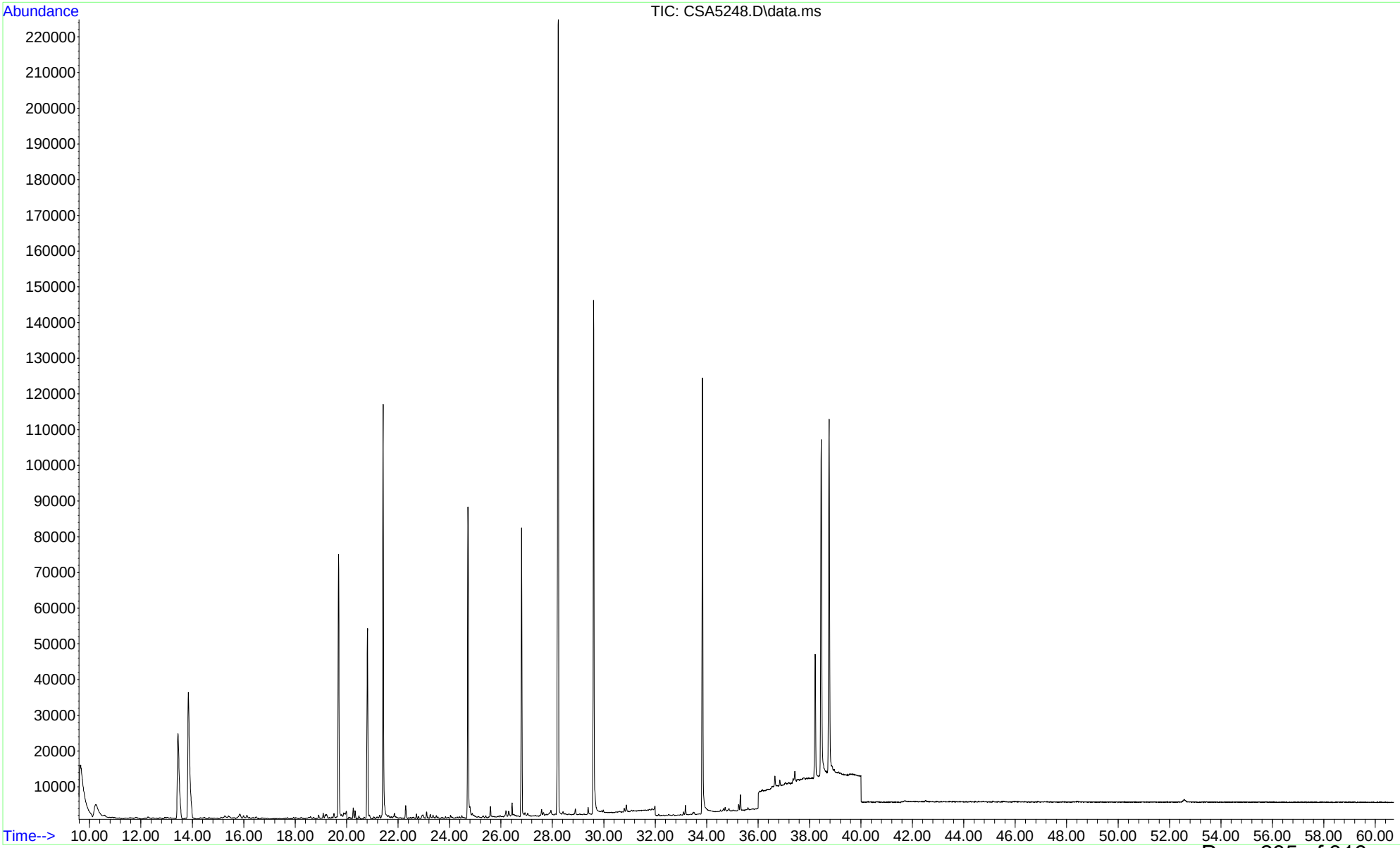

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5249.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  12:20     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sw_m|hc|01
Misc Info  :
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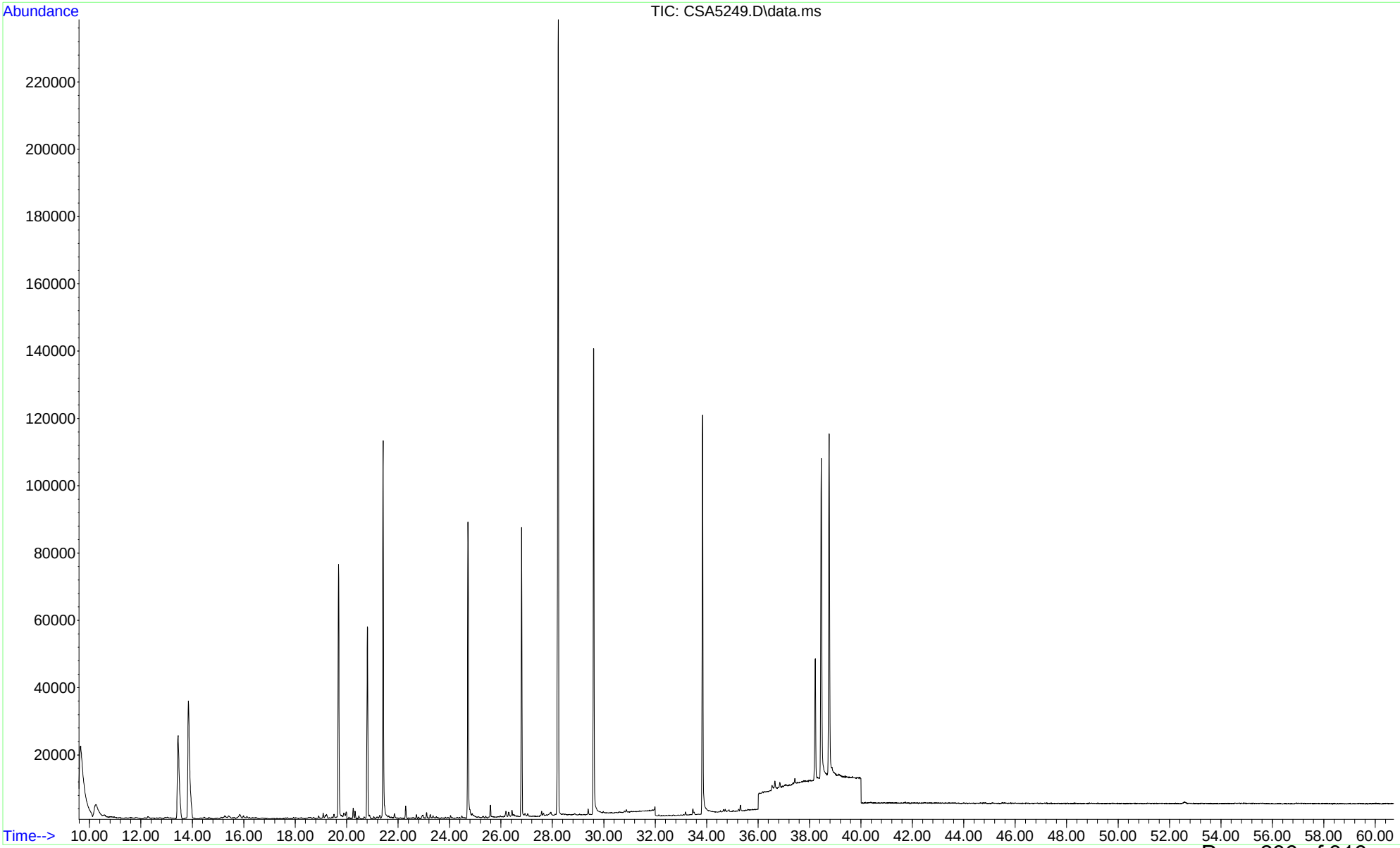

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5250.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  14:36     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sw_m|hc|02
Misc Info  :
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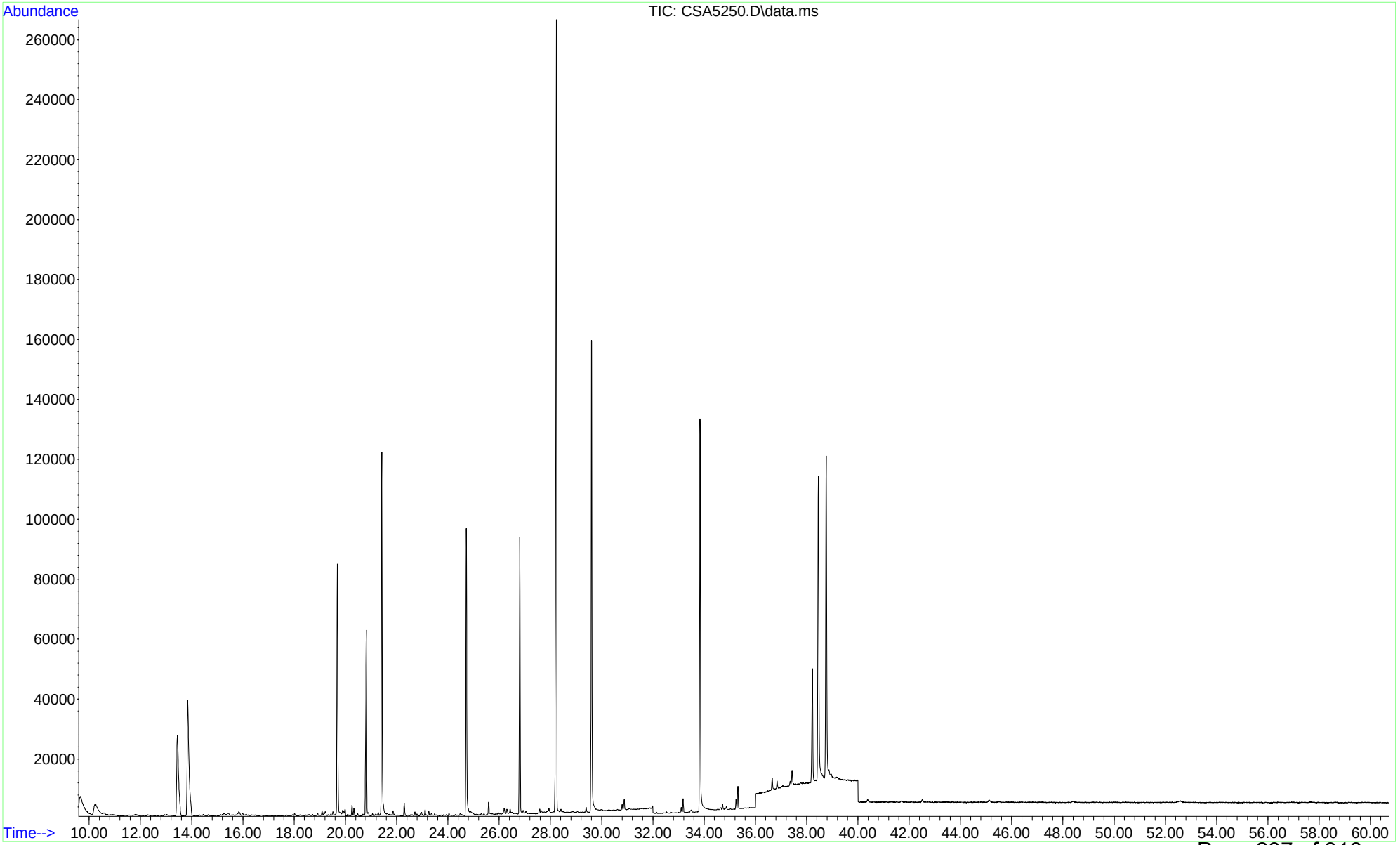

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5251.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  15:44     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sw_b|hc|01
Misc Info  :
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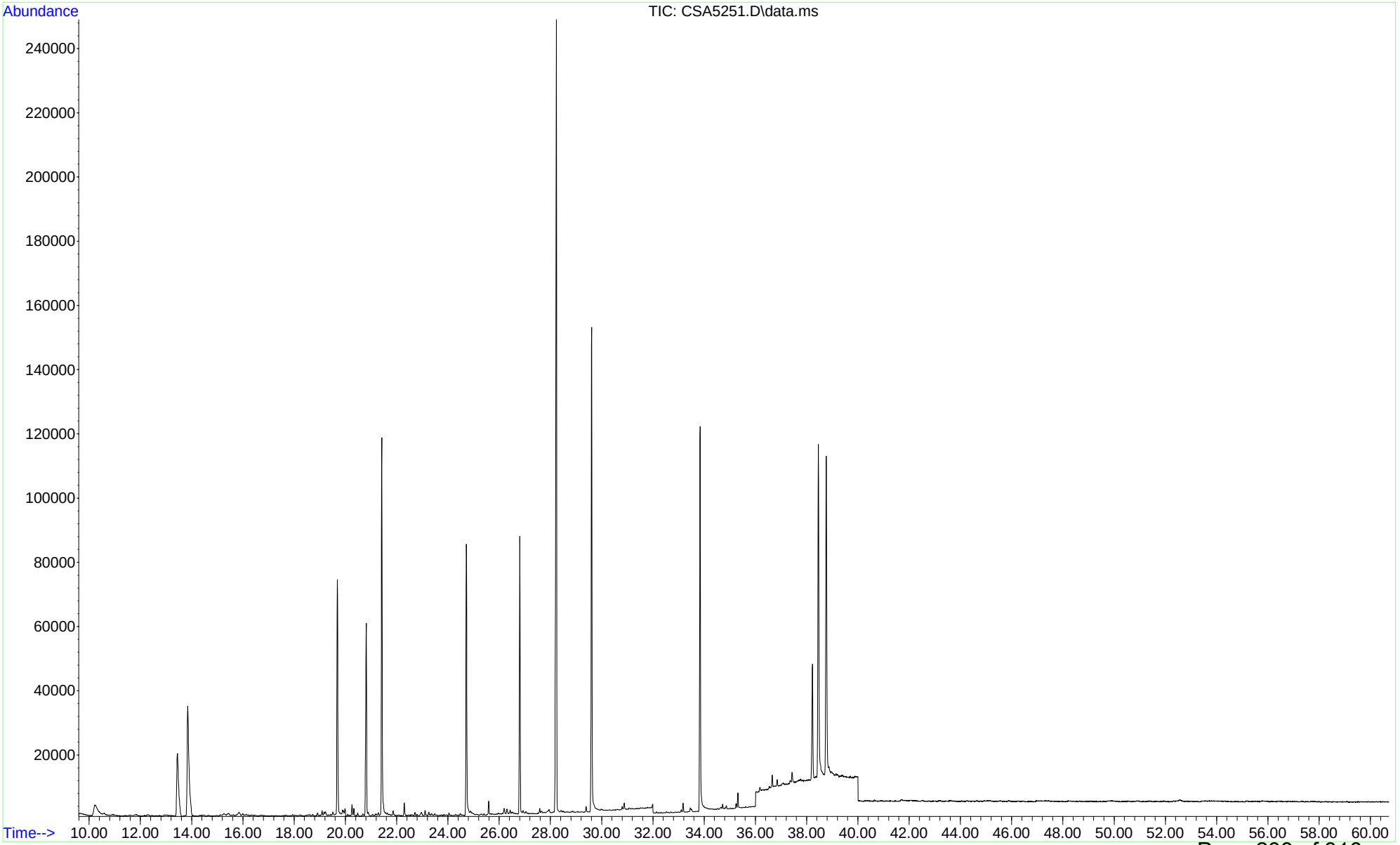

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5252.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  16:52     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-5|sw_b|hc|02
Misc Info  :
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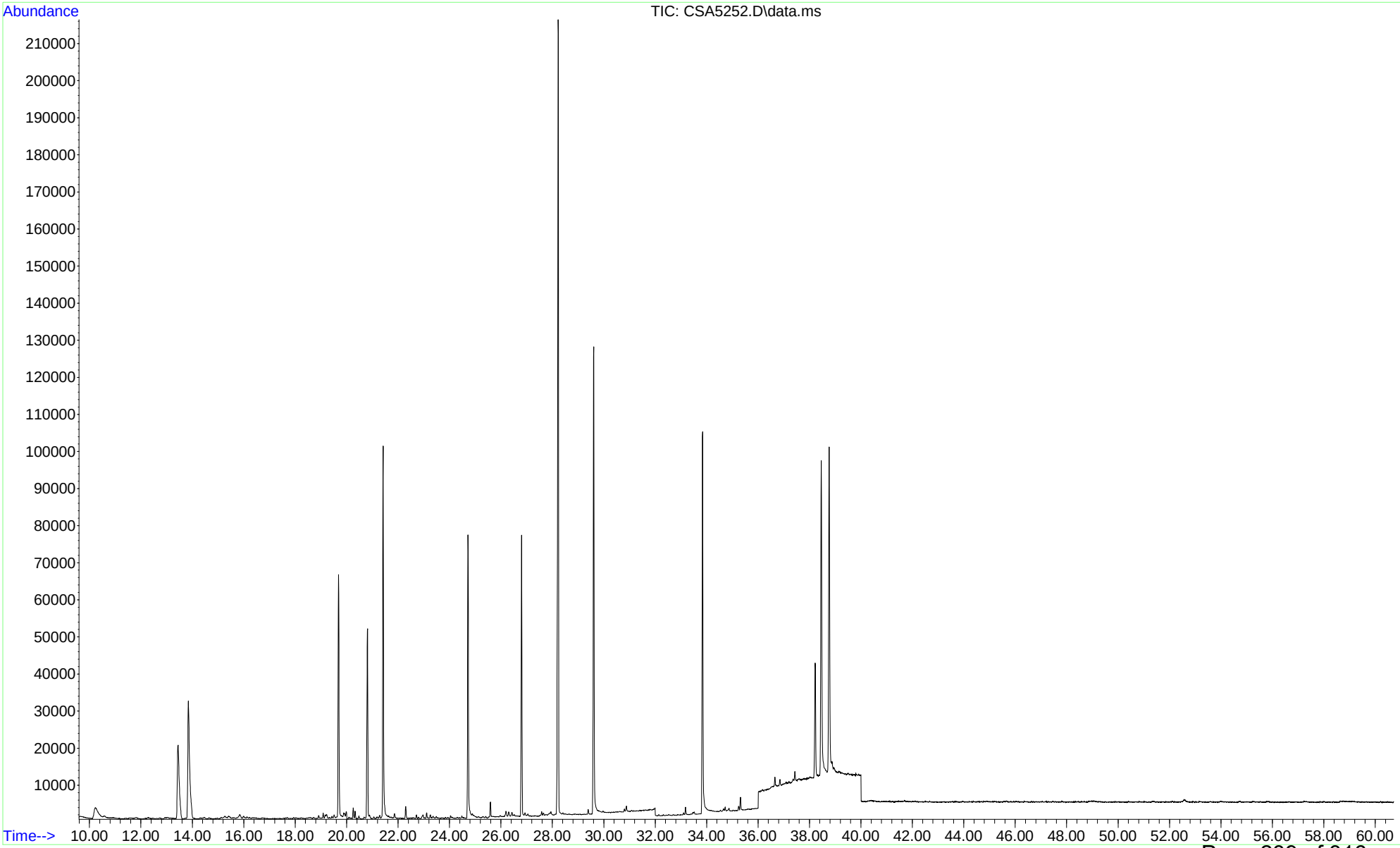
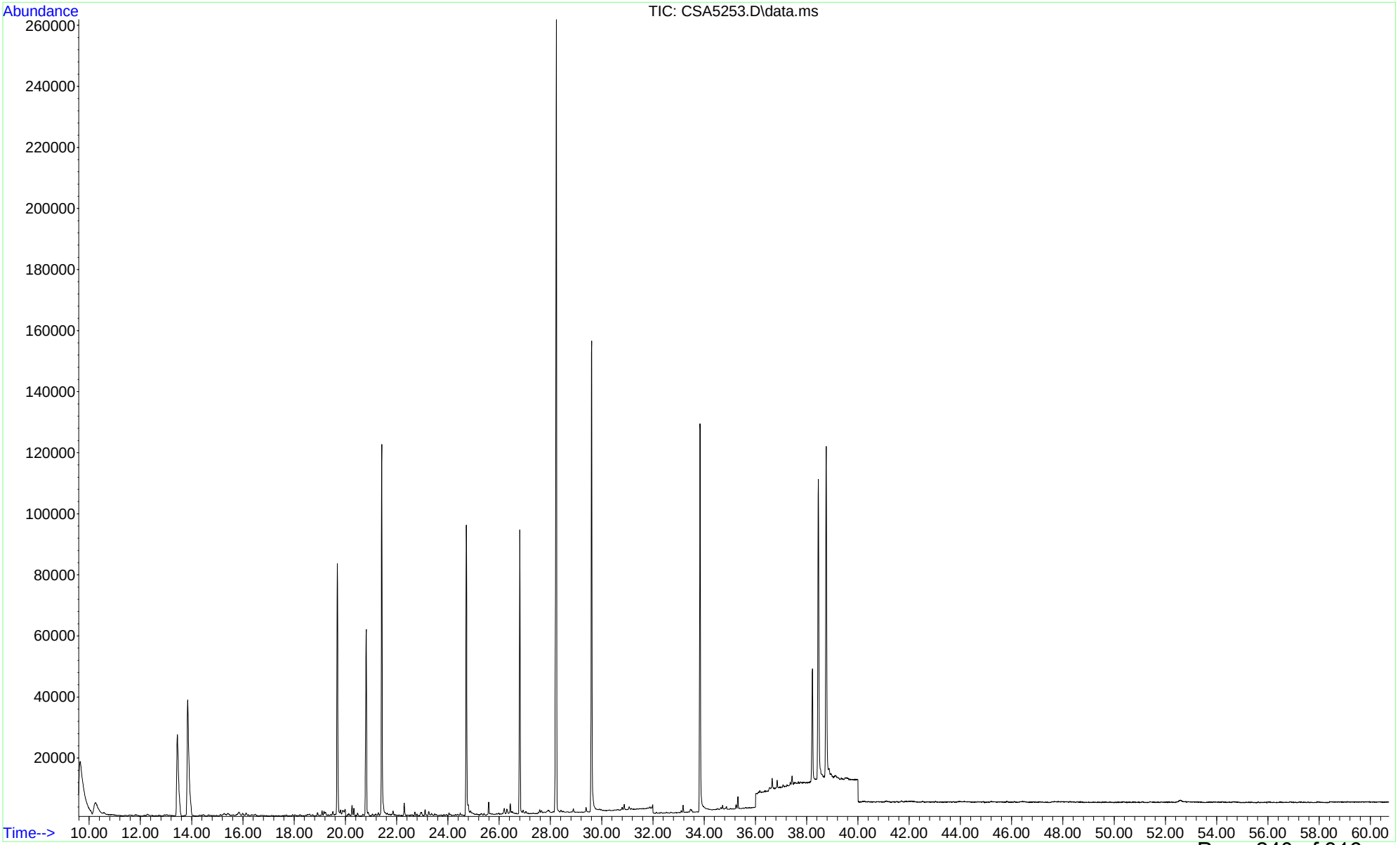


File :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
... ata\CSA5253.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 27 Mar 2020 18:00 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sw_s|hc|01
Misc Info :



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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5254.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  19:08     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sw_s|hc|02
Misc Info  :
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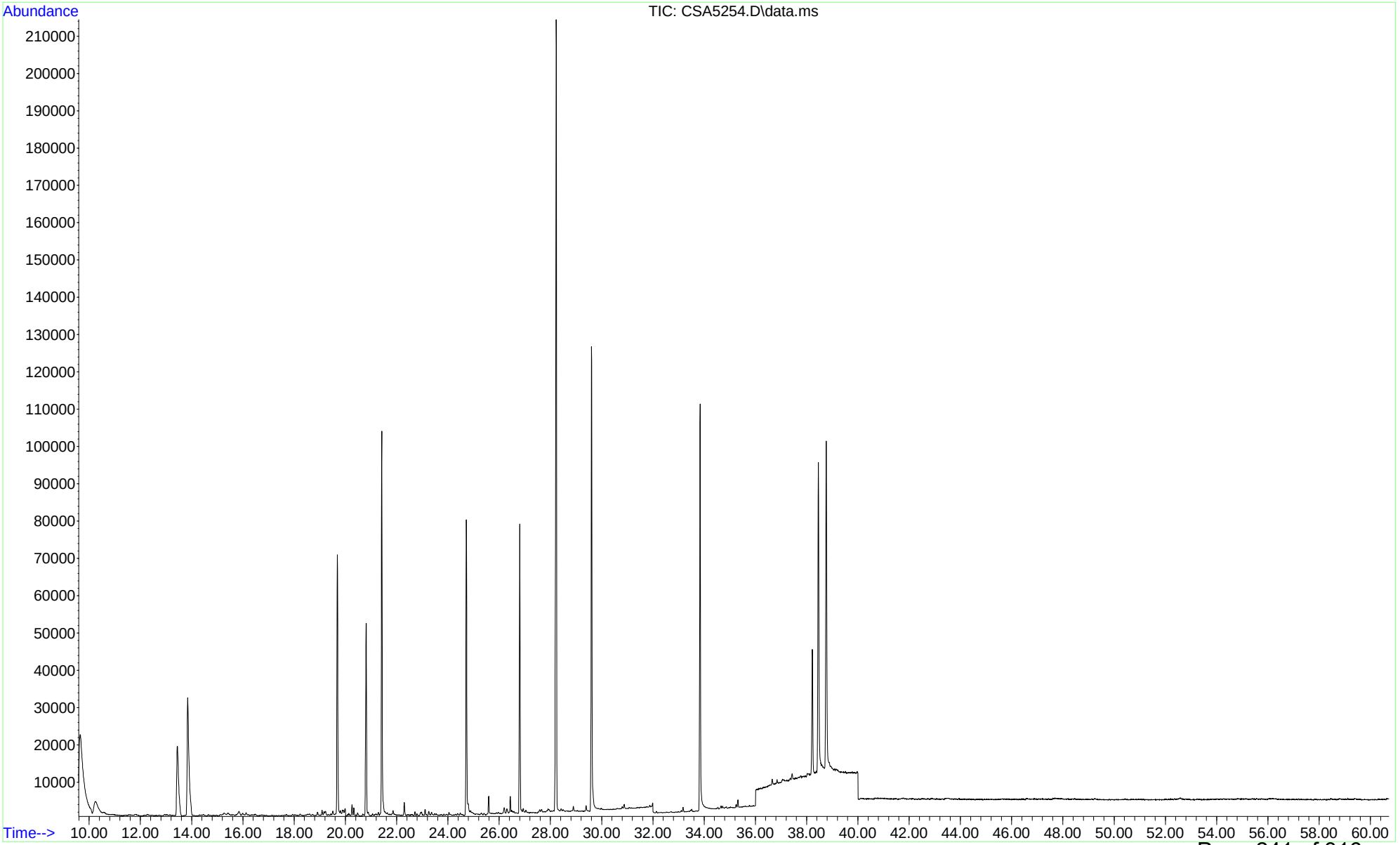

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5255.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  20:16     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sw_m|hc|01
Misc Info  :
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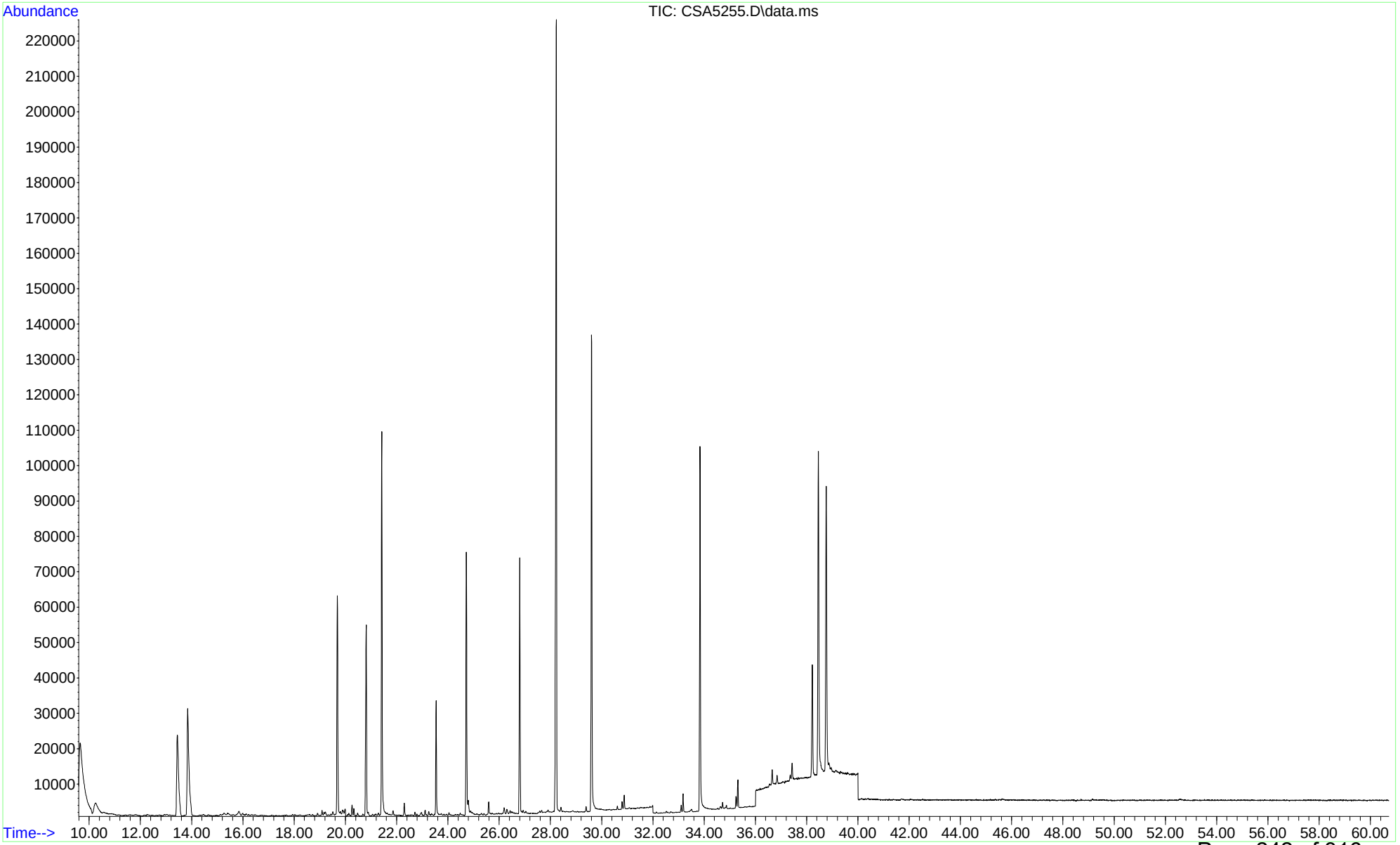

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File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5256.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  21:24     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sw_m|hc|02
Misc Info  :
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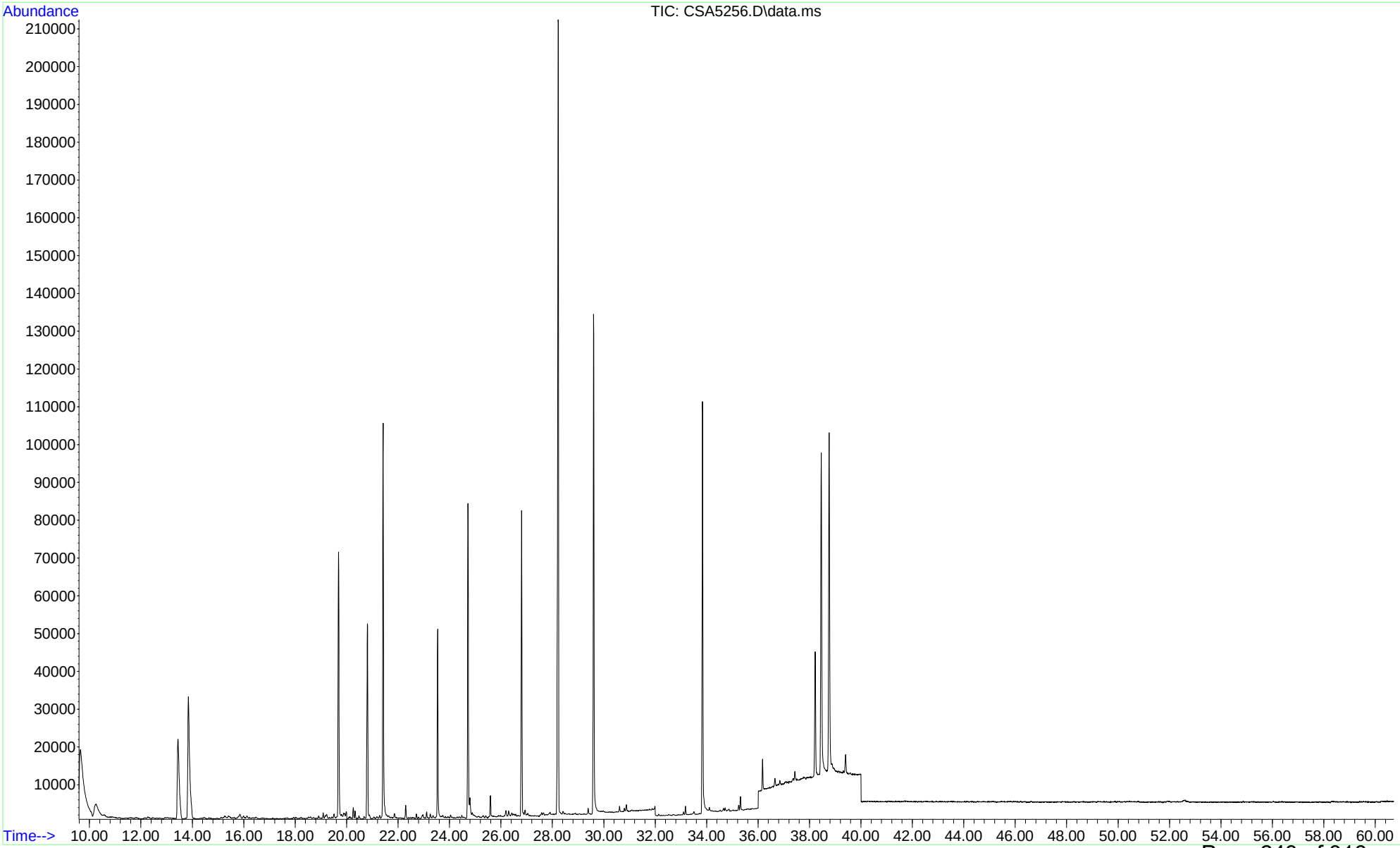

```
File       :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
...         ata\CSA5257.D
Operator   : ECM(YMIAO)
Instrument :   GCMS 7
Acquired   : 27 Mar 2020  22:32     using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sw_b|hc|01
Misc Info  :
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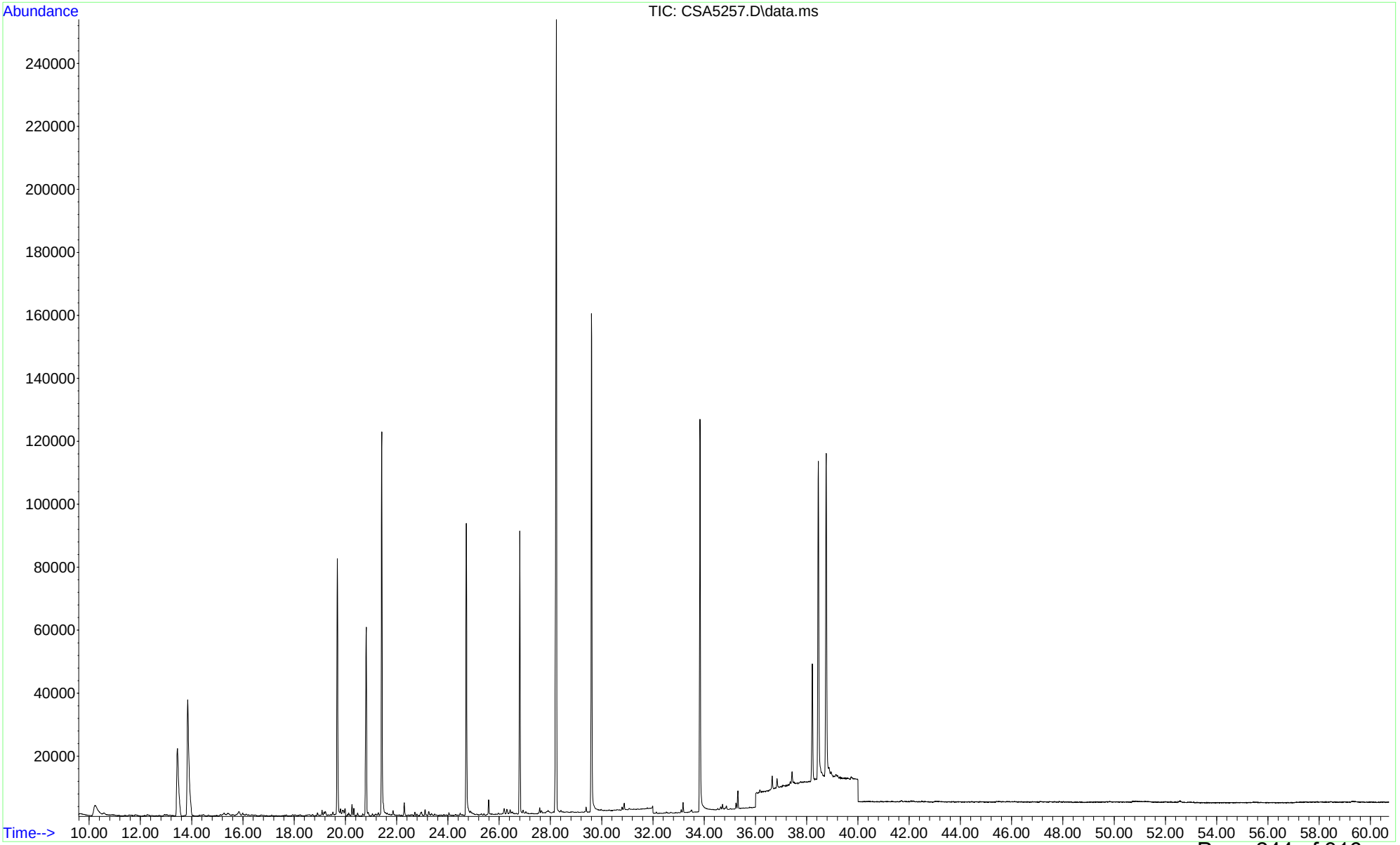
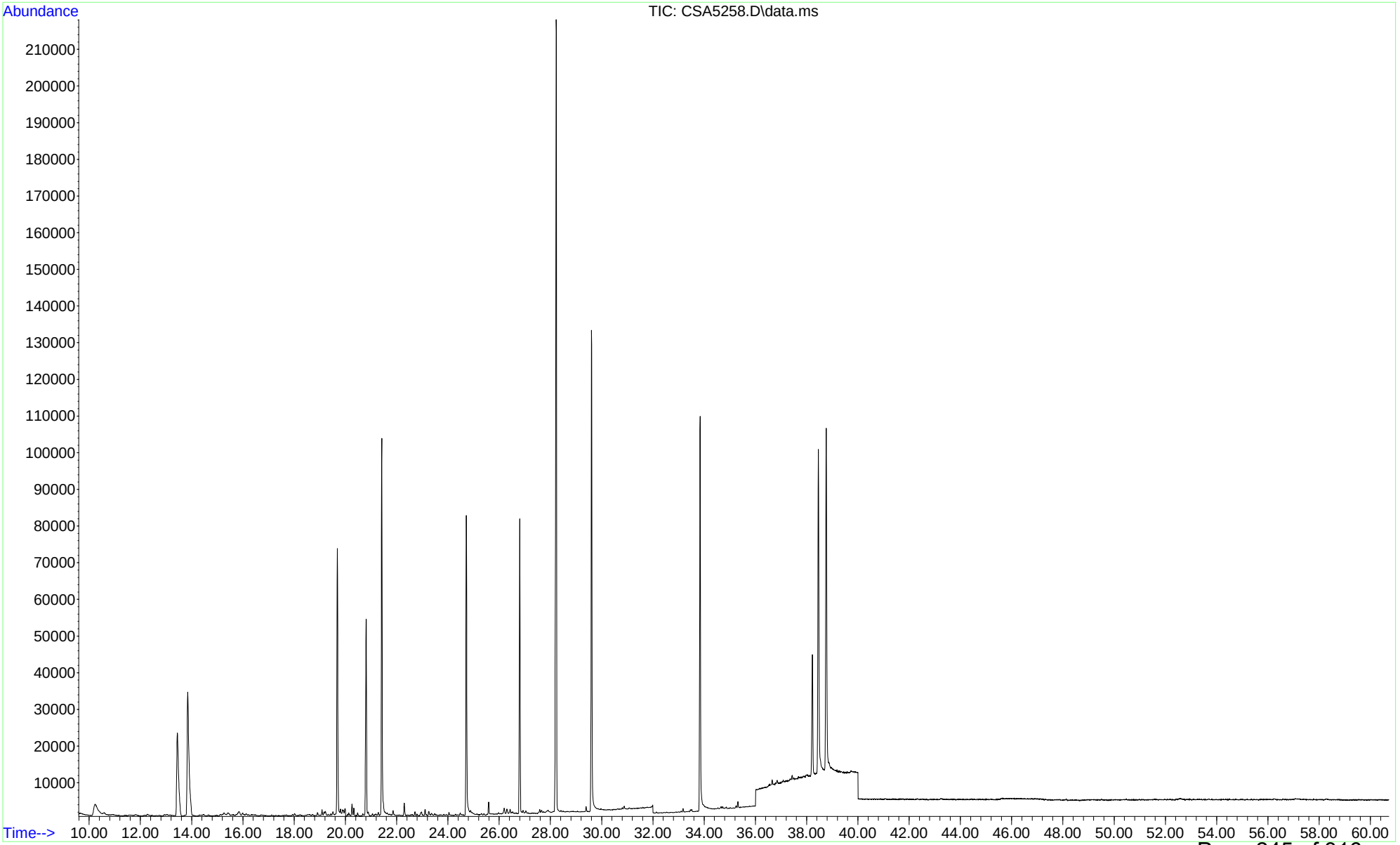


File :P:\2020\J20453 CSA 3532\PAH\ENV4075\ENV4075-MS70378PAH Raw D
... ata\CSA5258.D
Operator : ECM(YMIAO)
Instrument : GCMS 7
Acquired : 27 Mar 2020 23:40 using AcqMethod PAH-2018.M
Sample Name: 3532|03_20|HH-7|sw_b|hc|02
Misc Info :



Appendix B:

Infauna Listing

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Table B-1. Tabulated list of taxa abundance observed for infauna samples at all stations during the Hammerhead Development Environmental Baseline Survey.

Taxa/Station	HH-1	HH-2	HH-3	HH-4	HH-5	HH-6	HH-7	HH-8	TOTAL
Phylum Mollusca									
Corbula aequivalvis	0	0	0	0	1	0	0	0	1
Phylum Annelida									
Apoprionospio sp.a	2	0	0	0	0	0	0	0	2
Aricidea sp. a	0	0	0	0	0	1	0	1	2
Capitella capitata	0	0	0	0	1	0	0	0	1
Capitella sp. a	0	0	1	5	6	4	1	0	17
Cirratulus sp. a	1	1	1	1	2	1	0	0	7
Diplocirrus sp. a	0	1	0	0	0	0	0	0	1
Echiura sp. a	0	0	0	0	0	0	0	1	1
Eunice sp. a	0	1	1	0	2	0	0	0	4
Glycera sp. a	1	5	1	3	4	0	0	5	19
Grubeulepis sp. a	0	1	0	0	0	0	0	0	1
Gyptis sp. a	0	1	0	0	0	0	0	0	1
Hesione sp. a	0	0	0	0	3	0	0	0	3
Magelona sp.a	3	0	0	3	0	0	1	1	8
Maldane sp. a	1	0	0	1	0	2	0	1	5
Melinna sp. a	0	0	0	0	0	0	1	0	1
Nereis sp. a	0	2	2	1	1	1	0	0	7
Notomastus sp. a	0	6	0	1	1	1	0	1	10
Ophelia sp.a	0	0	0	0	0	2	0	0	2
Platynereis sp. a	0	2	3	1	0	0	0	0	6
Sclerocheilus sp. a	0	0	0	0	1	0	1	0	2
Sigalionidae sp. a	0	0	0	0	0	0	1	0	1
Sigambra tentaculata	0	2	1	0	0	0	1	0	4
Spionid sp.a	0	3	3	0	3	1	0	1	11
Terebellides sp. a	1	1	0	1	0	0	2	2	7
Phylum Arthropoda									
Ampelisica sp. a	1	1	4	2	1	1	3	2	15
Copepod sp. c	0	0	0	0	0	0	1	0	1
Diastylis sp. a	0	0	0	0	1	0	0	0	1
Gnathia sp. a	0	0	2	3	0	0	2	0	7
Idotea sp. a	2	0	2	0	2	3	1	0	10
Stomatopod sp. a	0	0	2	0	1	2	1	0	6
Phylum Echinodermata									
Ophiuroidea sp. a	0	0	0	1	0	0	0	0	1
Ophiuroidea sp. b	0	0	0	0	1	0	0	0	1
Other									
Nematode sp. a	0	2	6	4	12	3	7	1	35
Nemertean sp. a	0	0	0	0	1	0	0	0	1
Sipunculid sp. a	0	0	0	1	0	0	0	0	1
Phylum Chordata									
Branchiostoma sp.a	0	0	0	0	0	0	1	0	1
Number of Taxa	**8**	**14**	**13**	**14**	**18**	**12**	**14**	**10**	**37**
Number of Individuals	**12**	**290**	**29**	**28**	**44**	**22**	**24**	**16**	**204**

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Appendix C:

Sediment Metals Regression Plots

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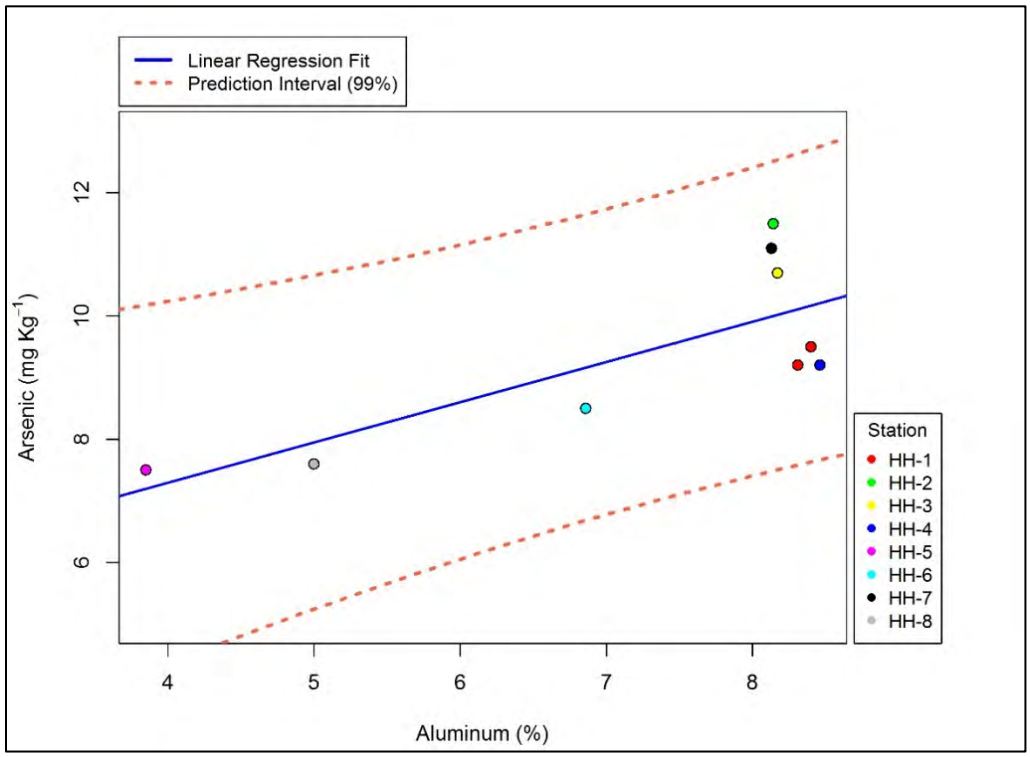

Figure C-1. Linear regression for relationship between sediment percent aluminum and concentrations of arsenic.

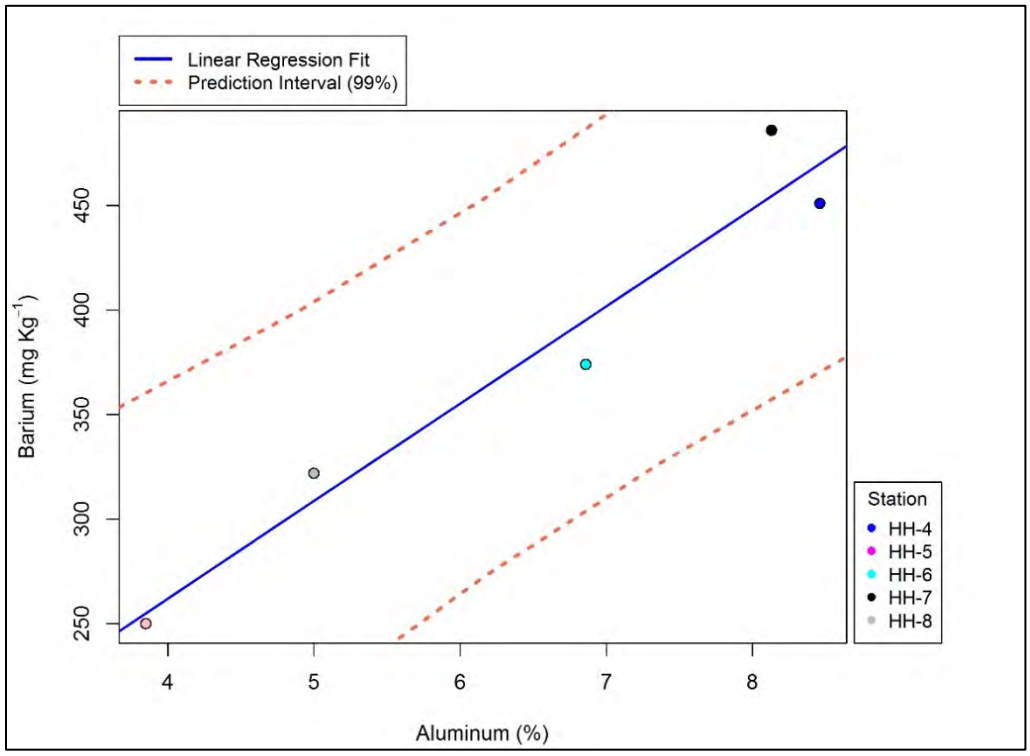

Figure C-2. Linear regression for relationship between sediment percent aluminum and concentrations of barium.

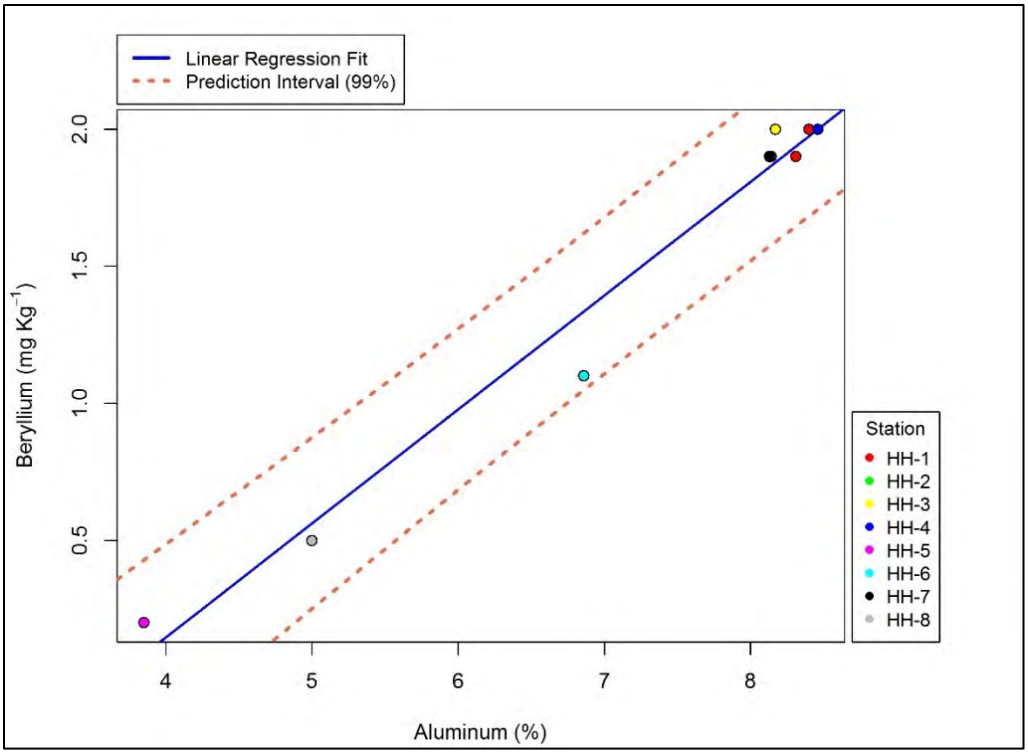

Figure C-3. Linear regression for relationship between sediment percent aluminum and concentrations of beryllium.

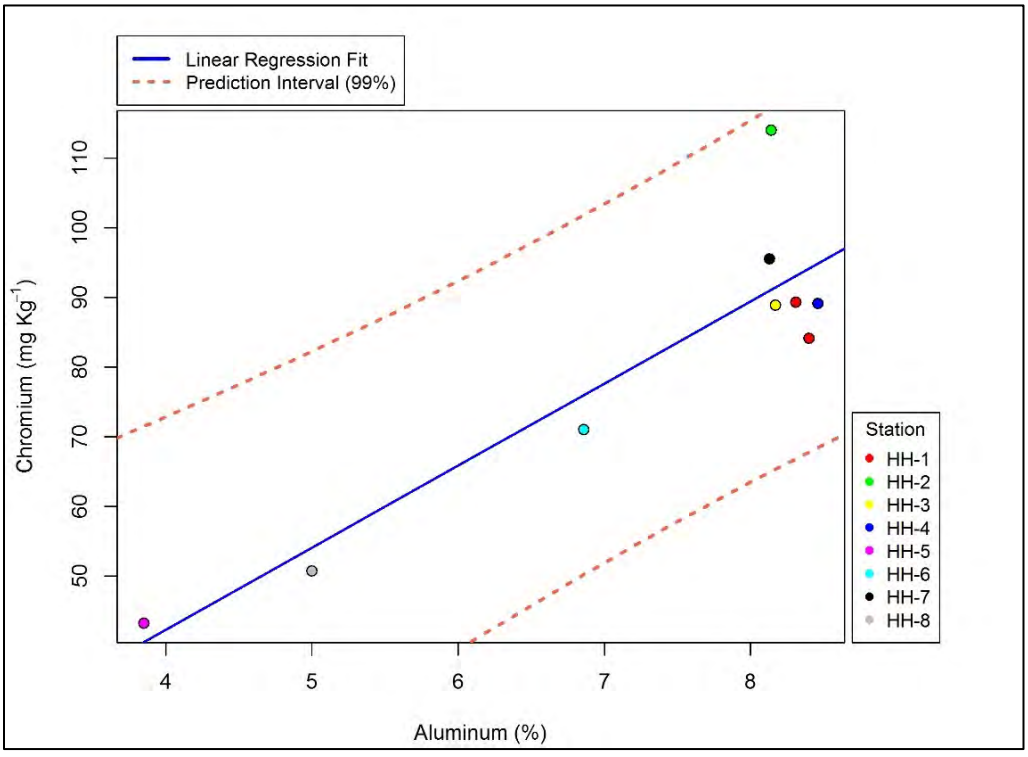

Figure C-4. Linear regression for relationship between sediment percent aluminum and concentrations of chromium.

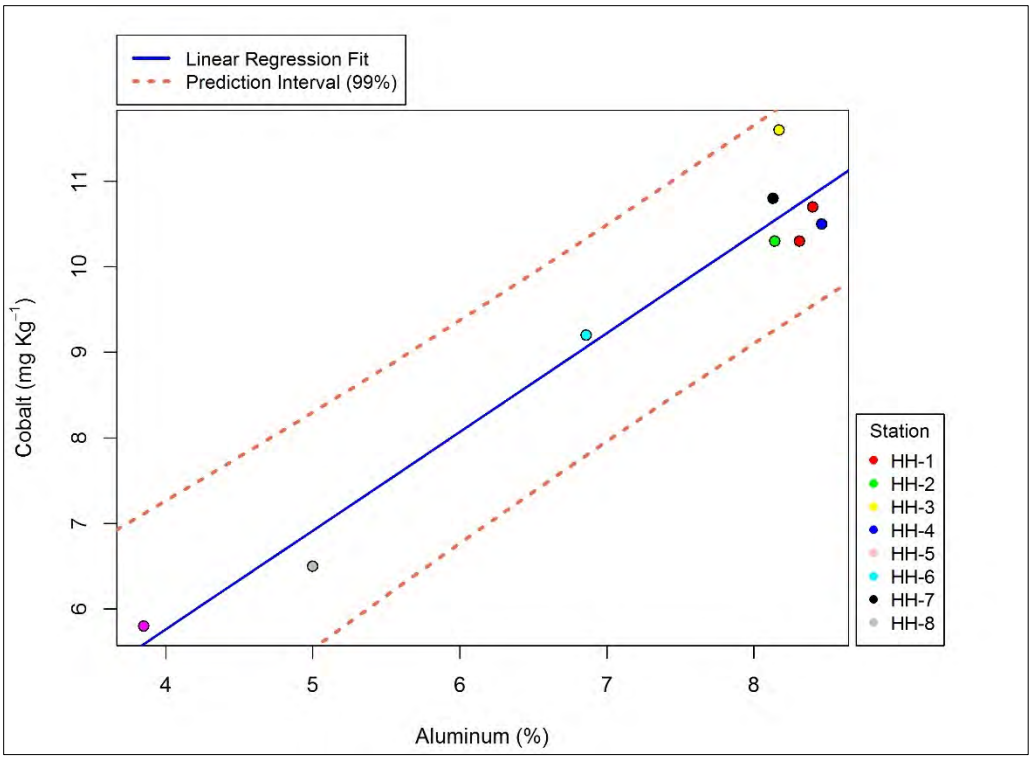

Figure C-5. Linear regression for relationship between sediment percent aluminum and concentrations of cobalt.

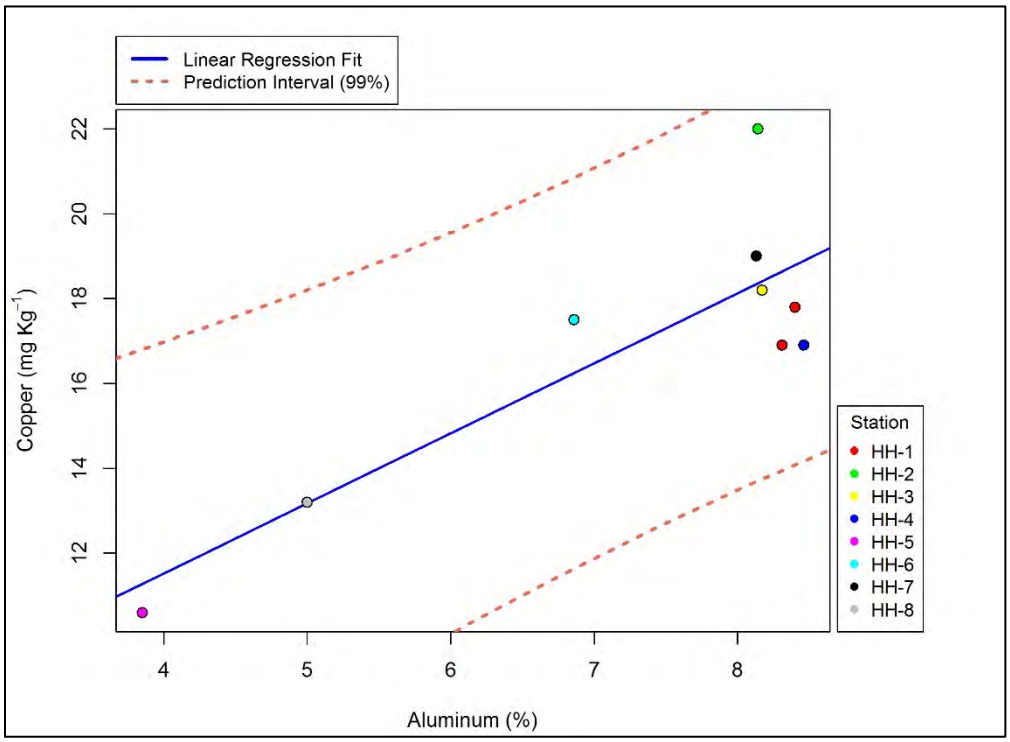

Figure C-6. Linear regression for relationship between sediment percent aluminum and concentrations of copper.

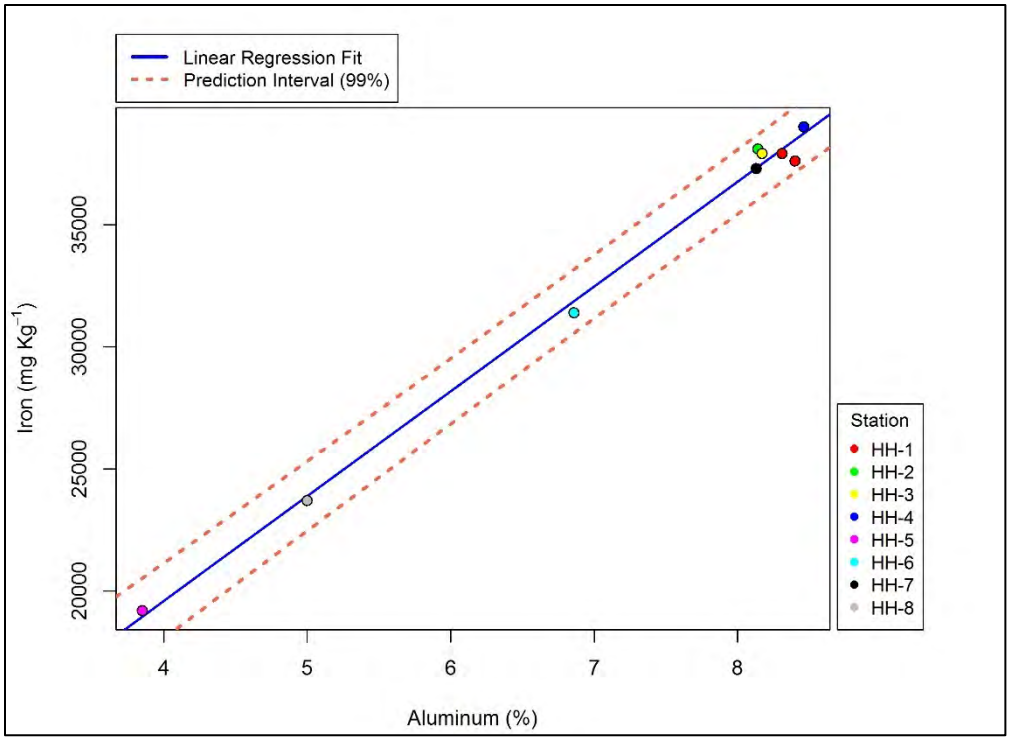

Figure C-7. Linear regression for relationship between sediment percent aluminum and concentrations of iron.

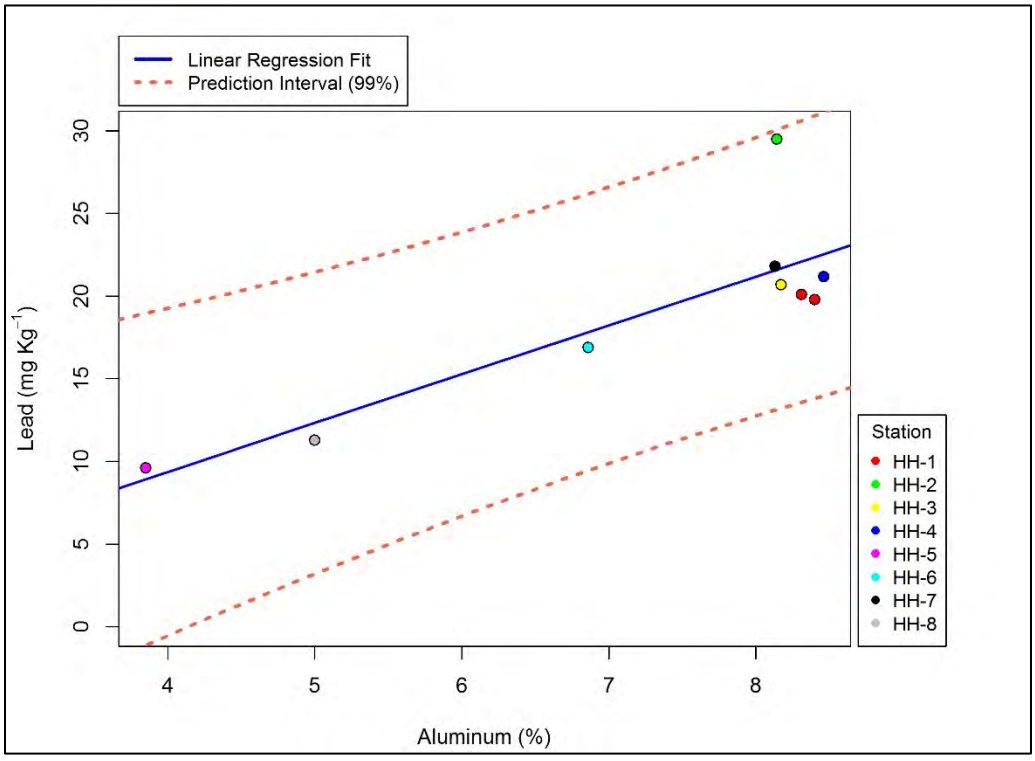

Figure C-8. Linear regression for relationship between sediment percent aluminum and concentrations of lead.

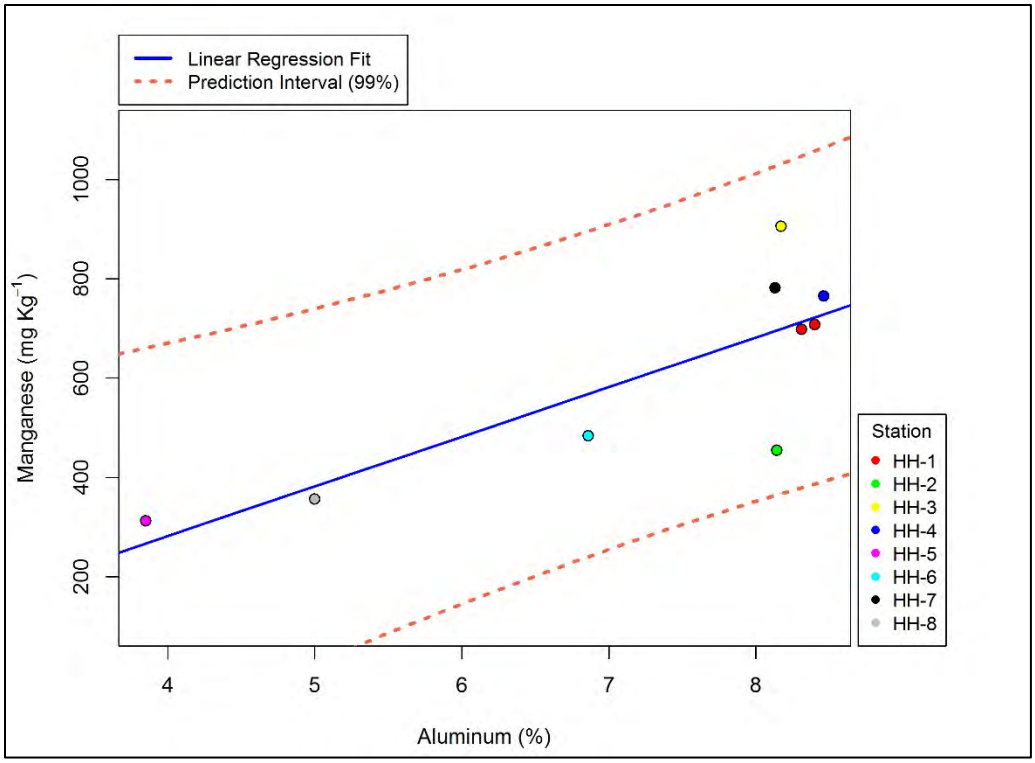

Figure C-9. Linear regression for relationship between sediment percent aluminum and concentrations of manganese.

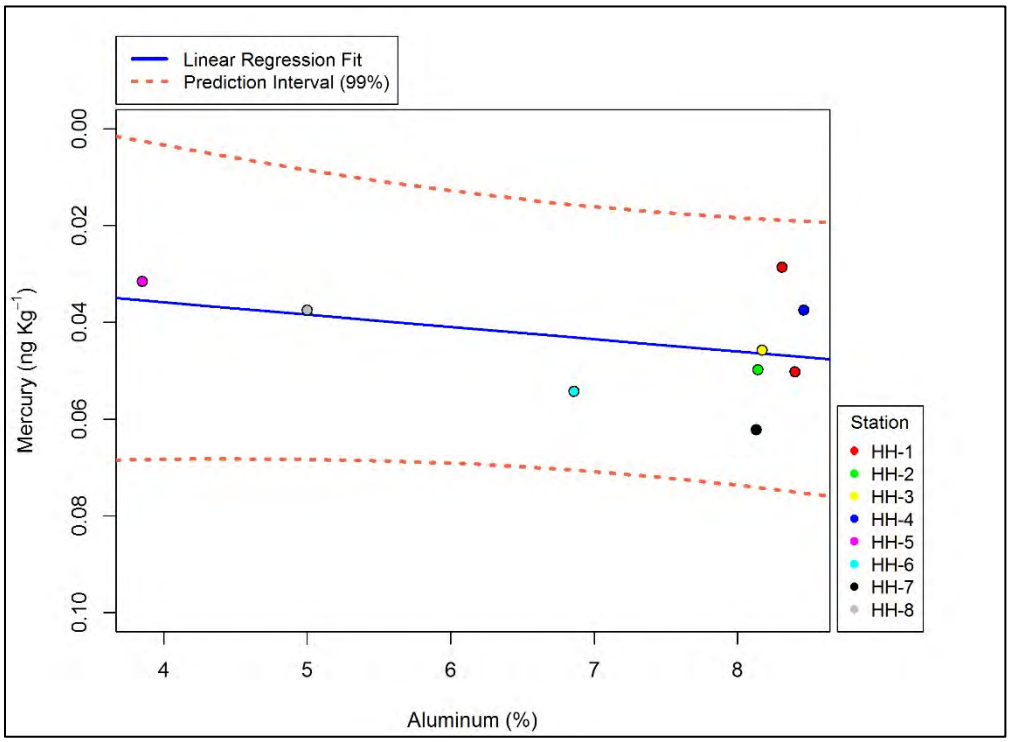

Figure C-10. Linear regression for relationship between sediment percent aluminum and concentrations of mercury.

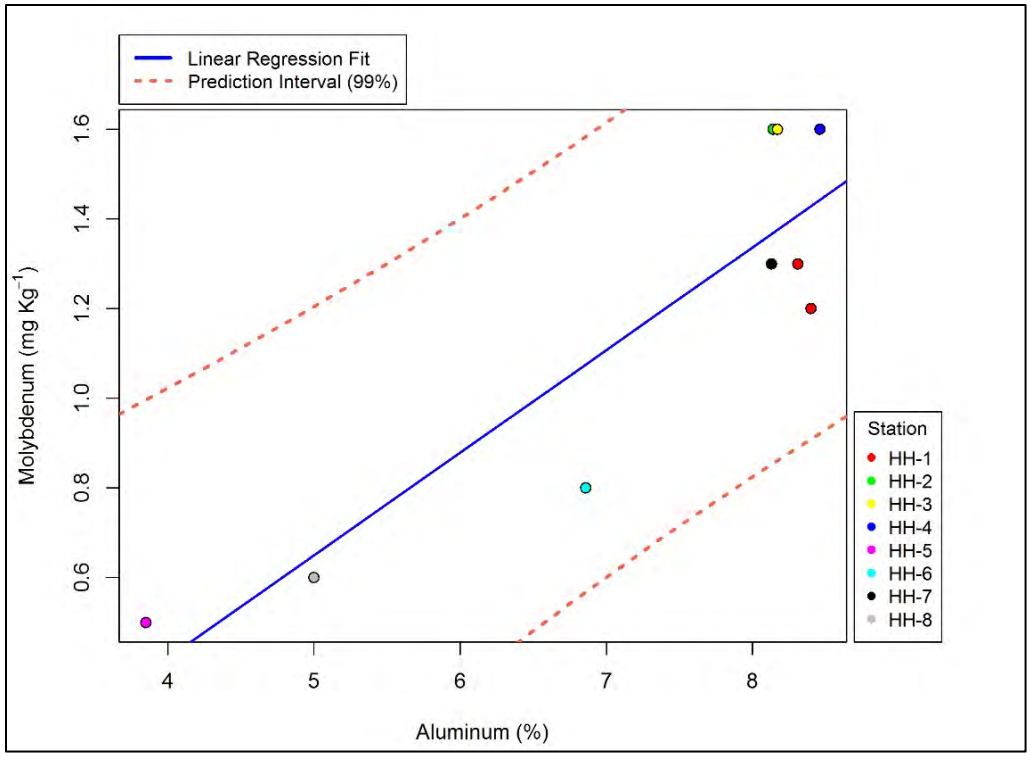

Figure C-11. Linear regression for relationship between sediment percent aluminum and concentrations of molybdenum.

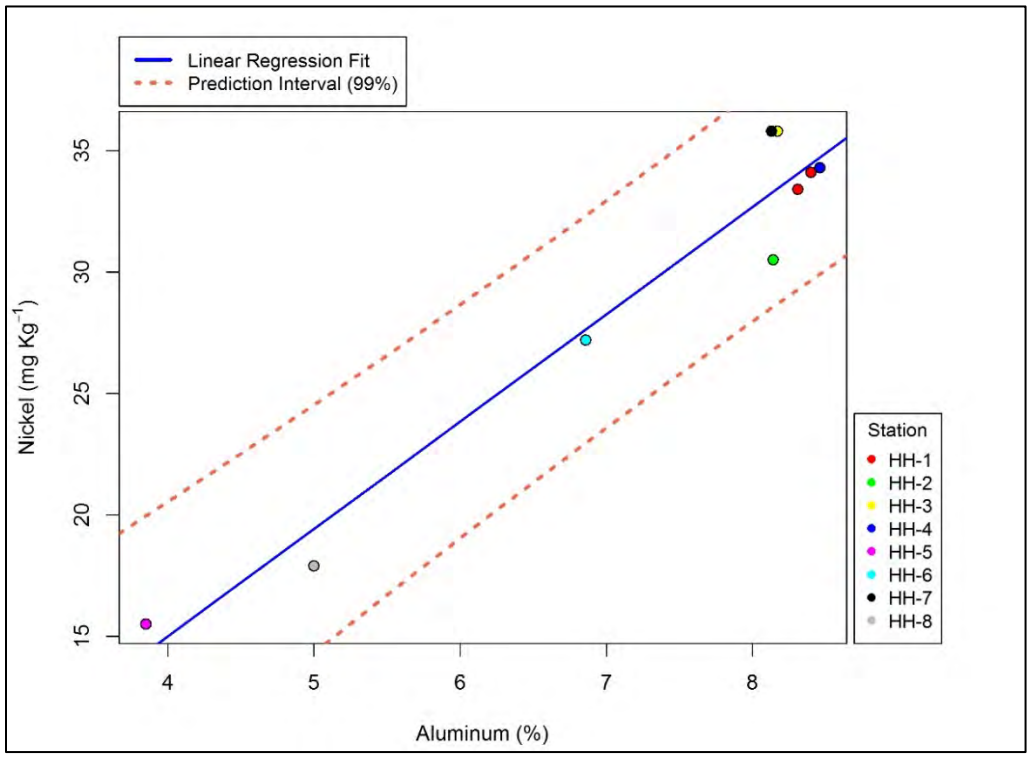

Figure C-12. Linear regression for relationship between sediment percent aluminum and concentrations of nickel.

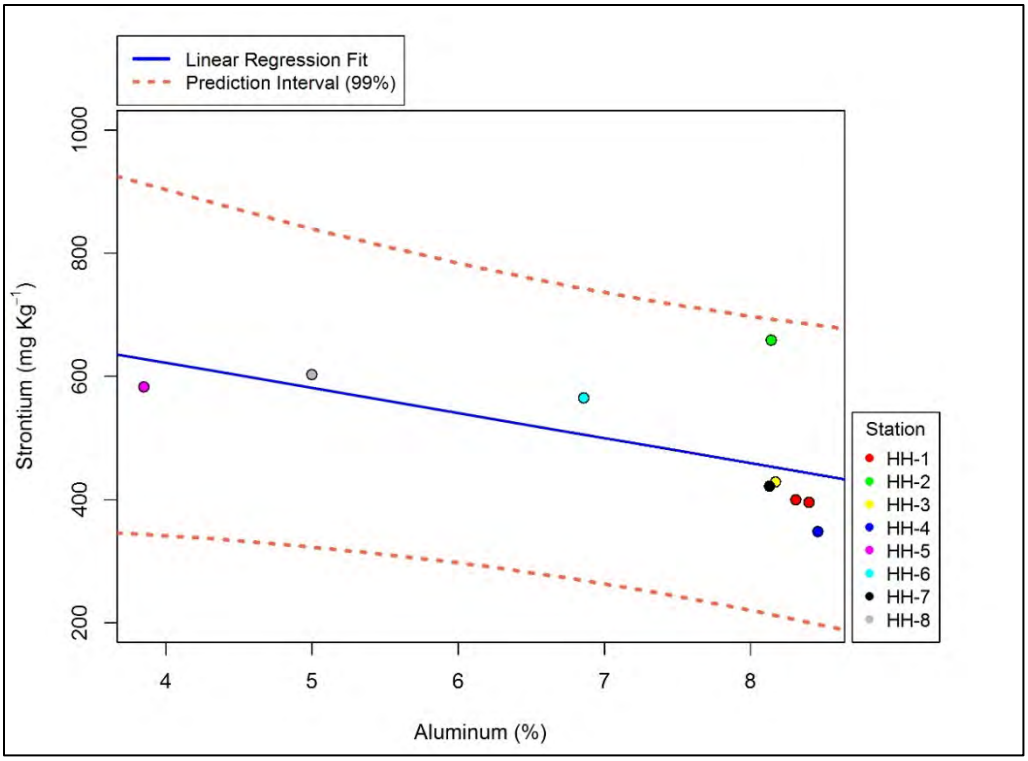

Figure C-13. Linear regression for relationship between sediment percent aluminum and concentrations of strontium.

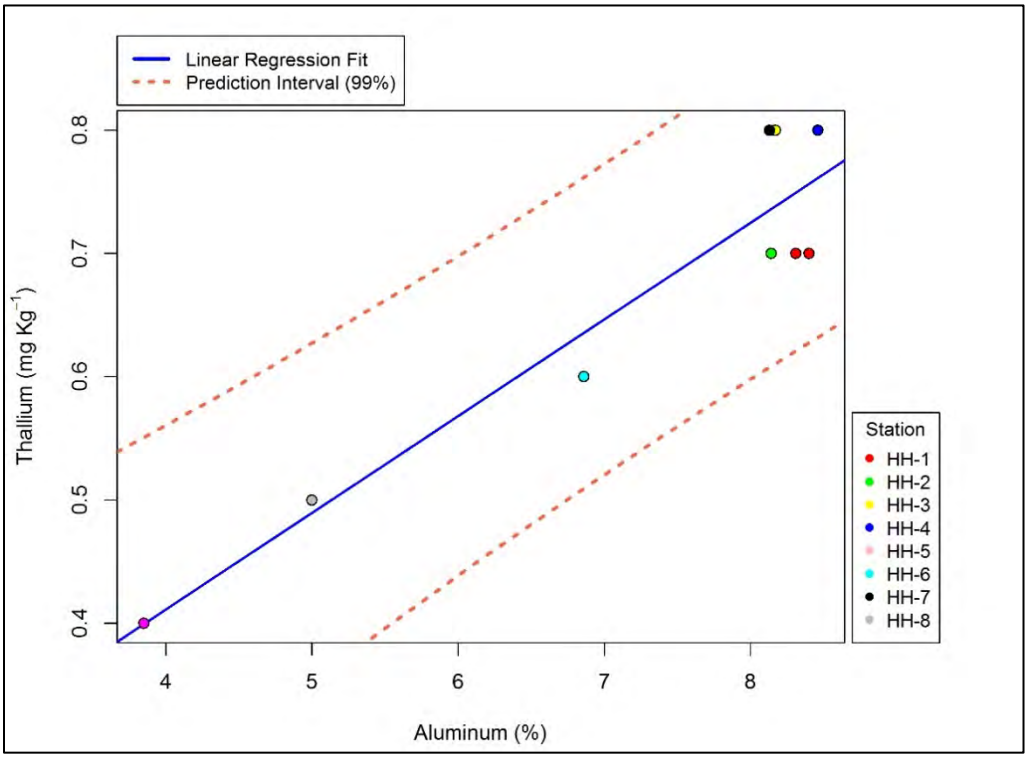

Figure C-14. Linear regression for relationship between sediment percent aluminum and concentrations of thallium.

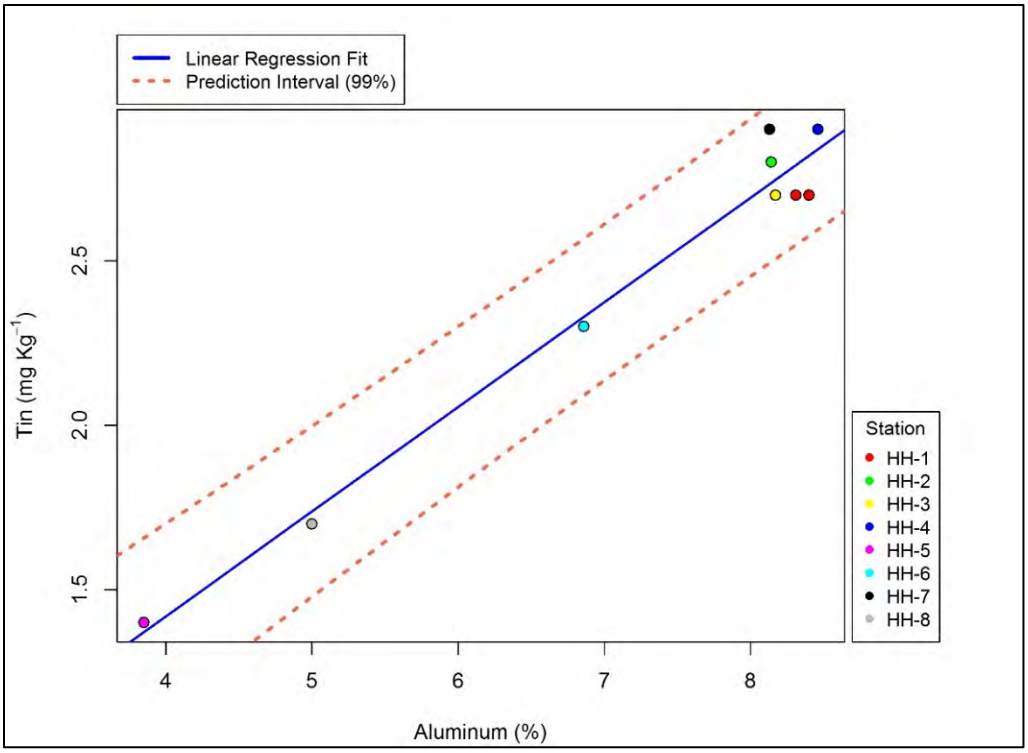

Figure C-15. Linear regression for relationship between sediment percent aluminum and concentrations of tin.

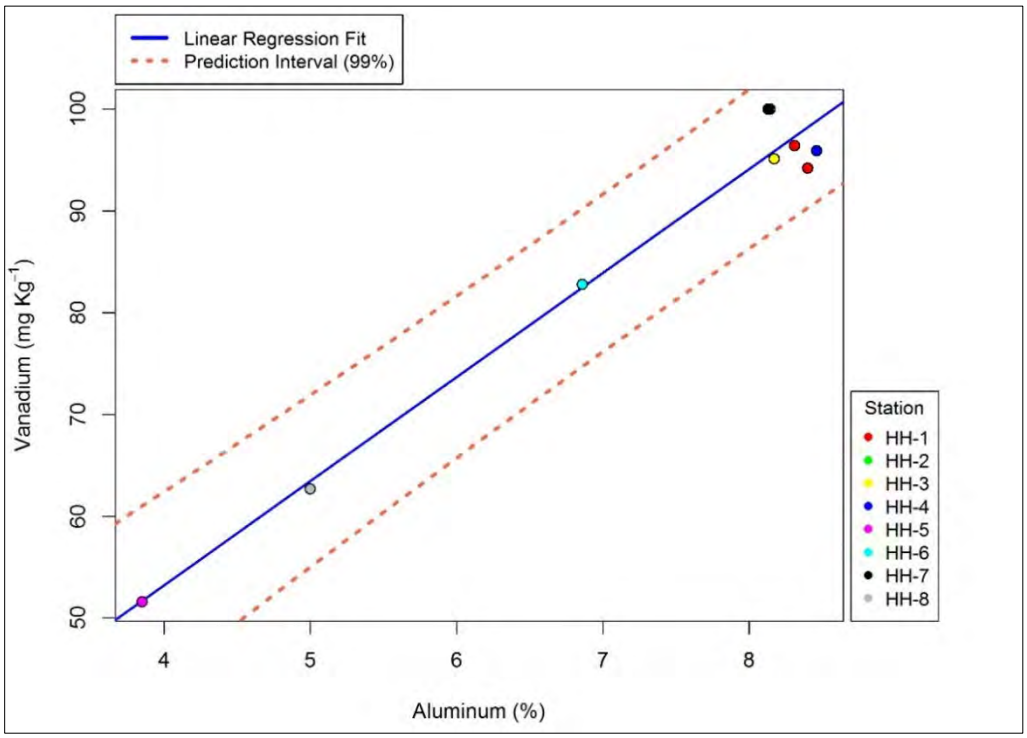

Figure C-16. Linear regression for relationship between sediment percent aluminum and concentrations of vanadium.

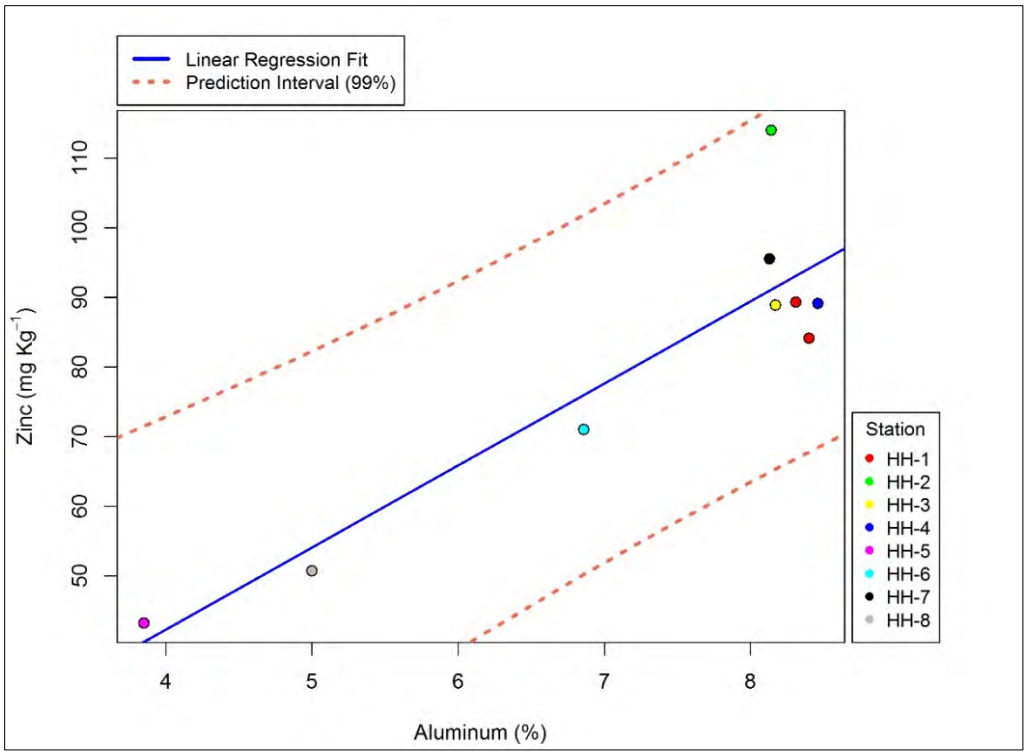

Figure C-17. Linear regression for relationship between sediment percent aluminum and concentrations of zinc.

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Appendix D:

Hydrographic Profiles

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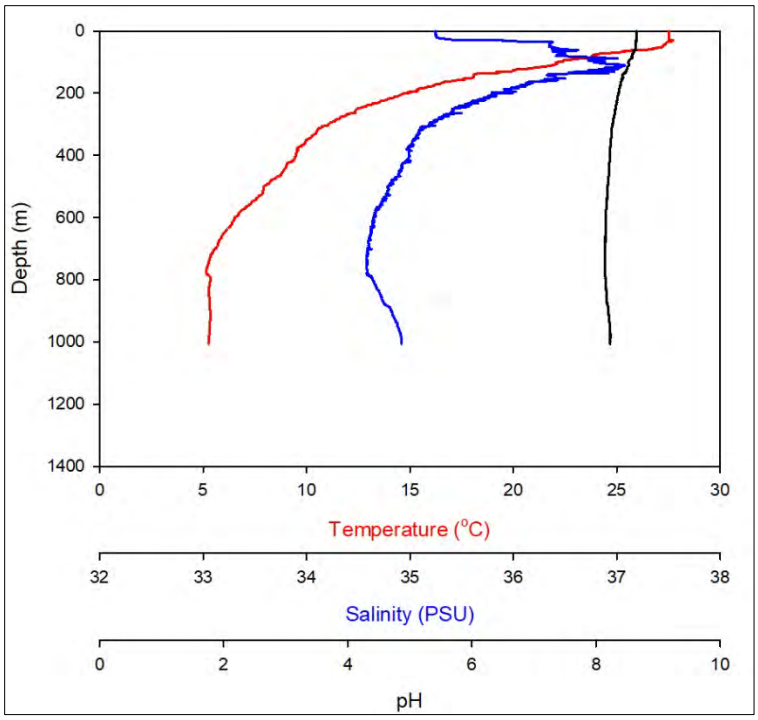

Figure D-1. Water column profile for temperature, salinity, and pH from Station HH-1 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

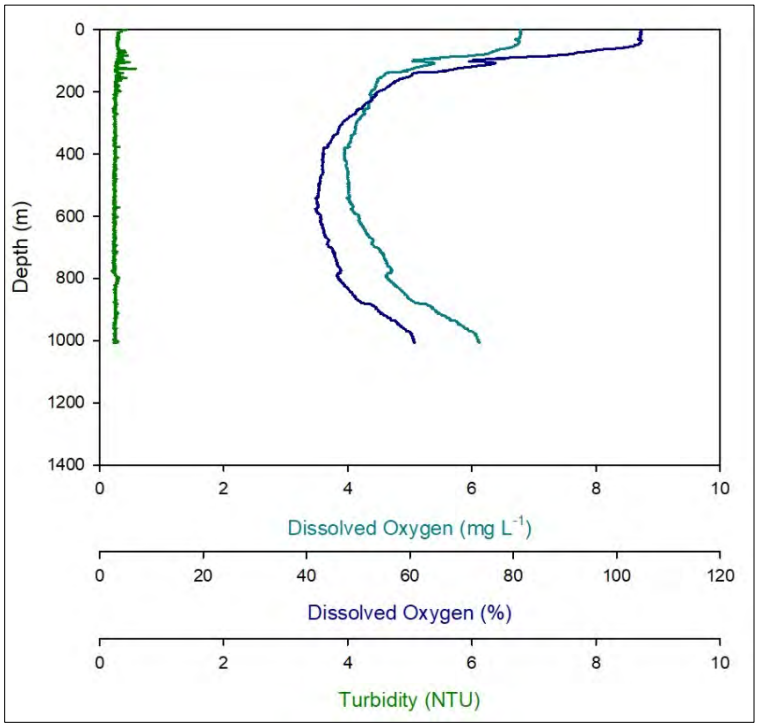

Figure D-2. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-1 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

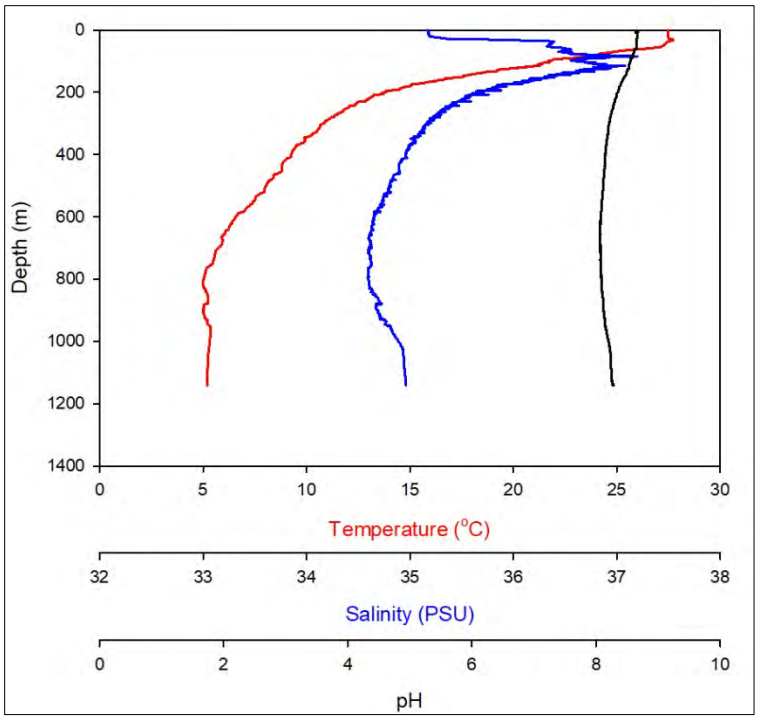

Figure D-3. Water column profile for temperature, salinity, and pH from Station HH-2 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

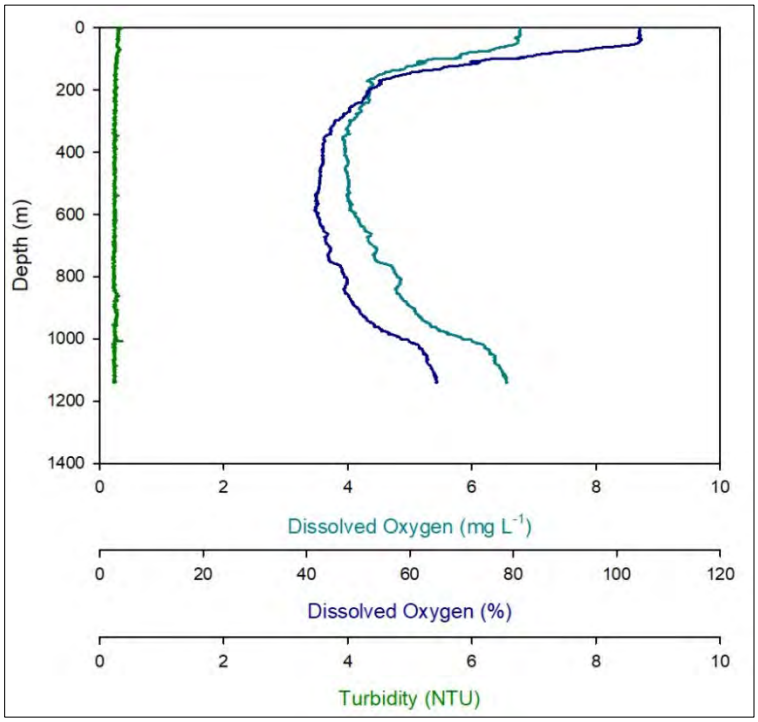

Figure D-4. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-2 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

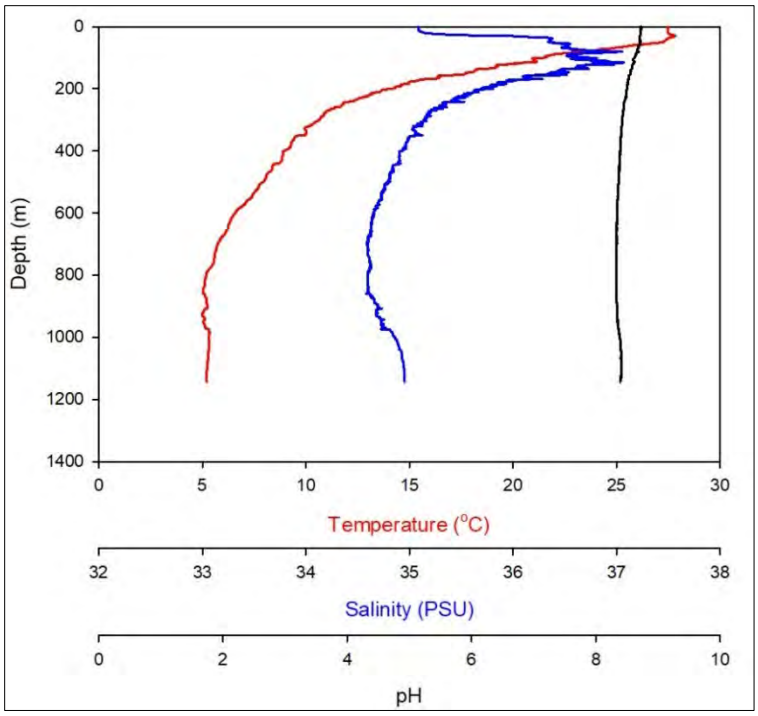

Figure D-5. Water column profile for temperature, salinity, and pH from Station HH-3 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

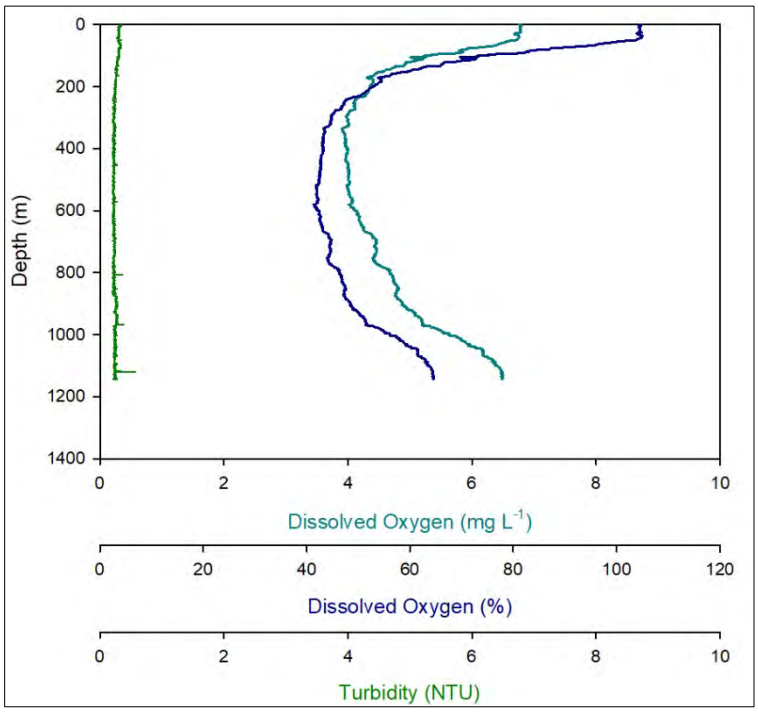

Figure D-6. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-3 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

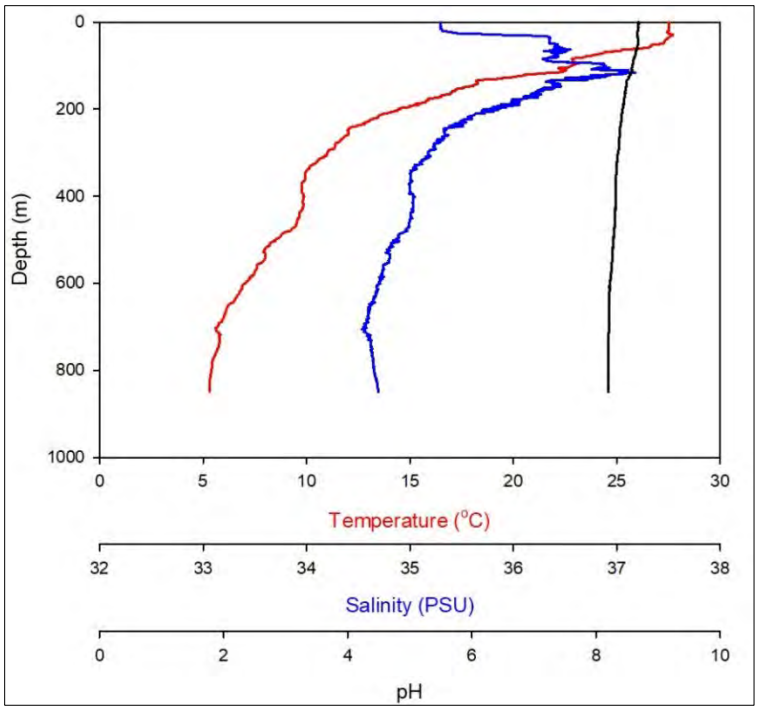

Figure D-7. Water column profile for temperature, salinity, and pH from Station HH-4 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

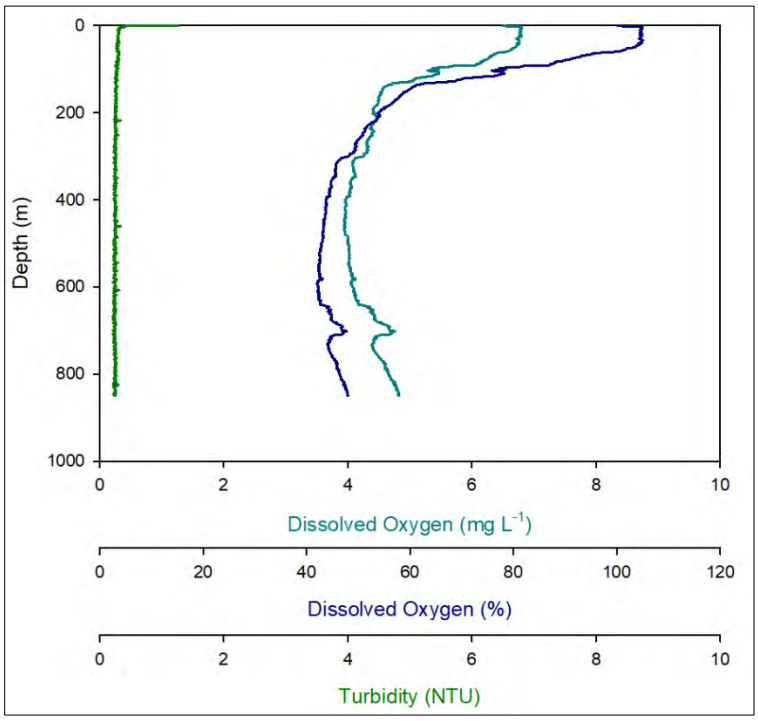

Figure D-8. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-4 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

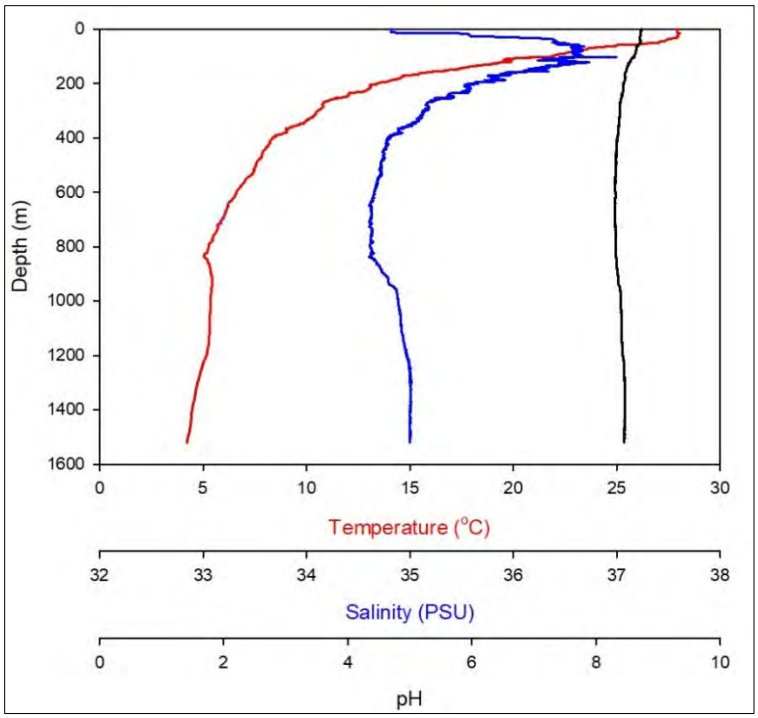

Figure D-9. Water column profile for temperature, salinity, and pH from Station HH-5 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

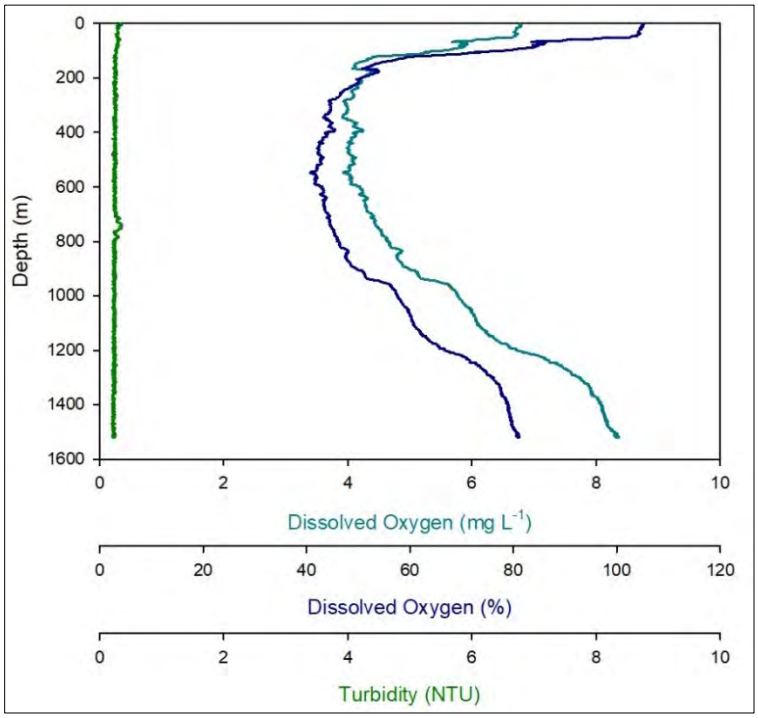

Figure D-10. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-5 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

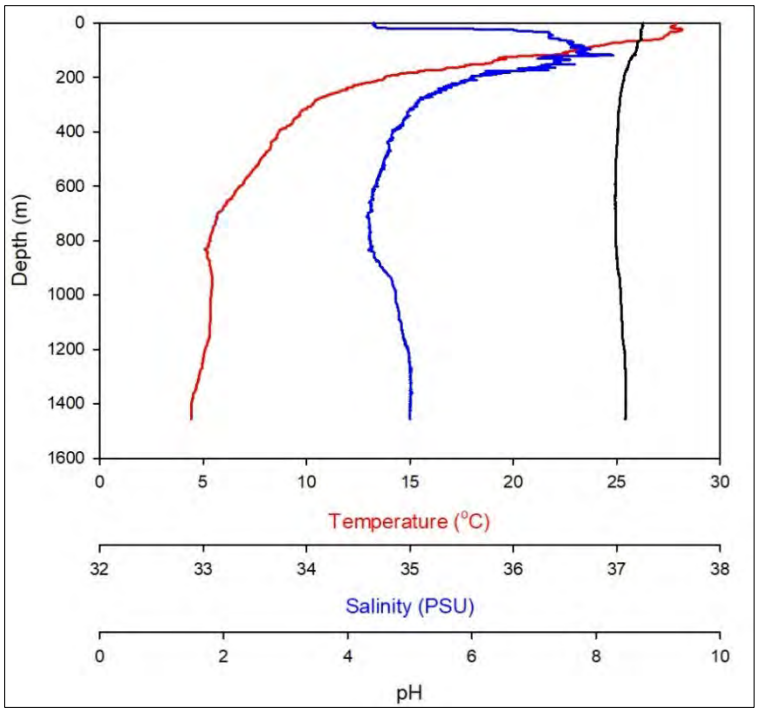

Figure D-11. Water column profile for temperature, salinity, and pH from Station HH-6 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

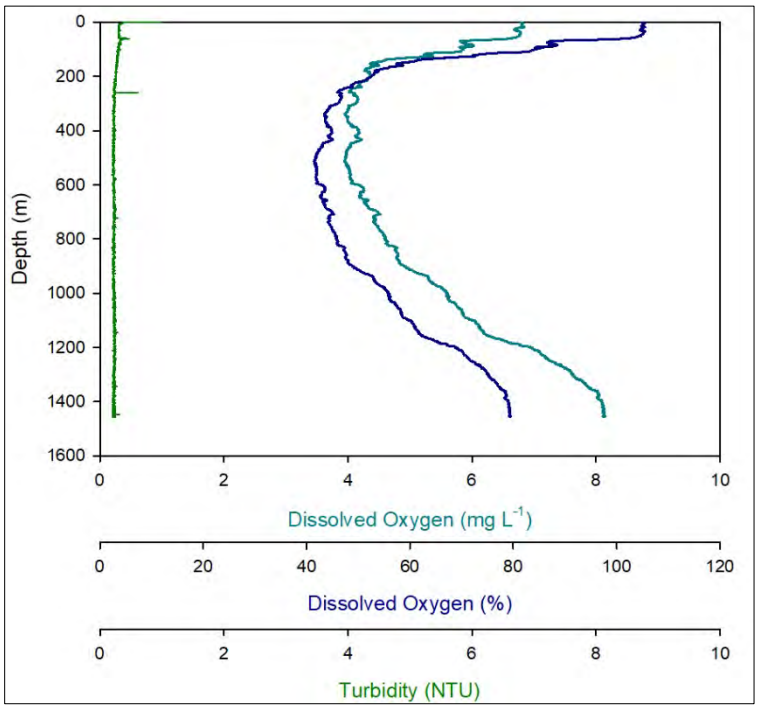

Figure D-12. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-6 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

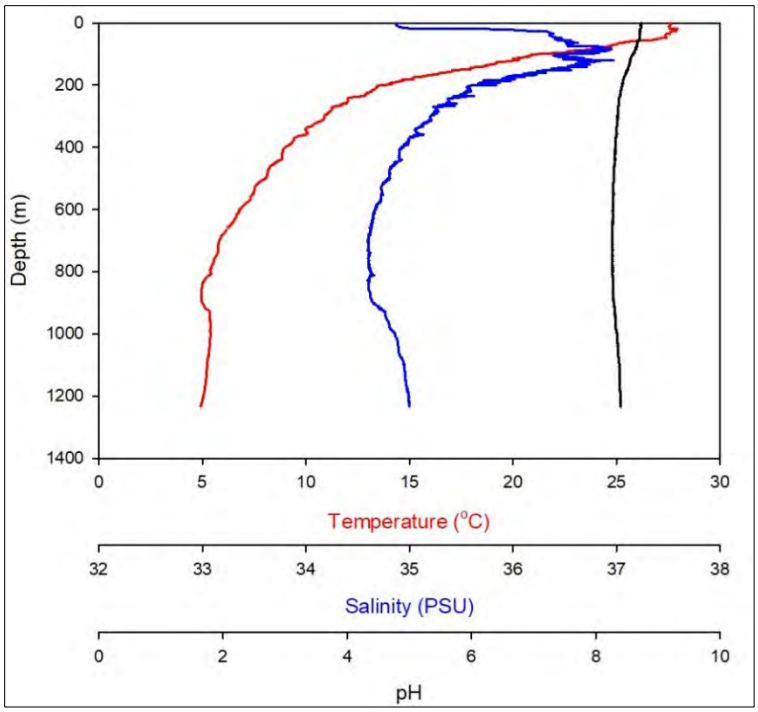

Figure D-13. Water column profile for temperature, salinity, and pH from Station HH-7 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

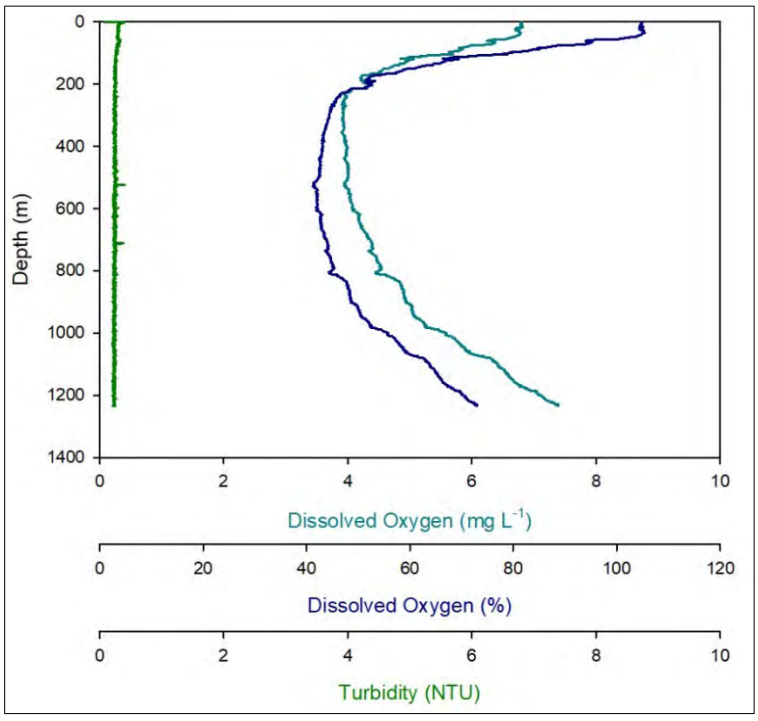

Figure D-14. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-7 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

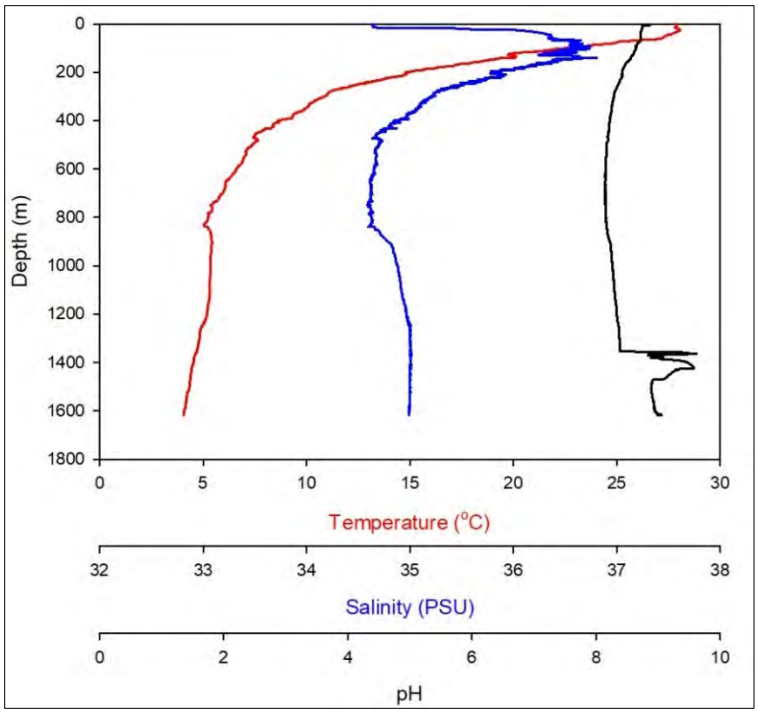

Figure D-15. Water column profile for temperature, salinity, and pH from Station HH-8 during the Hammerhead Development Environmental Baseline Survey. PSU = practical salinity units.

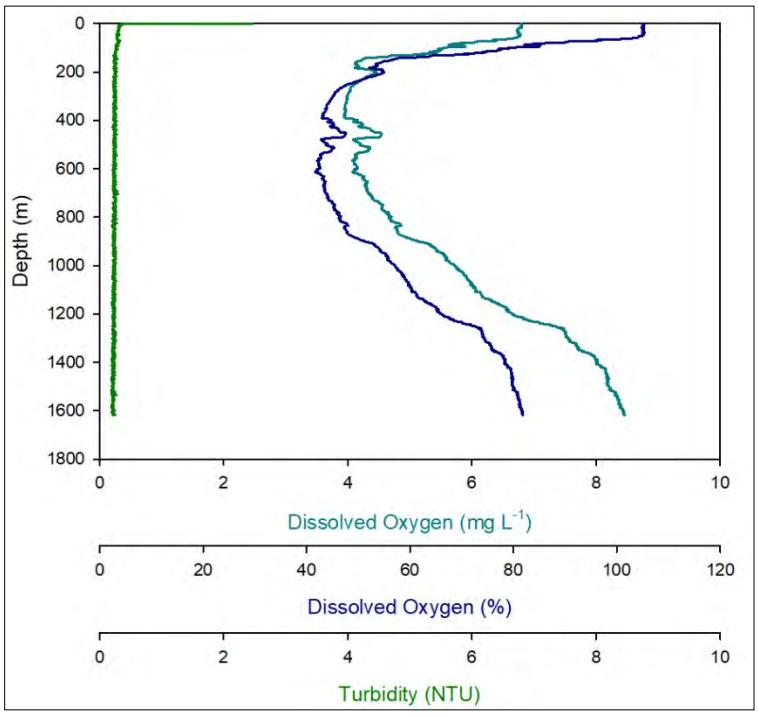

Figure D-16. Water column profile for dissolved oxygen (concentration and saturation) and turbidity from Station HH-8 during the Hammerhead Development Environmental Baseline Survey. NTU = nephelometric turbidity units.

APPENDIX J

IUCN-Listed Coastal and Marine Species Known from Guyana with Red List Status Classified as Data Deficient

Resubmitted without changes

March 2022

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Table J-1: IUCN-Listed Coastal and Marine Species Known From Guyana with Red List Status Classified as Data Deficient

Scientific Name	Common Name
Mammals	
Orcinus orca	Killer Whale
Fishes	
Dermatolepis inermis	Marbled Grouper
Elops smithi	Malacho
Genyatremus luteus	Torroto Grunt
Lonchurus elegans	Blackfin Croaker
Mugil liza	Lebranche Mullet
Sciades passany	Passany Sea Catfish
Tetrapturus georgii	Roundscale Spearfish
Torpedo nobiliana	Great Torpedo Ray
Invertebrates	
Holothuria arenicola	Sea Cucumber
Panulirus argus	Caribbean Spiny Lobster
Panulirus laevicauda	Smoothtail Spiny Lobster
Scyllarides delfosi	Three-spot Slipper Lobster

Source: International Union for Conservation of Nature. 2021. 2021 Red List of Threatened Species Version 2021-1. Accessed: June 2021. Retrieved from: http://www.iucnredlist.org/

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APPENDIX K

Marine Bird Study Report: Marine Bird Survey 2017–2020

Resubmitted without changes

March 2022

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Marine Bird Survey Report

Year 2 Marine Bird Study

Esso Exploration and Production Guyana Limited

January 2020

Project No. 0477264

The business of sustainability

ERM

January 2020

Marine Bird Survey Report

Year 2 Marine Bird Study

Environmental Resources Management

210 New Market Street
Georgetown, Guyana

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1. INTRODUCTION

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), Environmental Resources Management (ERM) conducted five seasonal marine bird surveys in the Stabroek Block and surrounding waters offshore Guyana between September 2018 and October 2019. These surveys, collectively referred to as the Year 2 Marine Bird Study, were a continuation of the Year 1 Marine Bird Study conducted pursuant to a condition of the Environmental Permit for the Liza Phase 1 Development Project.

The Year 2 Marine Bird Study is an elective study commissioned by EEPGL, and was not conducted pursuant to any regulatory requirement. The objective was to build on the Year 1 Marine Bird Study and continue to document the marine bird assemblage offshore Guyana and identify seasonal patterns in bird abundance and species composition.

This report summarizes the results of the Year 2 surveys and compares results across all marine bird surveys conducted to date for the Year 1 and Year 2 studies.

2. SURVEY METHODS

The Year 2 Marine Bird Study consisted of five seasonal surveys of marine birds conducted between September 2018 and October 2019. The Year 2 Marine Bird Study was a continuation of the Year 1 Marine Bird Study, which consisted of two surveys conducted in September 2017 and April 2018 (Table 2-1). In total, 7 seasonal surveys, including 11 individual survey events encompassing approximately 750 survey hours, have been conducted to date for the Year 1 and Year 2 studies. Table 2-1 summarizes information about each of these surveys and Figure 2-1 depicts the locations of the surveys and the bird sightings.

Similar to the Year 1 Marine Bird Study, the marine bird surveys were conducted by teams of international and Guyanese bird specialists aboard vessels conducting various types of work between the Stabroek Block and Georgetown or within the Stabroek Block. The surveys applied the protocol established for the Year 1 Marine Bird Study to facilitate comparison of data across surveys. During each survey, one or two observers were stationed on a vessel's top deck. To minimize observer fatigue and eyestrain caused by continuous observation, observers conducted 30-minute surveys, each followed by a 15- or 30-minute break, between the hours of 05:30 and 17:30. At the beginning of each 30-minute observation period, the observers noted sky condition, wind strength, intensity of swells, density of whitecaps (which tend to impede visibility of birds near the water surface), boat speed, and bow direction. During each 30-minute observation period, the observers continuously scanned the vessel and the ocean surrounding the vessel with binoculars (10 x 40 or 10 x 50 magnification) to locate and identify any birds present. The observers noted the locations of birds relative to the vessel (general direction or, when possible, compass heading), along with their estimated distance from the observer (greater or less than 300 meters [984.3 feet]) and direction of movement. Observers recorded data electronically in Microsoft Excel using a data entry template developed for the surveys by ERM and the specialist team[1] (Appendix A). Whenever possible, observers collected global positioning system points at the locations of sightings and photographed birds[2] for documentation and, in some cases, later species identification or confirmation. Appendix B contains

[1] An electronic data collection tool using the Survey 123 platform was piloted during three of the five Year 2 marine bird surveys and determined to be unsuitable for offshore use due to weather conditions, the fragility of the data entry tool (ruggedized IPad), and the lack of consistent and strong internet connection.

[2] Photographic equipment used during the marine bird surveys included Digital Single Lens Reflex (DSLR) cameras with magnification of 300 millimeters or higher.

the photographic records of bird species documented offshore Guyana during the EEPGL-commissioned marine bird surveys conducted to date.

Table 2-1: Summary of EEPGL-Commissioned Marine Bird Surveys Conducted within the Stabroek Block and between the Stabroek Block and Georgetown, Guyana (2017–2019)

Survey Name	Number of Survey Events per Survey	Survey Date	Survey Area	Mobile or Stationary Survey Vessel [a]	Survey Hours
YEAR 1 MARINE BIRD STUDY					
Fall 2017 Survey	1	30 September 2017–7 October 2017	Between Georgetown and the Stabroek Block	Mobile	46
Spring 2018 Survey	2	9 April 2018–16 April 2018	Between Georgetown and the Stabroek Block	Mobile	113
Survey 1a	—	9 April 2018–15 April 2018	Within Stabroek Block	Mobile	60.2
Survey 1b	—	9 April 2018–16 April 2018	Between Georgetown and the Stabroek Block	Mobile	52.8
YEAR 2 MARINE BIRD STUDY					
Fall 2018 Survey	3		Between Georgetown and Stabroek Block and within Stabroek and Canje Blocks	Mobile and Stationary	232.8
Survey 1a	—	15 September 2018–25 September 2018	Between Georgetown and Stabroek Block and within Stabroek and Canje Blocks	Mobile	49.5
Survey 1b	—	1 October 2018–6 October 2018	Between Georgetown and Stabroek Block and within Stabroek Block	Mobile	23.5
Survey 1c	—	17 September 2018–1 October 2018	Within Stabroek Block	Stationary	159.8
Winter 2019 Survey	1	28 January 2019–4 February 2019	Within Stabroek Block	Stationary	36.5
Spring 2019 Survey	2		Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	81.2
Survey 1a	—	18 April 2019–23 April 2019	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	52
Survey 1b	—	20 April 2019–26 April 2019	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	29.2
Summer 2019 Survey	1	27 June 2019–17 July 2019	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	139.5
Fall 2019 Survey	1	17 September 2019–3 October 2019	Within Stabroek Block	Stationary	100.5
All Surveys Combined	**7 seasonal surveys (11 individual survey events)**	**--**	**--**	**--**	**749.5**

[a] Refers to whether the survey occurred aboard a stationary or mobile vessel. The stationary vessels were drill ships and the mobile vessels were various types of drill ship support vessels or sampling vessels.

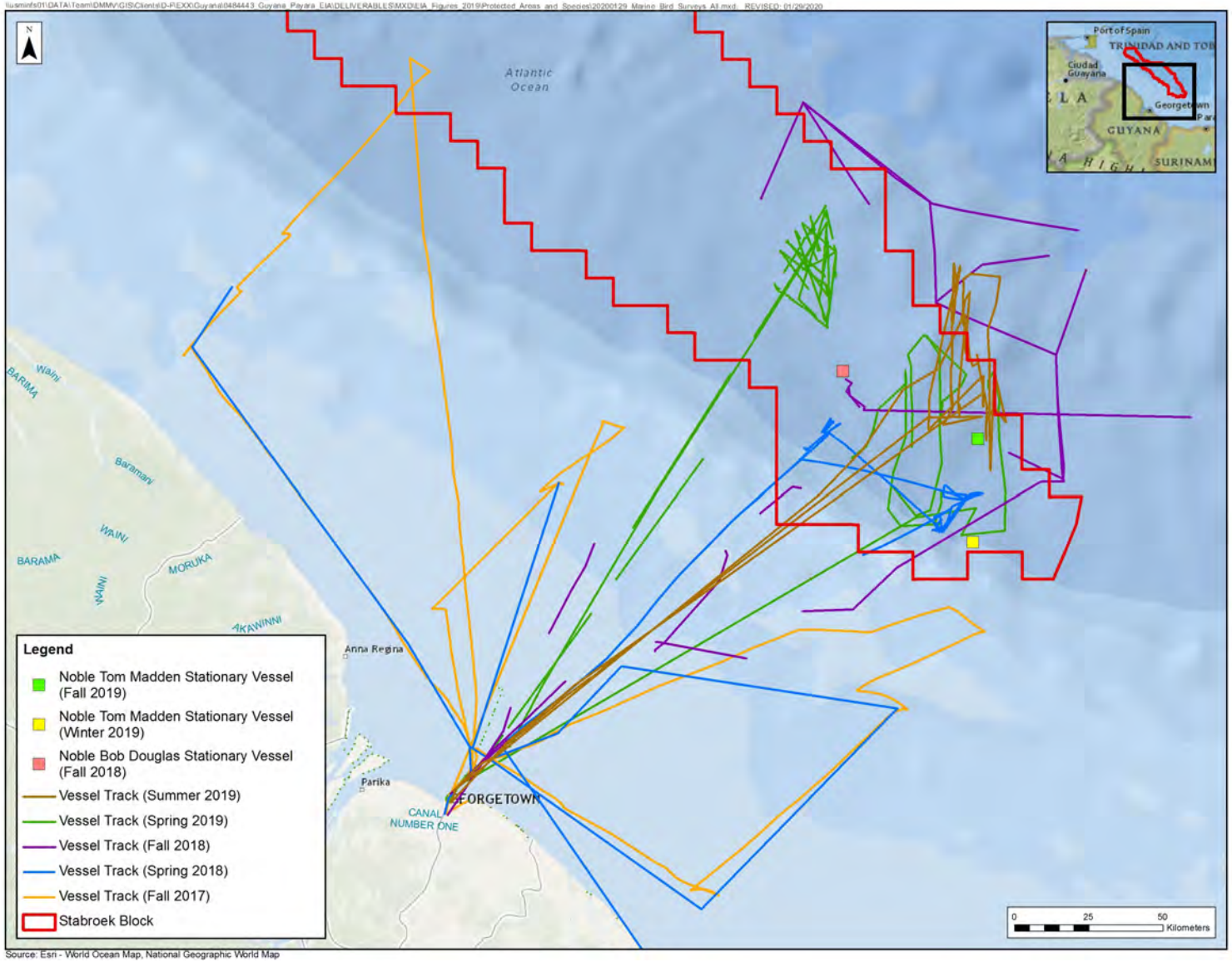


Figure 2-1: Map of Marine Bird Survey Locations, 2017–2019

3. YEAR 2 MARINE BIRD STUDY RESULTS

The five marine bird surveys conducted during the Year 2 Marine Bird Study yielded a total of 1,510 bird observations representing 51 species offshore Guyana (defined for the purpose of the study as greater than 3.1 miles (5 kilometers) from shore). Additional bird observations were recorded at the port in Georgetown or very near the shoreline, and all of those observations were of non-migratory landbird or coastal bird species that are not representative of the offshore marine bird community. As such, for the purposes of this analysis and report, only birds observed more than 3.1 miles (5 kilometers) from shore were included in the analysis to allow for more clear characterization of the offshore marine bird community.

Table 3-1 presents the bird species observed offshore and their abundance during each of the five surveys conducted as part of the Year 2 Marine Bird Study. The following subsections summarize the results of each of the five surveys.

3.1 Fall 2018 Survey

Three surveys (two mobile and one stationary) were performed between 15 September and 6 October 2018. The surveys included 18 survey days and a total of 232.8 survey hours. The detection rate varied among the three surveys, from 0.73 to 13.4 birds per survey hour (average 2.73). The high detection rate of 13.4 birds per survey hour for Survey 1b was driven by one observation of a large flock of Common Terns (n = 190), which skewed the detection rate; the adjusted detection rate without the single flock of Common Terns was 5.28 for Survey 1b, yielding an adjusted average of 1.92 across all surveys.

Across all three Fall 2018 Survey events, 637 birds were recorded of 28 species (Table 3-1). Ten species were Nearctic-Neotropical migrant landbirds or shorebirds that were migrating south *en route* to their wintering areas; the remainder were nearshore and pelagic seabirds actively foraging in the offshore survey area or commuting between offshore foraging sites. Because the surveys were conducted aboard vessels travelling different routes, the species and numbers recorded varied among the three Fall 2018 Survey events. In both Surveys 1a and 1b, the dominant marine bird species observed was Magnificent Frigatebird, while in Survey 1c, the dominant marine bird observed was Masked Booby. Across all three surveys, Common Terns and Laughing Gulls were the most abundant species recorded offshore.

Overall bird diversity was relatively high in Survey 1a compared with the other two Fall 2018 Survey events, and Survey 1a documented a notable number and assemblage of migrating landbirds.

3.2 Winter 2019 Survey

The Winter 2019 Survey was a stationary survey conducted from 28 January to 4 February 2019, with 36.5 survey hours. Two nocturnal observation periods of 30 minutes each did not record any birds. This survey documented 58 birds of seven species during the diurnal observation periods (Table 3-1). The diurnal observation periods yielded a bird detection rate of 1.59 birds per survey hour.

All of the species observed were nearshore marine or pelagic seabirds - some of which winter in the region, while others are vagrants or permanent residents. Roughly half of the bird observations recorded during this survey most likely involved only two individual birds that were observed repeatedly over the course of the survey—a single Brown Noddy (*Anous stolidus*) and a single Great Black-backed Gull—both of which were roosting on the drill ship. The most abundant species recorded were Magnificent Frigatebird and Masked Booby. The survey also documented breeding interactions, including courtship activity, among boobies and Magnificent Frigatebirds.

3.3 Spring 2019 Survey

Two mobile marine bird survey events were conducted on two separate vessels from 20–26 April and 18–23 April 2019. In total, the survey effort encompassed 81.2 survey hours. Survey 1a recorded 4.3 birds per survey hour, while Survey 1b recorded 1.54 birds per survey hour.

In total, 269 individual birds were recorded of 21 species (Table 3-1). Nineteen species were pelagic or nearshore marine, several occurring almost exclusively offshore in this region. Two species were Nearctic-breeding shorebirds seen migrating through the survey area. The dominant marine bird species observed was Wilson's Storm-Petrel (*Oceanites oceanicus*), followed by Masked Booby, Sooty Tern (*Onychoprion fuscatus*), and Leach's Storm-Petrel (*Oceanodroma leucorhoa*; International Union for Conservation of Nature Vulnerable).

3.4 Summer 2019 Survey

One mobile survey was conducted in between 27 June and 17 July 2019 (139.5 hours of survey effort). In total, 251 individual birds were recorded of 10 species (Table 3-1). The detection rate was 1.8 birds per survey hour. However, the detection rate for this survey was skewed by a few large groups of Magnificent Frigatebirds, with four observations totaling 107 birds. Without these four observations, the detection rate was 1.0 bird per survey hour.

Similar to other surveys, Magnificent Frigatebird was the dominant marine species observed. Masked Booby, Brown Booby (*Sula leucogaster*), and Common Tern were also among the most commonly observed (Table 3-1). Five species were nearshore marine, three were pelagic, and one was a shorebird.

3.5 Fall 2019 Survey

One stationary survey was conducted from 17 September to 3 October 2019. The total survey effort was 100.5 survey hours, and the detection rate was 0.94 birds per survey hour (Table 3-1).

Ninety-four birds were recorded from 16 species (Table 3-1). Seven species of migratory landbirds were observed, including 41 barn swallows (*Hirundo rustica*), the most abundant species during this survey. Another six species were migratory shorebirds, such as sandpipers and plovers. The remaining species were the more typical pelagic and nearshore marine species, the most abundant of which were Masked Booby, Brown Booby, and Common Tern.

Table 3-1: Bird Species Observed during EEPGL-Commissioned Marine Bird Surveys Conducted in the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2019

			Year 1				Year 2				
Common Name	**Scientific Name**	**Life History Category**	**2017 Fall**	**2018 Spring**	**2018 Fall**	**2019 Winter**	**2019 Spring**	**2019 Summer**	**2019 Fall**	**Total Abundance**	**Number of Surveys Observed**
Arctic Tern	*Sterna paradisea*	Pelagic					1			1	1
Audubon's Shearwater	*Puffinus lherminieri*	Pelagic					5	4		9	2
Brown Booby	*Sula leucogaster*	Pelagic	1	1	4		2	17	8	33	6
Brown Noddy	*Anous stolidus*	Pelagic	2		2	1				5	3
Bulwer's Petrel	*Bulweria bulwerii*	Pelagic		1	4					5	2
Cory's Shearwater	*Calonectris borealis*	Pelagic					1			1	1
Great Shearwater	*Ardenna gravis*	Pelagic			1		1	1		3	3
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Pelagic		17			23			40	2
Manx Shearwater	*Puffinus puffinus*	Pelagic					1			1	1
Masked Booby	*Sula dactylatra*	Pelagic		3	37	21	66	22	20	169	6
Parasitic Jaeger	*Stercorarius parasiticus*	Pelagic		2			3			5	2
Pomarine Jaeger	*Stercorarius pomarinus*	Pelagic	2	4		5	3		1	15	5
Red-billed Tropicbird	*Phaethon aethereus*	Pelagic		2			6			8	2
Red-footed Booby	*Sula sula*	Pelagic	1	2	2	2			2	9	5
Sooty Shearwater	*Ardenna grisea*	Pelagic				2				2	1
Sooty Tern	*Onychoprion fuscatus*	Pelagic					43			43	1
White-tailed Tropicbird	*Phaethon lepturus*	Pelagic					2			2	1
Wilson's Storm-Petrel	*Oceanites oceanicus*	Pelagic		5			68			73	2
Great Black-backed Gull	*Larus marinus*	Nearshore Marine				1				1	1

			Year 1				Year 2				
Common Name	**Scientific Name**	**Life History Category**	**2017 Fall**	**2018 Spring**	**2018 Fall**	**2019 Winter**	**2019 Spring**	**2019 Summer**	**2019 Fall**	**Total Abundance**	**Number of Surveys Observed**
Black Skimmer	*Rynchops niger*	Nearshore Marine	1				12			13	2
Black Tern	*Chlidonias niger*	Nearshore Marine			46					46	1
Bridled Tern	*Onychoprion anaethetus*	Nearshore Marine	13		2					15	2
Brown Pelican	*Pelecanus occidentalis*	Nearshore Marine	1		2			7		10	3
Cayenne Tern	*Thalasseus eurygnatha*	Nearshore Marine	10							10	1
Common Tern	*Sterna hirundo*	Nearshore Marine	28	9	190		9	14	8	258	6
Laughing Gull	*Leucophaeus atricilla*	Nearshore Marine	19	11	102		3	5	1	141	6
Least Tern	*Sternula antillarum*	Nearshore Marine			11					11	1
Magnificent Frigatebird	*Fregata magnificens*	Nearshore Marine	136	8	65	26	12	177	3	427	7
Roseate Tern	*Sterna dougalli*	Nearshore Marine			2					2	1
Royal Tern	*Thalasseus maximus*	Nearshore Marine	3	3	6		2	3		17	5
Sandwich Tern	*Thalasseus sandvicensis*	Nearshore Marine	1		8					9	2
Little Blue Heron	*Egretta caerulea*	Coastal	5		5			1		11	3
American Golden Plover	*Pluvialis dominica*	Shorebird							1	1	1
Black-bellied Plover	*Pluvialis squatarola*	Shorebird			25					25	1
Least Sandpiper	*Calidris minutilla*	Shorebird			2					2	1
Lesser Yellowlegs	*Tringa flavipes*	Shorebird			5				2	7	2
Pectoral Sandpiper	*Calidris melanotos*	Shorebird	1							1	1
Ruddy Turnstone	*Arenaria interpres*	Shorebird		1	4					5	2
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird					1		1	2	2
Semipalmated Sandpiper	*Calidris pusilla*	Shorebird	1		16					17	2
Spotted Sandpiper	*Actitis macularius*	Shorebird	1						1	2	2

			Year 1			Year 2					
Common Name	**Scientific Name**	**Life History Category**	**2017 Fall**	**2018 Spring**	**2018 Fall**	**2019 Winter**	**2019 Spring**	**2019 Summer**	**2019 Fall**	**Total Abundance**	**Number of Surveys Observed**
Whimbrel	*Numenius phaeopus*	Shorebird	1				5			6	2
Cliff Swallow	*Petrochelidon pyrrhonota*	Migratory Landbird			8				2	10	2
Bank Swallow	*Riparia riparia*	Migratory Landbird			1					1	1
Barn Swallow	*Hirundo rustica*	Migratory Landbird	4		84				41	129	3
Black-whiskered Vireo	*Vireo altiloquus*	Migratory Landbird							1	1	1
Bobolink	*Dolichonyx oryzivorus*	Migratory Landbird			1					1	1
Eastern Kingbird	*Tyrannus tyrannus*	Migratory Landbird							1	1	1
Purple Martin	*Progne subis*	Migratory Landbird			1					1	1
Yellow Warbler	*Setophaga petechia*	Migratory Landbird							1	1	1
Yellow-billed Cuckoo	*Coccyzus americanus*	Migratory Landbird							1	1	1
Eurasian Collared-Dove	*Streptopelia decaocto*	Non-migratory Landbird			1					1	1
Total Abundance			**231**	**69**	**637**	**58**	**269**	**251**	**95**	**1610**	
Total Species Richness			**19**	**14**	**28**	**7**	**21**	**10**	**17**	**52**	

Note: Table excludes bird observations recorded at the Georgetown port and within approximately 3.1 miles (5 kilometers) from shore.

3.6 Year 2 Survey Overview

Consistent with the Year 1 Marine Bird Study results, the Year 2 survey events varied considerably in bird species assemblage, bird abundance, and species richness, as well as in detection rate (observations per number of survey effort hours). Across all surveys, Magnificent Frigatebird (*Fregata magnificens*) was the most commonly observed species, followed by Masked Booby (*Sula dactylatra*), Common Tern (*Sterna hirundo*), and Laughing Gull (*Leucophaeus atricilla*).

Five species were observed in the Year 2 surveys that had not previously been documented in Guyana's offshore waters, including: Red-billed Tropicbird (*Phaethon aethereus*), Manx Shearwater (*Puffinus puffinus*), White-tailed Tropicbird (*Phaethon lepturus*), Great Black-backed Gull (*Larus marinus*), and Arctic Tern (*Sterna paradisea*). Appendix B contains photographs of each of these species. This adds to two new species records for Guyana documented during the Year 1 Marine Bird Study, which included Bridled Tern (*Onychoprion anaethetus*) and Bulwer's Petrel (*Bulweria bulwerii)*. Two species documented in prior reporting as new records for Guyana (Band-rumped Storm-Petrel [*Oceanodroma castro*] and Long-tailed Jaeger [*Stercorarius longicaudus*]), have recently been confirmed through photographic review by taxonomic specialists to be other previously recorded species, so the corrected total of new species records for Guyana associated with the EEPGL marine bird surveys conducted to date is seven species.

The Year 2 surveys included survey events in each of the four seasons (winter, spring, summer, and fall); this allowed for a comparison of seasonal differences in species assemblage and bird abundance. The surveys documented clear seasonal differences in bird species composition, bird abundance, and bird species richness. Shorebirds and migratory landbird species were only recorded during spring and/or fall surveys in Year 2 (Figure 3-1), and more species were observed in both of the fall surveys (2018 and 2019) than in the spring survey (2019). Overall species richness was highest during fall and spring surveys (Figure 3-2), while bird abundance was highest in fall 2018 followed by both spring and summer 2019 (Figure 3-3). Summer 2019 had high abundance of fewer species, all of which were pelagic and nearshore marine species. Winter 2019 had few species (low species richness), all of which were pelagic and nearshore marine species similar to those observed in the summer 2019 survey, and low abundance (Table 3-1 and Figures 3-1 and 3-2).

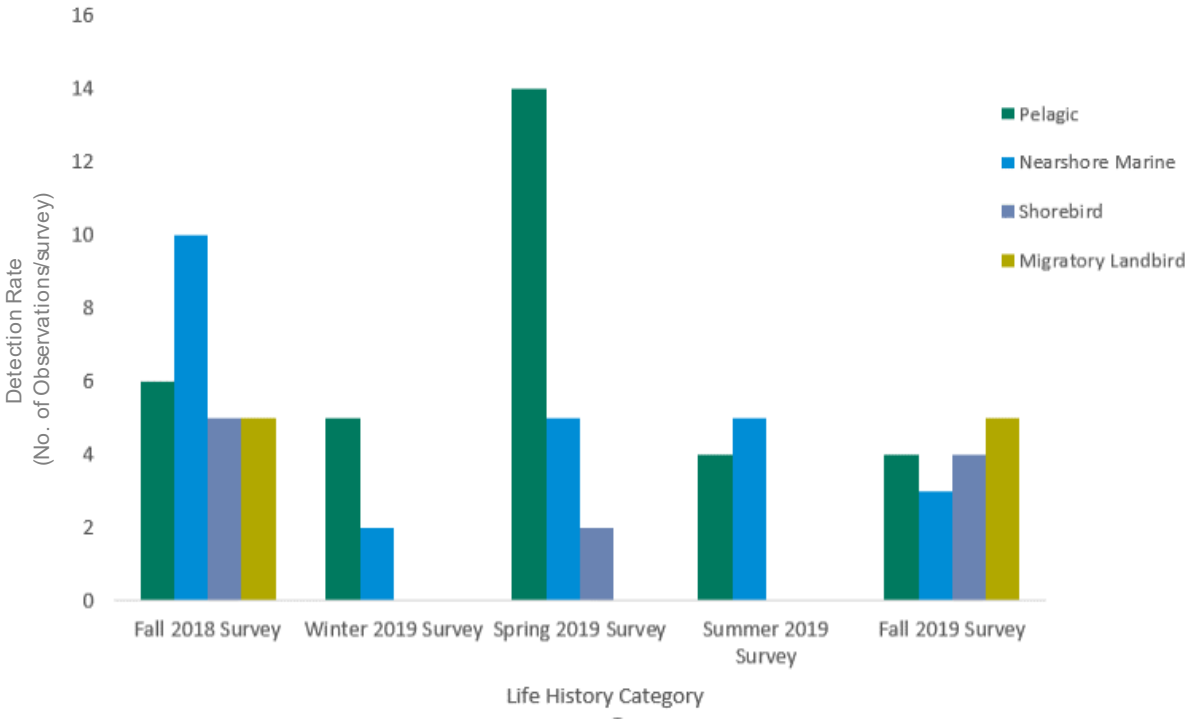


Figure 3-1: Life History Category of Birds Observed, Marine Bird Study Year 2

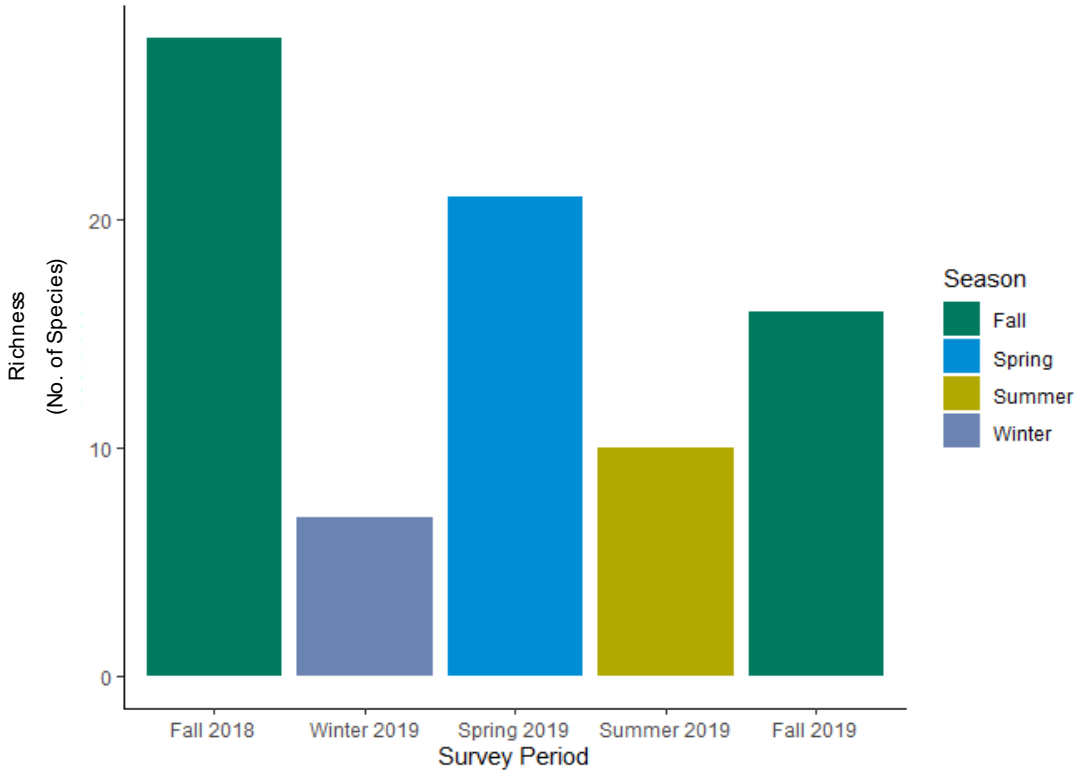


Figure 3-2: Bird Species Richness by Survey Period, Marine Bird Study Year 2

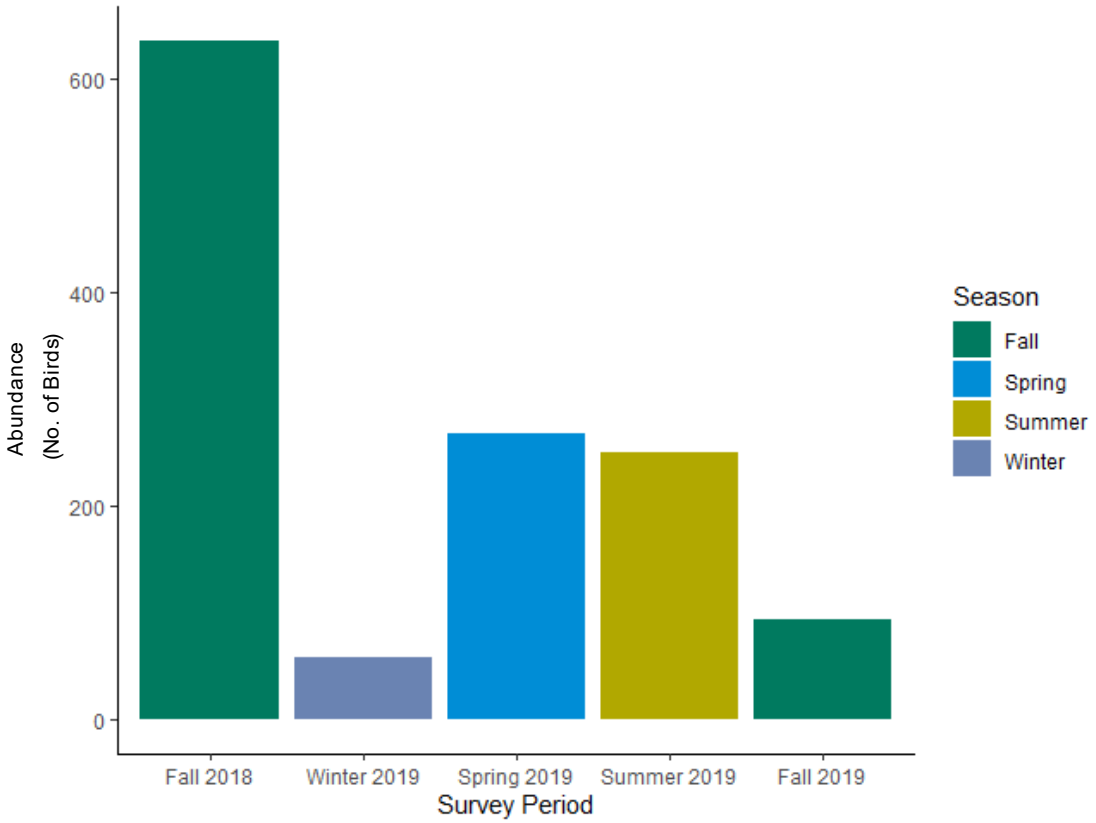


Figure 3-3: Bird Abundance by Survey Period, Marine Bird Study Year 2

4. OVERVIEW OF ALL EEPGL-COMMISSIONED MARINE BIRD SURVEYS CONDUCTED TO DATE 2017–2019

The 11 EEPGL-commissioned marine bird survey events conducted to date yielded a total of 2,169 bird observations representing 73 bird species within the Stabroek Block and the area between Georgetown and the Stabroek Block. Excluding birds observed within 3.1 miles (5 kilometers) from shore, the surveys yielded 1,610 bird observations of 52 species offshore Guyana (Table 4-1). Fewer than half of the species observed during the surveys are classified as pelagic species[3] (19 of 52 species). The other species are migratory shorebirds (19 species) or landbirds (8 species) that fly over the Caribbean during seasonal (spring and fall) migrations, nearshore marine birds undertaking regional (short-distance) movements between breeding and non-breeding areas (13 species), coastal birds on long-distance offshore foraging trips (1 species), and non-migratory landbirds that were offshore for unknown reasons (1 species).

[3] Includes species that spend their lives at sea except when breeding.

Table 4-1: Summary of Bird Abundance, Species Richness, and Detection Rate for EEPGL-Commissioned Marine Bird Surveys Conducted within the Stabroek Block and between the Stabroek Block and Georgetown, Guyana (2017–2019) [a]

Survey Name	Survey Date	Mobile or Stationary Survey Vessel	Survey Hours	Bird Abundance	Bird Species Richness	Detection Rate (# observations/ survey hour)
YEAR 1 MARINE BIRD STUDY						
Fall 2017 Survey	30 September 2017–7 October 2017	Mobile	46	231	19	5.02
Spring 2018 Survey		Mobile	113	69	14	0.61
Survey 1a	9 April 2018–15 April 2018	Mobile	60.2	29	10	0.48
Survey 1b	9 April 2018–16 April 2018	Mobile	52.8	40	7	0.76
YEAR 2 MARINE BIRD STUDY						
Fall 2018 Survey		Mobile and Stationary	232.8	637	28	2.74
Survey 1a	15 September 2018–25 September 2018	Mobile	49.5	206	20	4.16
Survey 1b	1 October 2018–6 October 2018	Mobile	23.5	314	13	13.36[b]
Survey 1c	17 September 2018–1 October 2018	Stationary	159.8	117	12	0.73
Winter 2019 Survey	28 January 2019–4 February 2019	Stationary	36.5	58	7	1.59
Spring 2019 Survey		Mobile	81.2	269	21	3.31
Survey 1a	18 April 2019–23 April 2019	Mobile	52	224	18	4.31
Survey 1b	20 April 2019–26 April 2019	Mobile	29.2	45	8	1.54
Summer 2019 Survey	27 June 2019–17 July 2019	Mobile	139.5	251	10	1.80[b]
Fall 2019 Survey	17 September 2019–3 October 2019	Stationary	100.5	95	17	0.94
All Surveys Combined	--	--	749.5	1,610	52	2.15

[a] Excludes birds observed within 3.1 miles (5 kilometers) from shore.

[b] Fall 2018 Survey 1b and Summer 2019 Survey detection rates are skewed by large flocks of Common Tern (n= 190) and Magnificent Frigatebird (n = 107) respectively. Corrected detection rates are 1.92 for fall 2018 (5.27 for Survey 1b), and 1.0 for summer 2019.

Bird abundance and species richness varied across the survey periods and between the Year 1 and Year 2 studies (Table 4-1 and Figures 4-1 through 4-3). Fall 2018, the first survey period of Year 2, had the highest abundance and richness of any survey period, and the third-highest detection rate when survey effort was considered. The fall 2018 surveys recorded many migratory coastal and landbird species, documenting use of the area by latitudinal migrants. Neither of the Year 1 surveys (fall 2017 and spring 2018) had particularly high abundance (Figure 4-1), but all spring and fall surveys across years had higher species richness than the winter and summer surveys (Figure 4-2), due to the presence of migratory species in spring and fall. Winter 2019 had the lowest bird abundance and species richness,

but also had among the lowest number of survey hours; hence when detection rate is considered, the number of observations was within the range of detection rates for other EEPGL-commissioned marine bird surveys (Figure 4-3). Detection rate varied greatly between survey periods, likely linked to random variation in presence and detectability of birds rather than season or year (Figure 4-3).

The differences seen across survey periods in both the Year 1 and Year 2 studies are typical of seasonal patterns—with higher richness and abundance during migration periods—as well as some random variation between periods. The following are key seasonal differences:

- Fall surveys in both years had a preponderance of migratory swallow and migratory shorebird species (e.g., sandpipers, plovers, etc.).
- A substantial portion of the pelagic birds sighted during the spring surveys in both years was Leach's Storm-Petrel.
- Winter and summer surveys had lower abundance[4], and the species assemblage was heavily dominated by pelagic and nearshore marine species.

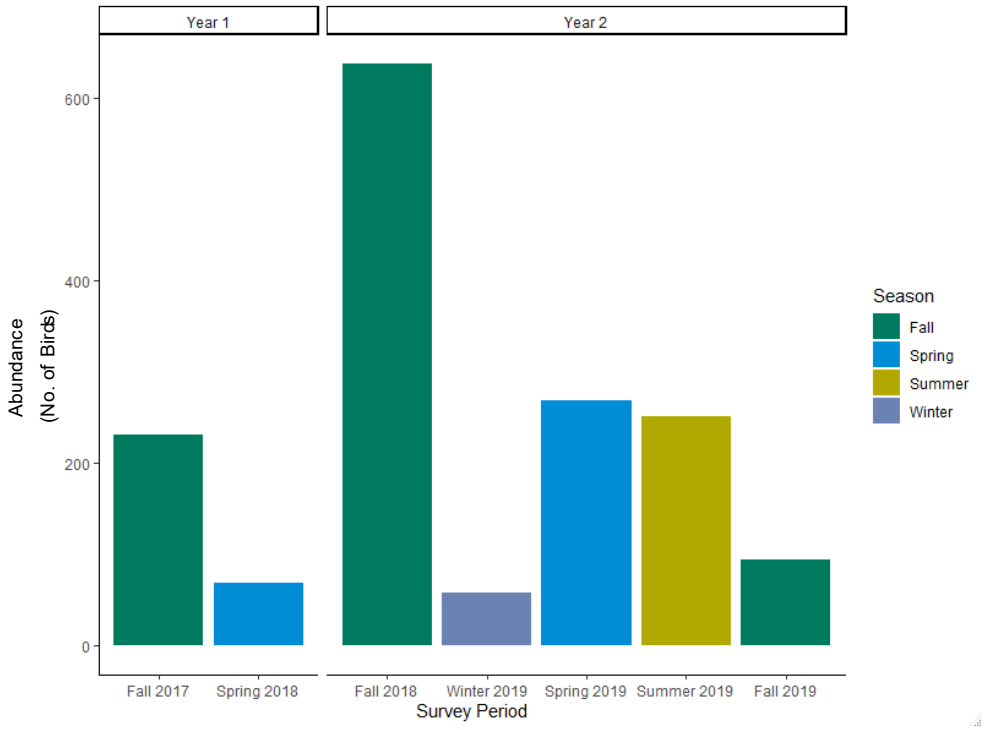


Figure 4-1: Bird Abundance across Survey Periods and Years of the Marine Bird Study

[4] Overall bird abundance recorded for the Summer 2019 Survey depicted in Figure 4-1 was skewed high due to the presence of one large flock of Magnificent Frigatebirds.

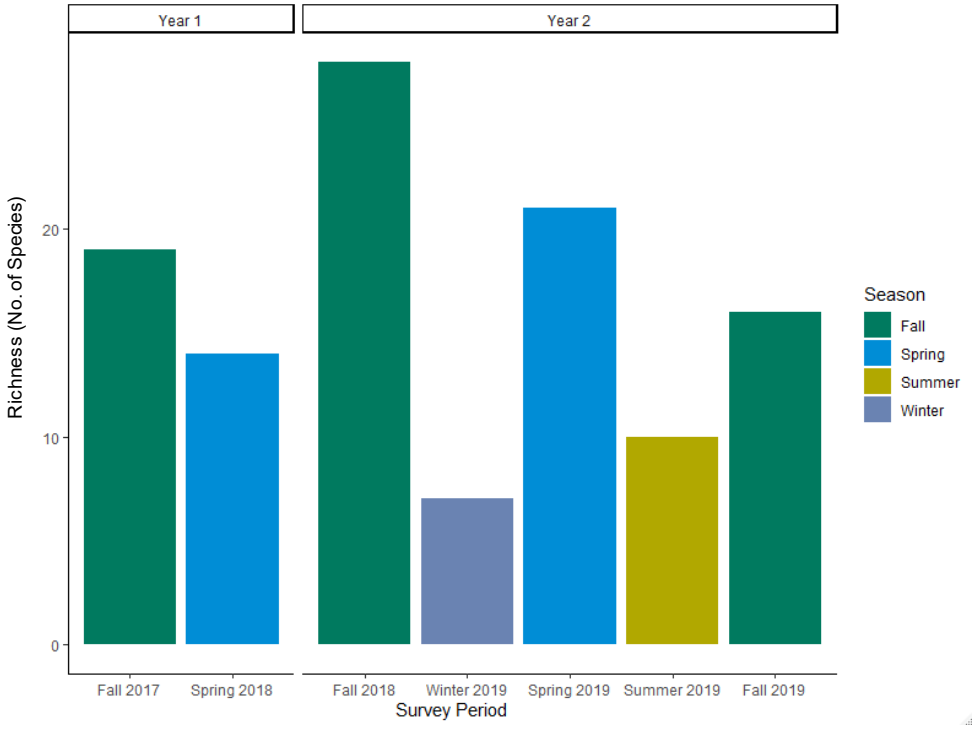


Figure 4-2: Bird Species Richness across Survey Periods and Years of the Marine Bird Study

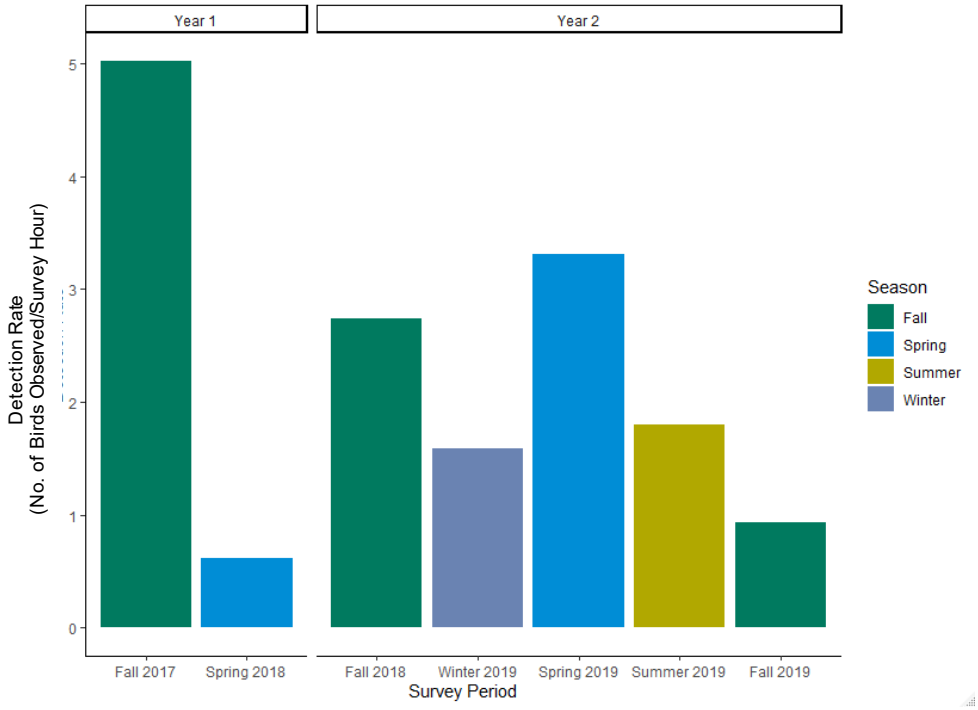


Figure 4-3: Detection Rate across Survey Periods and Years of the Marine Bird Study

5. CONCLUSIONS

The results of the EEPGL-commissioned marine bird surveys conducted to date make clear that the Guyana offshore avifauna changes substantially and consistently across a broad geographic area over the course of the year. The data indicate that the seasonal differences in bird community composition are driven by the occurrence in fall and spring of migratory species that breed at northern latitudes in late spring and summer and move offshore and to South America during the winter months.

Overall, the following points can be drawn from the EEPGL-commissioned marine bird surveys conducted to date:

1. A wide complement of seabirds (including 19 pelagic and 13 nearshore marine species), including two species of global conservation importance (Leach's Storm-Petrel and Black-capped Petrel [*Pterodroma hasitata*][5]), occur in the Stabroek Block and surrounding waters.
2. Spring and fall surveys in both years recorded numerous species of migratory shorebirds and landbirds from North America, confirming that at least some individuals of these species arrive in Guyana over water rather than by following the continental coastline.
3. Seasonal, latitudinal migration of seabirds, shorebirds, and landbirds occurs in the Stabroek Block and surrounding waters.
4. Seabird abundance is generally low far offshore but increases with proximity to shoreline, and many seabirds - such as terns and gulls - specialize in the nearshore environment instead of far offshore.
5. Bird observations recorded within and near the Stabroek Block were largely of lone individuals, which is generally characteristic of seabirds when far offshore.
6. Many of the species observed during the Spring 2018 Survey and Spring 2019 Survey were northern breeders that had not yet departed for the breeding grounds (or were passing through, e.g., Arctic Tern), suggesting that Guyana's offshore marine ecosystem may be an important staging area[6] for seabirds breeding in both the northern hemisphere.
7. During both the Spring 2018 Survey and Spring 2019 Survey, the bird species composition documented within and near the Stabroek Block was dominated by storm-petrels of at least two species—Wilson's Storm-Petrel, an abundant seabird breeding in the far southern Atlantic, and Leach's Storm-Petrel, which breeds in New England and maritime Canada and is listed as Vulnerable by the International Union for Conservation of Nature. Neither of these species was observed during the Fall 2018 Survey or the Fall 2017 Survey, indicating that their use of offshore Guyana waters is strictly seasonal (spring). The presence of these birds in substantial numbers during the spring surveys of both years (2018 and 2019) highlights the importance of this area as a regular migration waypoint for these species from both northern and southern hemispheres.

Prior to the EEPGL-commissioned surveys, there was little understanding of the populations of seabirds and other birds (migrating and vagrant birds) in the Guyanese waters of the southern Caribbean. The two years of EEPGL-commissioned bird surveys constitute a notable increase in the knowledge of Guyana's offshore bird communities, as is confirmed by the documentation of seasonal migrations in the Stabroek Block by a wide range of bird species and seven new species records for Guyana generated during the surveys.

[5] Black-capped Petrel was not observed during EEPGL-commissioned marine bird surveys but rather recorded by Protected Species Observers while conducting other work in the Stabroek Block during the time period from 2015 to 2019. Discussions with species experts indicate that the species likely occurs as a rare transient offshore Guyana.

[6] Staging areas are areas along bird migration corridors that are consistently used by migrating birds for foraging and resting.

6. RECOMMENDED NEXT STEPS

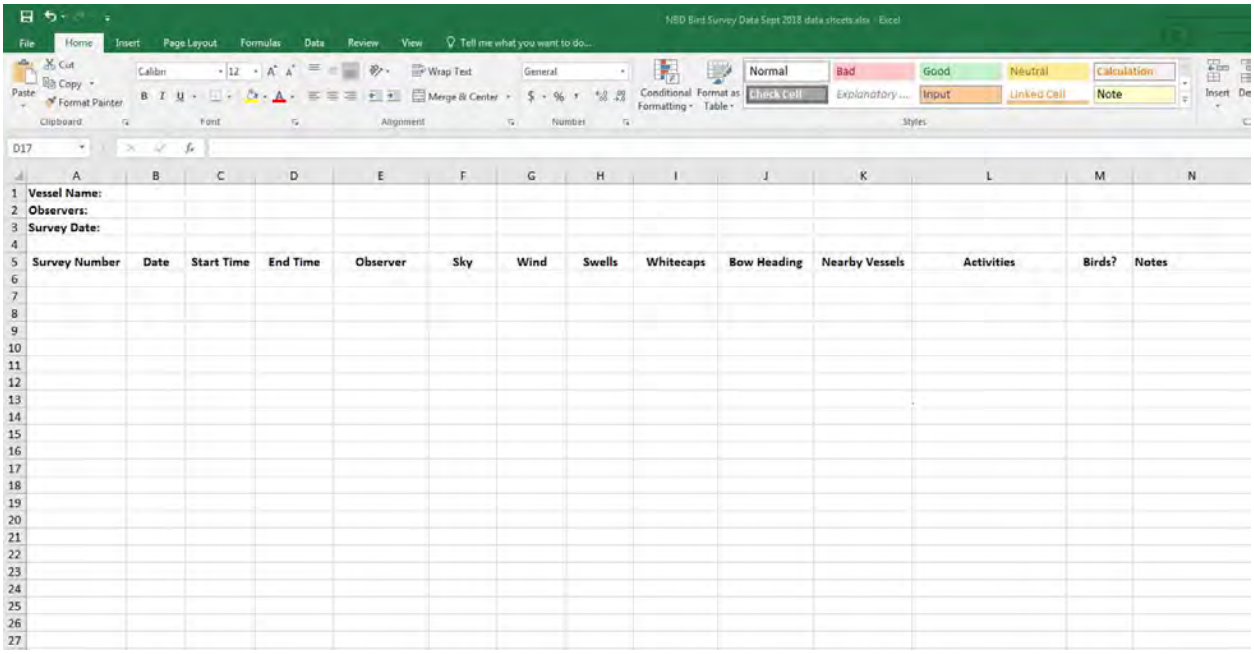
The two years of EEPGL-commissioned offshore marine bird survey data collected to date constitute a notable increase in the knowledge of Guyana's offshore bird community. The data clearly demonstrate a highly dynamic community within and around the Stabroek Block that changes substantially with seasons and across years. Understanding these patterns is important for impact assessment and emergency response planning as well as conservation and management. ERM recommends continuing the EEPGL marine bird survey program and expanding its geographic scope into other blocks to further establish the marine bird baseline in the region for use as a basis for future impact assessment and monitoring.

Continuing the survey program would yield important information on the variability in seasonal and annual patterns of bird abundance and species composition; potentially document the presence of presumed present but yet-to-be-confirmed species, including the Endangered Black-capped Petrel (reported only during Protected Species Observer surveys with no photographic documentation); determine if there are spatial patterns in marine bird use offshore Guyana; and likely confirm the presence of additional species, particularly during migration. The information gathered during additional surveys would further strengthen the marine bird baseline and document the degree of variability in offshore marine bird use, which is particularly important in light of a rapidly changing regional and global environment.

Should the survey continue, ERM recommends several changes to the marine bird survey protocol to maximize the data collection potential of the effort: (1) add a pre-dawn and dusk check of specific vessel areas that are accessible per vessel rules and that are potentially suitable for bird use or are known by the vessel crew to be used by birds - to allow for quantification of bird use of survey vessels; and (2) use a simple and inexpensive passive radar system that could be placed on stationary offshore features (e.g., drill ships) to record the height and density of day- and night-migrating birds passing over the vessels. This would help document the prime migratory periods during fall and spring and the flight orientation and passage rates for diurnal and nocturnal migrating birds through the region, which is a major scientific data gap that has implications for emergency response planning as well as coastal management, as many of the migratory birds passing through offshore Guyana are shorebirds that use the Guyana coastline as wintering sites or migratory stopover points. The presence of EEPGL's stationary features offshore Guyana, on which these types of radar devices could be installed, presents an excellent opportunity to passively and very cost effectively collect data on migratory birds; this would augment EEPGL's ongoing marine and coastal bird survey programs and potentially provide key information for a future government-led coastal bird monitoring program should one be developed.

To drive local capacity building, we recommend the continued training of local specialists Meshach Pierre and Leon Moore in all aspects of the survey program (survey planning, health and safety planning, survey, data quality control and management, and reporting) and training of at least one additional Guyanese specialist in the marine bird protocol.

APPENDIX A ELECTRONIC DATA ENTRY TEMPLATE FOR THE MARINE BIRD SURVEY



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Vessel Name:**													
2	**Observers:**													
3	**Survey Date:**													
4														
5	**Survey Number**	**Date**	**Start Time**	**End Time**	**Observer**	**Sky**	**Wind**	**Swells**	**Whitecaps**	**Bow Heading**	**Nearby Vessels**	**Activities**	**Birds?**	**Notes**
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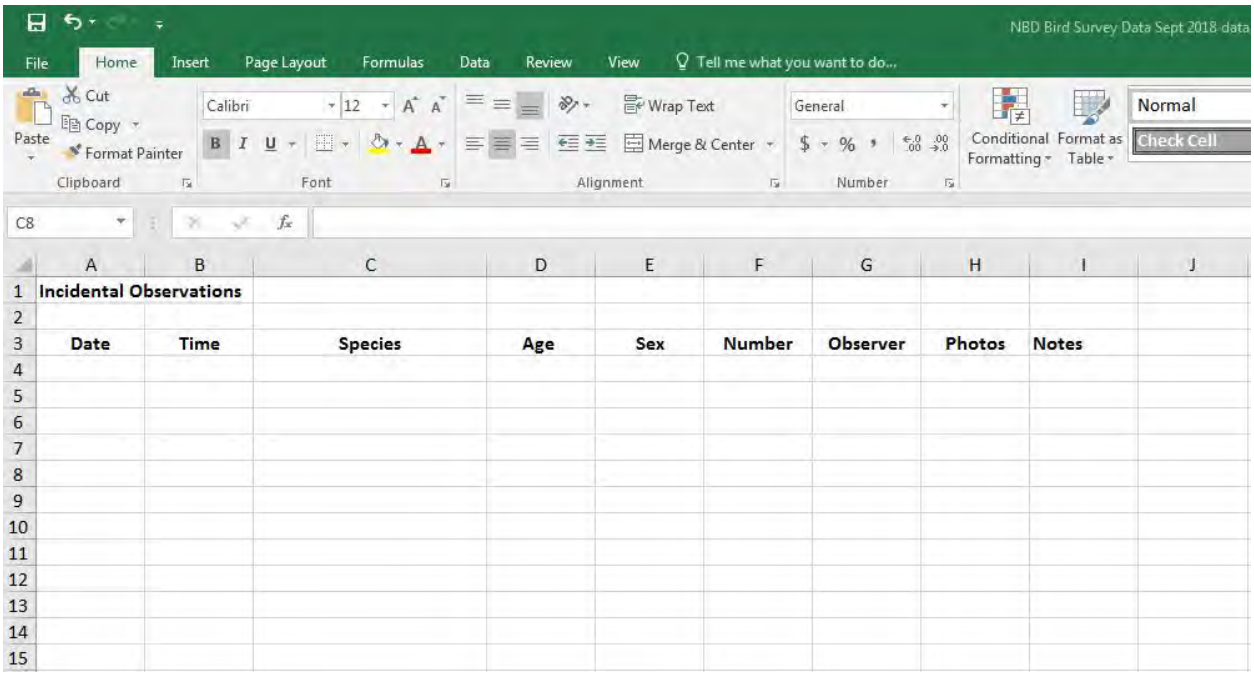

	A	B	C	D	E	F	G	H	I	J
1	**Incidental Observations**									
2										
3	**Date**	**Time**	**Species**	**Age**	**Sex**	**Number**	**Observer**	**Photos**	**Notes**	
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5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

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3	Bird surveyors Garey Sway and Jeffrey McCrary aboard the transfer vessel traveling between the *Thor Magni* and the *Delta Monarch*
4	Bird Surveyor Leon Moore
5	Bird Surveyor Meshach Plerre
6	Bird Surveyor Brian O'Shea
7	Audubon's Shearwater *(Puffinus lherminieri)*
8	Cory's Shearwater *(Calonectris borealis)*—breeding adult
9	Manx Shearwater *(Puffinus puffinus)*
10	Great Shearwater *(Ardenna gravis)*
11	Bulwer's Petrel *(Bulweria bulweri)*
12	Arctic Tern *(Sterna paradisea)*
13	Arctic Tern
14	Cayenne Tern *(Thalasseus eurygnatha)*
15	Common Tern *(Sterna hirundo)*
16	Bridled Tern *(Onychoprion anaethetus)*
17	Royal Tern (*Thalasseus maximus)*
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Photo No.	Photo Caption
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Photo 1: Bird Surveyor Jeffrey McCrary

Photo 2: Bird Surveyor Garey Sway

Photo 3: Bird surveyors Garey Sway and Jeffrey McCrary aboard the transfer vessel traveling between the *Thor Magni* and the *Delta Monarch*

Photo 4: Bird Surveyor Leon Moore

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Photo 7: Audubon's Shearwater (*Puffinus lherminieri*)

Photo 8: Cory's Shearwater (*Calonectris borealis*)

Photo 9: Manx Shearwater (*Puffinus puffinus*)

Photo 10: Great Shearwater (*Ardenna gravis*)

Photo 11: Bulwer's Petrel (*Bulweria bulweri*)

Photo 12: Arctic Tern (*Sterna paradisea*)

Photo 13: Arctic Tern

Photo 14: Cayenne Tern (*Thalasseus eurygnatha*)

Photo 15: Common Tern (*Sterna hirundo*)

Photo 16: Bridled Tern (*Onychoprion anaethetus*)

Photo 17: Royal Tern (*Thalasseus maximus*)

Photo 18: Sooty Tern (*Onychoprion fuscatus*)

Photo 19: Leach's Storm-Petrel (*Oceanodroma leucorhoa*)

Photo 20: Leach's Storm-Petrel

Photo 21: Wilson's Storm-Petrel (*Oceanites oceanicus*)

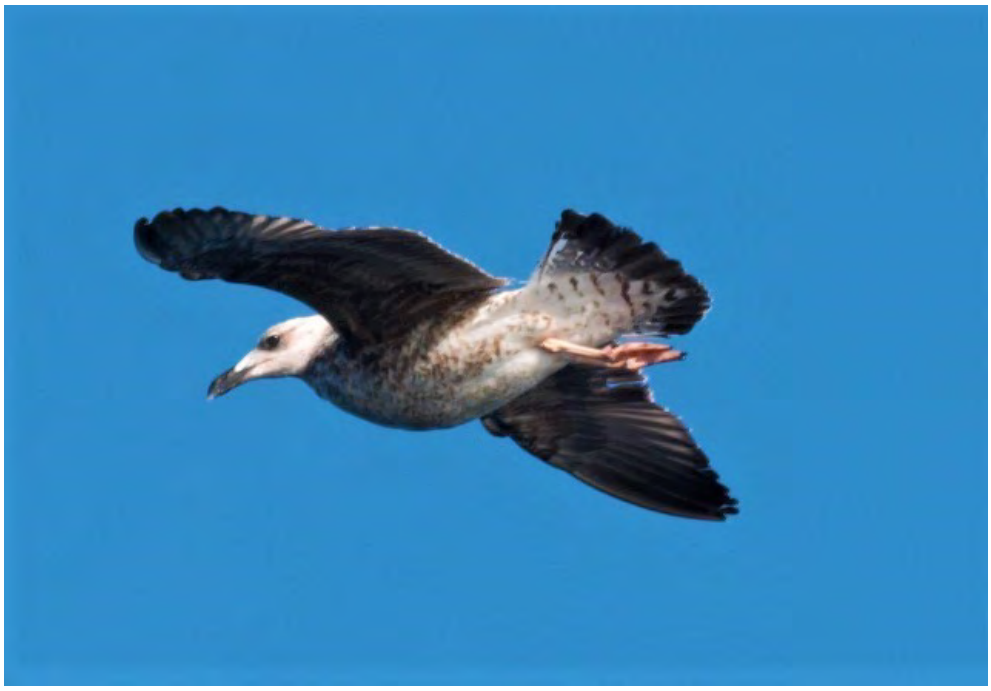

Photo 22: Great Black-backed Gull (*Larus marinus*) in immature plumage

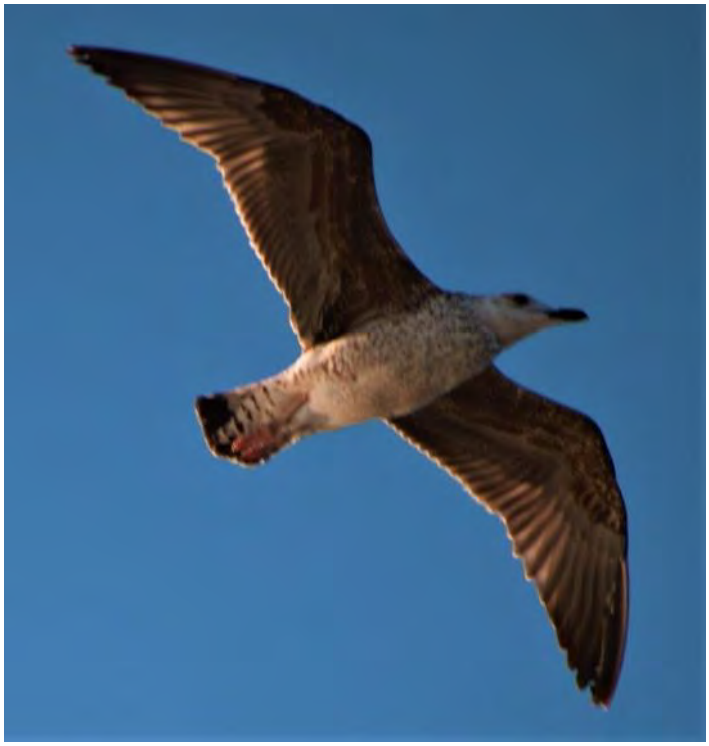

Photo 23: Great Black-backed Gull in immature plumage

Photo 24: Brown Booby (*Sula leucogaster*)

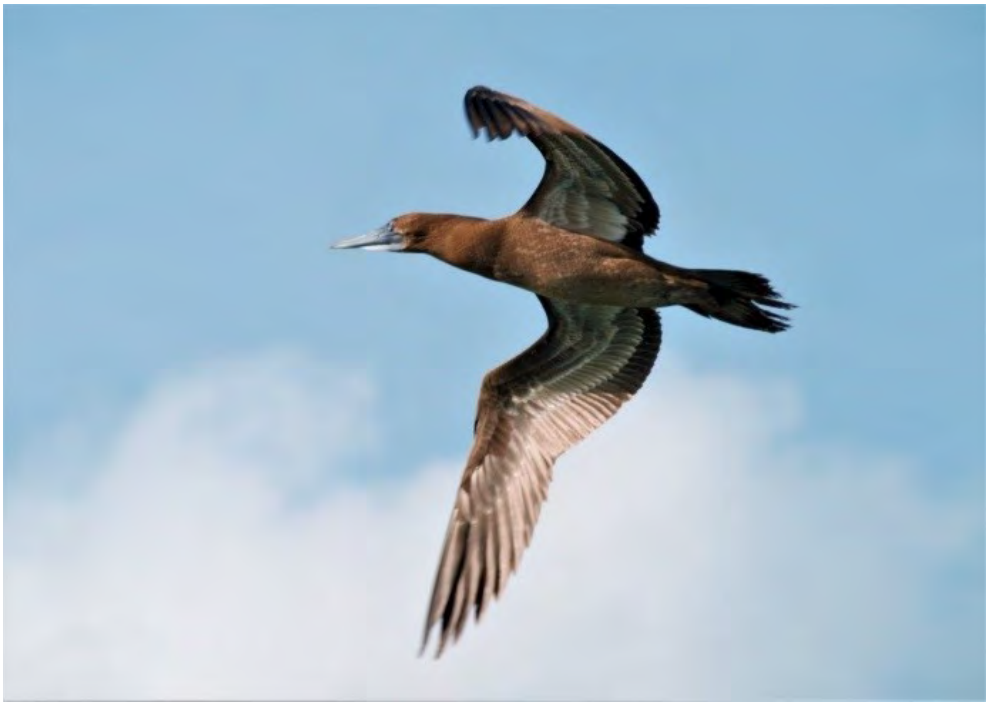

Photo 25: Brown Booby

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Photo 41: Ruddy Turnstone (*Arenaria interpres*)

Photo 42: Ruddy Turnstone

Photo 43: Pomarine Jaeger (*Stercorarius pomarinus*)

Photo 44: Pomarine Jaeger

Photo 45: Parasitic Jaeger (*Stercorarius parasiticus*)

Photo 46: Parasitic Jaeger

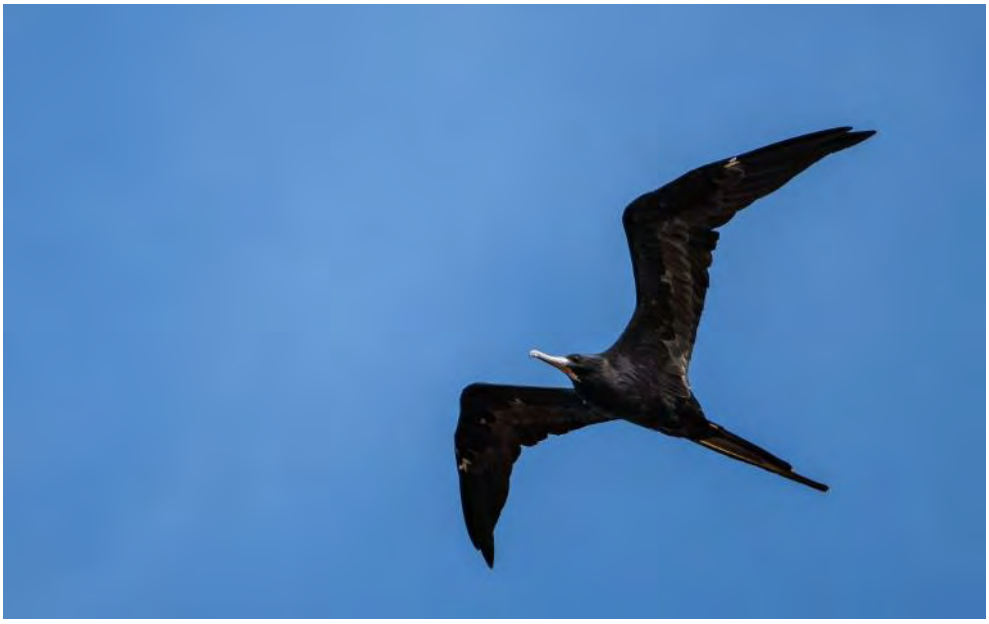

Photo 47: Magnificent Frigatebird—adult male

Photo 48: Magnificent Frigatebird—adult female

Photo 49: Magnificent Frigatebird in immature plumage

Photo 50: Magnificent Frigatebird in immature plumage with fish

Photo 51: Magnificent Frigatebird in immature plumage with fish and male Magnificent Frigatebird in young adult plumage in pursuit

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Photo 68: Yellow Warbler (*Setophaga petechia*) aboard a survey vessel

Photo 69: Black-whiskered Vireo (*Vireo altiloquus*) aboard a survey vessel

Photo 70: Yellow-billed Cuckoo (*Coccyzus americanus*)

APPENDIX L

Coastal Bird Survey Report: Coastal Bird Study 2017–2020

Resubmitted without changes

March 2022

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Coastal Bird Survey Report

Coastal Bird Study 2017-2020

Esso Exploration and Production Guyana Limited

December 2020

Project No.: 0486459

The business of sustainability

ERM

December 2020

Coastal Bird Survey Report

Coastal Bird Study 2017-2020

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Acronyms and Abbreviations

Name	Description
EEPGL	Esso Exploration and Production Guyana Limited
ERM	Environmental Resources Management
IBA	Important Bird Area
IBH	Important Bird Habitat
IUCN	International Union for Conservation of Nature
NT	Near Threatened
SBPA	Shell Beach Protected Area
VU	Vulnerable

1. INTRODUCTION

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), Environmental Resources Management (ERM) conducted eight seasonal coastal bird surveys, collectively referred to herein as the Coastal Bird Study, along the coastline of Guyana in Regions 2 through 6[1] between September 2017 and February 2020. The Coastal Bird Study was an elective study commissioned by EEPGL and was not conducted pursuant to any regulatory requirement. The objectives of the Coastal Bird Study were to document the distribution, abundance, and diversity of coastal birds along Guyana's coastline during different seasons and years. This report summarizes and compares the results of the eight surveys conducted for the Coastal Bird Study.

2. BACKGROUND

The bird community along Guyana's coastline is abundant and diverse, with 208 recorded species within 21 families representing multiple bird groups including but not limited to coastal birds such as parrots and macaws, passerines, waterfowl, colonial waterbirds, shorebirds, and raptors. The bird groups that are most strongly affiliated with the coast (collectively referred to as coastal birds in this report) are waterfowl, shorebirds, and colonial waterbirds.[2] Guyana's coastal bird community is better known than the marine bird community and that of the forested interior portions of the country, as coastal areas are easier to access than these environments. There is considerable public and scientific interest in coastal bird populations, and Guyana's coastal bird community contains many emblematic and charismatic species that support ecotourism. Nevertheless, no systematic, multi-year coastal bird survey of Guyana's coastline is known to have been conducted until this study.

Several other bird surveys along Guyana's coastline have been reported, but these surveys covered only a portion of the coastline (e.g., around Georgetown or within the Shell Beach Protected Area [SBPA]) and were short in duration (e.g., conducted during one or two seasons during the same year). Braun et al. (2007) developed a comprehensive checklist of the 814 bird species within 11 habitats documented in Guyana, including coastal habitats (mangrove forests had 47 coastal bird species documented, and mudflats had 38 coastal bird species documented; Braun et al. 2007). Another coastal bird survey conducted along the coast in the Georgetown region by Bayney and Da Silva (2005) documented 32 coastal bird species. A more recent bird survey within coastal mangrove habitats in southeast Guyana identified 37 coastal bird species (Da Silva 2014). Lastly, two biodiversity surveys undertaken within SBPA over roughly the past decade documented over 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats of Shell Beach (Mendonca et al. 2006; EPA et al. 2004). Collectively, species accounts from all these reports document the presence of 95 species of coastal birds from 32 families in Guyana.

[1] During the Spring 2018 survey, an opportunistic survey of a portion of the Region 1 coastline was conducted in coordination with other activities in the region. The survey covered only a small portion of the Region 1 shoreline outside of the Shell Beach Protected Area.

[2] Waterfowl are species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese). Shorebirds are found mainly on beaches and mudflats between the low and high water marks and are typically migratory, utilizing Guyana's coastline during the course of their bi-annual migrations. Colonial waterbirds are birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons).

3. SURVEY METHODS

The Coastal Bird Study consisted of eight seasonal surveys of coastal birds conducted between September 2017 and February 2020. Surveys were conducted by a team of Guyanese bird specialists in the following time periods.

- Winter 2020 Survey: Occurred 25 January to 5 February 2020 along the coastline in Regions 2 through 6 and the Essequibo Islands
- Fall 2019 Survey: Occurred 30 September to 10 October 2019 along the coastline in Regions 2 through 6 and the Essequibo Islands
- Summer 2019 Survey: Occurred 21 to 28 June 2019 along the coastline in Regions 2 through 6 and the Essequibo Islands
- Spring 2019 Survey: Occurred 27 March to 4 April 2019 along the coastline in Regions 2 through 6 and the Essequibo Islands
- Winter 2019 Survey: Occurred 22 January to 2 February 2019 along the coastline in Regions 2 through 6 and the Essequibo Islands
- Fall 2018 Survey: Occurred 14 to 15 September 2018 and 30 September to 3 October 2018 along the coastline in Regions 2 through 6 and the Essequibo Islands
- Spring 2018 Survey: Occurred 3 to 13 April 2018 and 16 to 24 April 2018 at coastal sites in Regions 1 through 6 and the Essequibo Islands
- Fall 2017 Survey: Occurred 23 to 27 September 2017 and 19 to 22 October 2017 at coastal sites in Regions 2 through 5 and the Essequibo Islands

In total, the Coastal Bird Study surveyed 112 sites (Table 3-1 and Appendix A). The number of sites surveyed during each of the eight survey events varied slightly based on the scope of the survey in a given year,[3] site accessibility, and refinements to the survey approach that were implemented to maximize survey efficiency and spatial coverage. Appendix A lists the coastal and island survey sites that were surveyed during the Coastal Bird Study, and includes a mapbook that depicts the locations of the sites. The coastal habitat types surveyed included mangrove (riverine and coastal), intertidal and tidal wetlands, mudflat, plantation (island surveys only), vegetated low bank, sand beach, and artificial coastal habitat types such as sea wall and jetty.

The coastal bird surveys were conducted using standardized point count methods tailored for coastal and island sites, as described below.

3.1 Coastal Point Count Surveys

Surveyors conducted 15-minute point count surveys at each of the survey sites. To the extent practicable, surveys were conducted in the morning hours between 06:00 a.m. and 10:00 a.m., when birds are most active. However, this was not always possible due to tidal stage and related site accessibility or other constraints.

At each survey site, observations were made within a radius of approximately 500 meters (0.3 mile) around the survey site. All birds seen and heard during the 15-minute surveys were recorded. Surveyors viewed birds with binoculars (10 x 40 or 10 x 50 magnification) and/or a spotting scope erected on a tripod (Bushnell 60x magnification). Survey site locations were electronically recorded using GPS, and the

[3] The scope of the surveys in 2017 only included Regions 2 through 5 and Region 1 was surveyed during only the Spring 2018 survey in conjunction with other work.

sites were photographed. Observers recorded data using an iPad equipped with the Survey 123 for ArcGIS application and a tailored electronic data collection form developed for the surveys by ERM (Appendix B). This electronic data collection system is compatible with ERM's EEPGL Project Geographic Information System platform.

The following information was collected during each point count survey:

- Survey location (latitude and longitude)
- Date
- Observation type (incidental, transect survey, point count survey)
- Start/stop time of survey
- Brief site/habitat description and site identification
- Weather (percent cloud cover, precipitation, wind speed, wind direction, temperature)
- For each species seen or heard:
    - Species identification (or lowest taxonomic level identifiable)
    - Number of individuals (if in a group)

3.2 Island Point Count Surveys

Surveys of the Region 3 island sites (Essequibo Islands) were conducted via boat. These sites were surveyed from the water using the same point count methodology as the land-based surveys described above.

Table 3-1: Number of Coastal Bird Sampling Sites by Region in the Coastal Bird Survey (2017–2020)

Region	Geographic Range of Survey Area	September/ October 2017	April 2018	September/ October 2018	January/ February 2019	March/ April 2019	June/July 2019	September/ October 2019	February/March 2020	Total [a]
1	Region 1 outside of SBPA	NS	18	NS	NS	NS	NS	NS	NS	18
2	Between the east bank of the Pomeroon River and the Supenaam River	5	6	6	6	6	7	7	7	7
3 (Coastal)	Coastal shoreline to Ruimzeight	3	3	7	7	7	7	7	7	7
3 (Essequibo Islands)	Tiger, Hog, Leguan, and Wakenaam Islands	32	50	52	51	27	27	27	27	52
4	Kingston Seaside to the Mahaica River mouth	20	20	16	16	16	12	12	12	20
5	Sans Souci to Woodley Park	6	6	6	6	6	6	6	6	6
6	Maida Seaside to Springlands	NS	5	5	5	8	8	8	8	8
Total		66	108	92	91	70	67	67	67	112

NS = not sampled

[a] Total unique sites surveyed from all surveys conducted between September 2017 and March 2020

4. COASTAL BIRD STUDY RESULTS

4.1 Species Assemblage

The 2017–2020 coastal bird surveys documented a total of 225 species and over 109,471 birds across all regions and survey sites. The 227 species include waterbirds (20 species), shorebirds (20 species), nearshore marine birds (13 species), migratory landbirds (12 species), and non-migratory landbirds (160 species). Coastal sites accounted for 211 species and island sites accounted for 145 species, with 130 species found at both coastal and island sites. All of the species documented during the 2017–2020 surveys have been previously recorded in Guyana, although many species (19) were newly documented in the coastal regions of the country. These new occurrences are likely due to the limited number of documented comprehensive surveys of coastal birds along the Guyana coast prior to these surveys. Of note is the Red Knot (*Calidris canutus;* International Union for Conservation of Nature [IUCN] Red List [IUCN 2020] Near Threatened), which was documented in both Fall 2018 and Winter 2019 surveys, and was thereby confirmed for the first time as overwintering in Guyana. In addition, some species previously known to occur along the Guyana coast, based on historical records, were not documented during this study; therefore, the coastal bird community likely has even higher bird species richness (number of species) than documented in this study. Appendix C contains the list of species documented during this study and denotes the regions where they were observed. Appendix D contains a photographic log of many of the species observed during this study.

The most common species observed during this study (inclusive of all surveys, more than 1,000 individuals each) included one species of nearshore marine bird, five species of waterbirds, three species of shorebirds, one species of migratory landbird, and two species of non-migratory landbirds, as follows:

- Nearshore Marine Bird
  - Black Skimmer (*Rynchops niger*)
- Waterbirds
  - Great Egret (*Ardea alba*)
  - Little Blue Heron (*Egretta caerulea*)
  - Scarlet Ibis (*Eudocimus ruber*)
  - Snowy Egret (*Egretta thula*)
  - Tricolored Heron (*Egretta tricolor*)
- Shorebirds
  - Lesser Yellowlegs (*Tringa flavipes*)
  - Semipalmated Plover (*Charadrius semipalmatus*)
  - Semipalmated Sandpiper (*Calidris pusilla*)
- Migratory Landbird
  - Barn Swallow (*Hirundo rustica*)
- Non-migratory Landbirds
  - Gray-breasted Martin (*Progne chalybea*)
  - Great Kiskadee (*Pitangus sulphuratus*)

Of particular note, Barn Swallow was a dominant species in all fall coastal bird surveys (2017, 2018, and 2019). This species also was a dominant species observed offshore Guyana during concurrent EEPGL-commissioned marine bird surveys in fall 2018 and fall 2019. The observance of large numbers of this species both offshore and onshore during the same time period in successive years is a strong indication of documentation of the fall migratory period for this species through Guyana, which was unknown prior to this survey.

4.2 Bird Abudance and Species Richness

4.2.1 Bird Abundance

Average bird abundance varied by season and region. The Summer 2019 survey recorded the lowest average abundance across all regions (Figure 4-1); this is likely due to the fact that many migrants are not present in Guyana during the summer months. There was moderate variation in average abundance across all regions during spring and fall surveys; surveys with higher abundance (e.g., Region 6 in Fall 2018; Figure 4-1) recorded large numbers of migrants, typically occurring in large groups. Outside the seasonal migration peaks, Region 5 had the highest average abundance across survey periods (Figure 4-1). Several sites in this region contain mudflats and coastal mangroves, which provide important foraging, roosting, and breeding habitat for many coastal birds in Guyana. In general, Region 3 had much lower average abundance (at both island and coastal sites) across all surveys than other regions. Despite having lower average abundance, data from these sites are particularly important to document the full range of coastal species present in Guyana. These Region 3 sites, particularly the Essequibo Islands sites, have unique riverine mangrove habitat that support species not recorded in any of the other regions.

One survey event of note is the September/October 2018 survey, which likely coincided with peak migration given the consistently high bird abundance across regions; Region 6 had over 2,000 birds per site during this survey, on average (Figure 4-1).

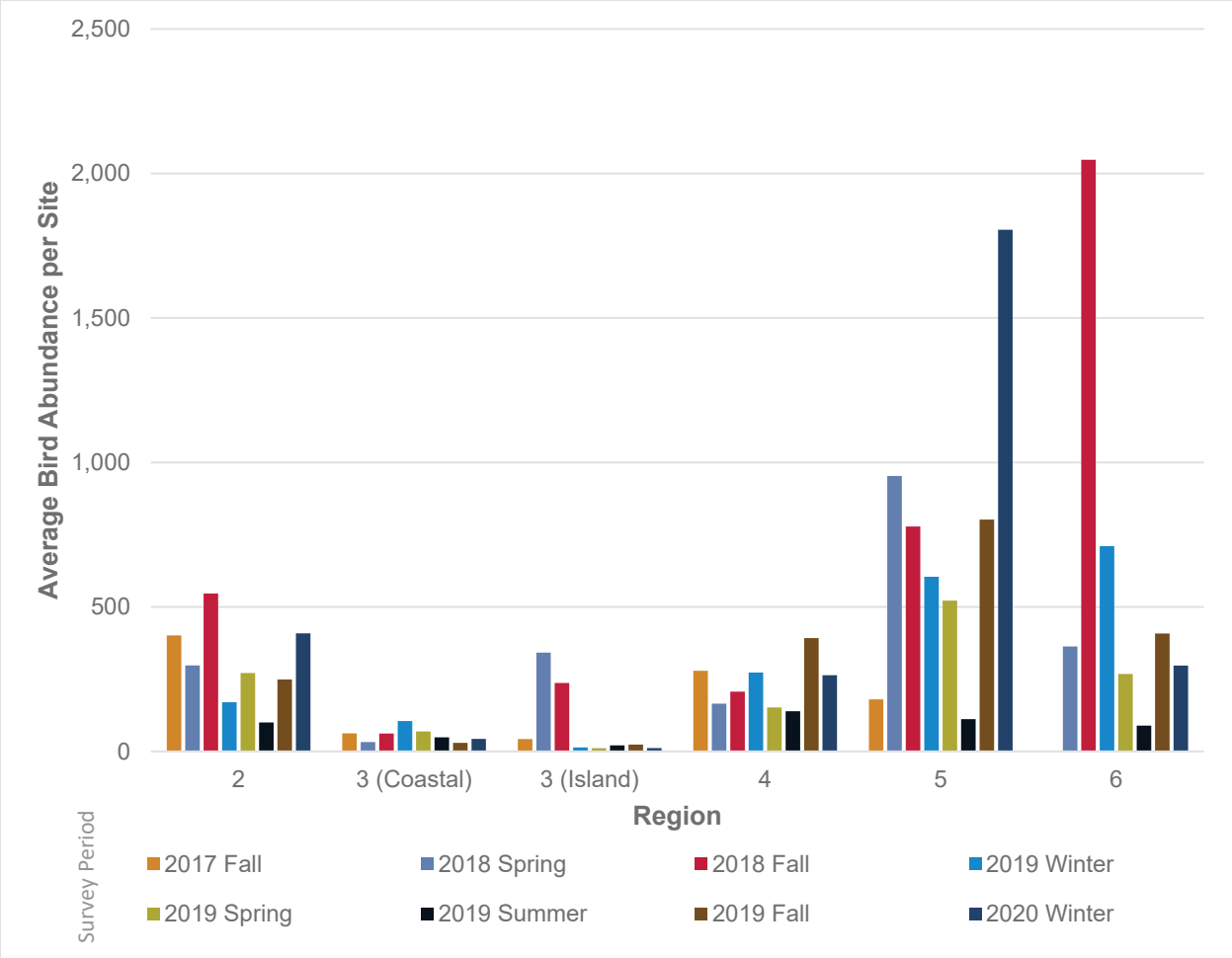


Figure does not include Region 1, which was surveyed in only Spring 2018.

Figure 4-1: Average Bird Abundance across Regions and Survey Periods 2017–2020

4.2.1.1 Bird Abundance by Life History Category

Species observed were grouped according to life history categories: Shorebirds (e.g., sandpipers), Waterbirds (e.g., egrets and herons), Nearshore Marine (e.g., gulls and terns), Non-migratory Landbirds (most species associated with inland habitats, including passerines and birds of prey), and Migratory Landbirds (e.g., some warblers). In terms of abundance, shorebirds and waterbirds were the most abundant species category across surveys, with few exceptions (Figure 4-2):

- The Summer 2019 survey had very few shorebirds.
- The Fall 2017 and Spring 2018 surveys had fewer shorebirds and higher numbers of non-migratory landbird species than other surveys.

The high numbers of birds (either waterbirds or shorebirds) observed in Spring and Fall 2018, Fall 2019, and Winter 2020 were related to large flocks of congregating birds being recorded.

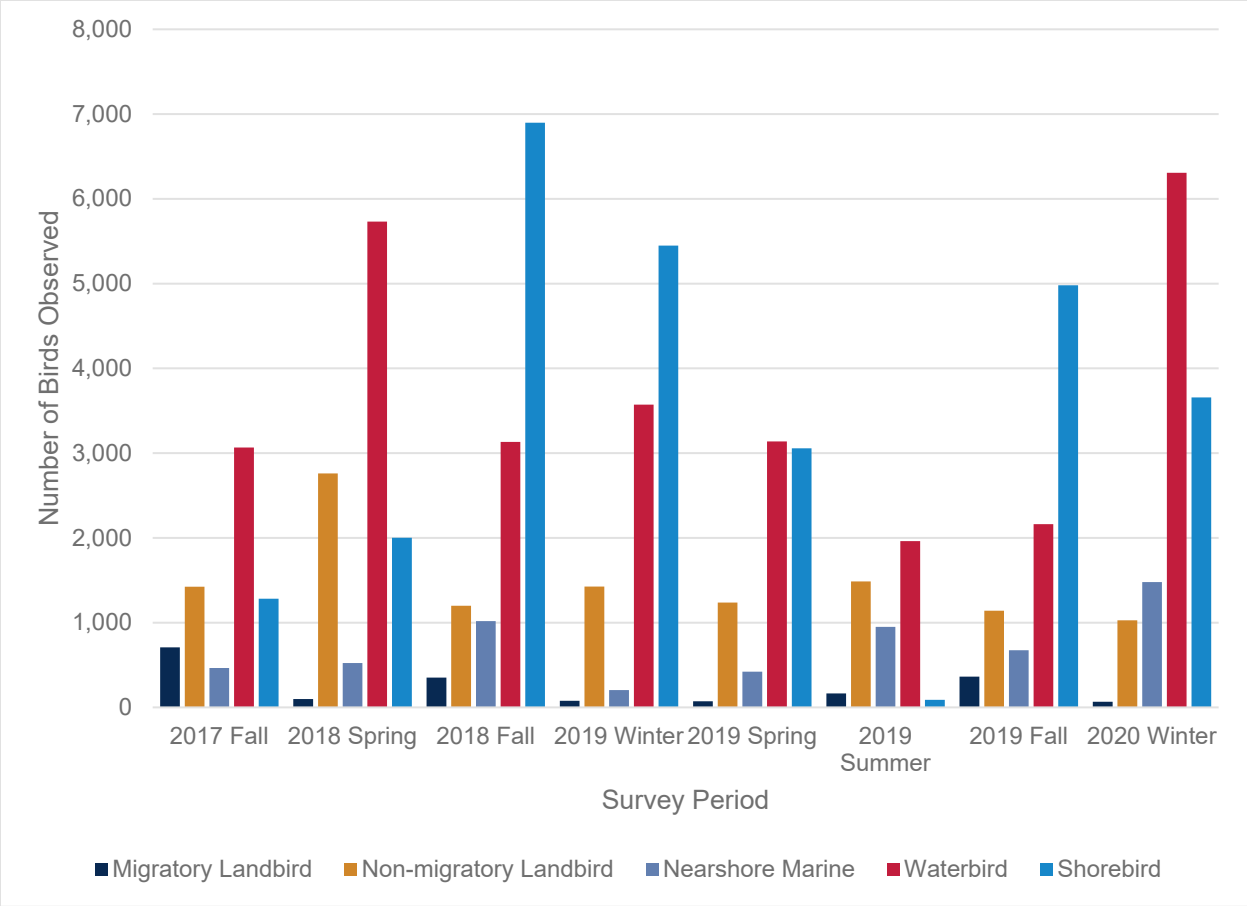


Figure does not include Region 1, which was surveyed during only the Spring 2018 survey.

Figure 4-2: Bird Abundance by Bird Category per Survey Period 2017–2020

4.2.2 Species Richness

Average species richness varied less than abundance across survey periods and regions. There were no clear seasonal patterns in species richness, with all coastal (i.e., non-island) surveys ranging between 11 and 21 species per site on average (Figure 4-3). Aside from two island surveys (Region 3), Region 5 generally had the highest species richness (Figure 4-3). Sites in this region contain extensive mudflat and mangrove habitats, which attract a diversity of species throughout the year. The Region 3 island sites typically had lower species richness than other regions, except during the Spring and Fall 2018 surveys, which recorded the two highest average species richness of the entire study (24 and 30 species per site, in Spring and Fall 2018, respectively; Figure 4-3). The lower species richness and abundance in this region is due to the number of sites surveyed along the entire coast on each island. There were typically around 50 island sites surveyed during each period, resulting in more sites with few or no birds at the time of survey, often as a byproduct of tide or other conditions. The high average species richness in Region 1 in Spring 2018 is likely due to the survey area covering a greater diversity of habitats, including more inland habitats than the other regions (i.e., riverine mangroves, wetlands, and riverine forests, which are not present in the coastal survey sites in Regions 2 through 6).

The island sites have different habitats than the coastal areas and, therefore, have unique bird species assemblages. Fifteen species were only documented at island sites during the entire survey. Many of the species unique to the island sites are inland species such as hawks, woodpeckers, and flycatchers.

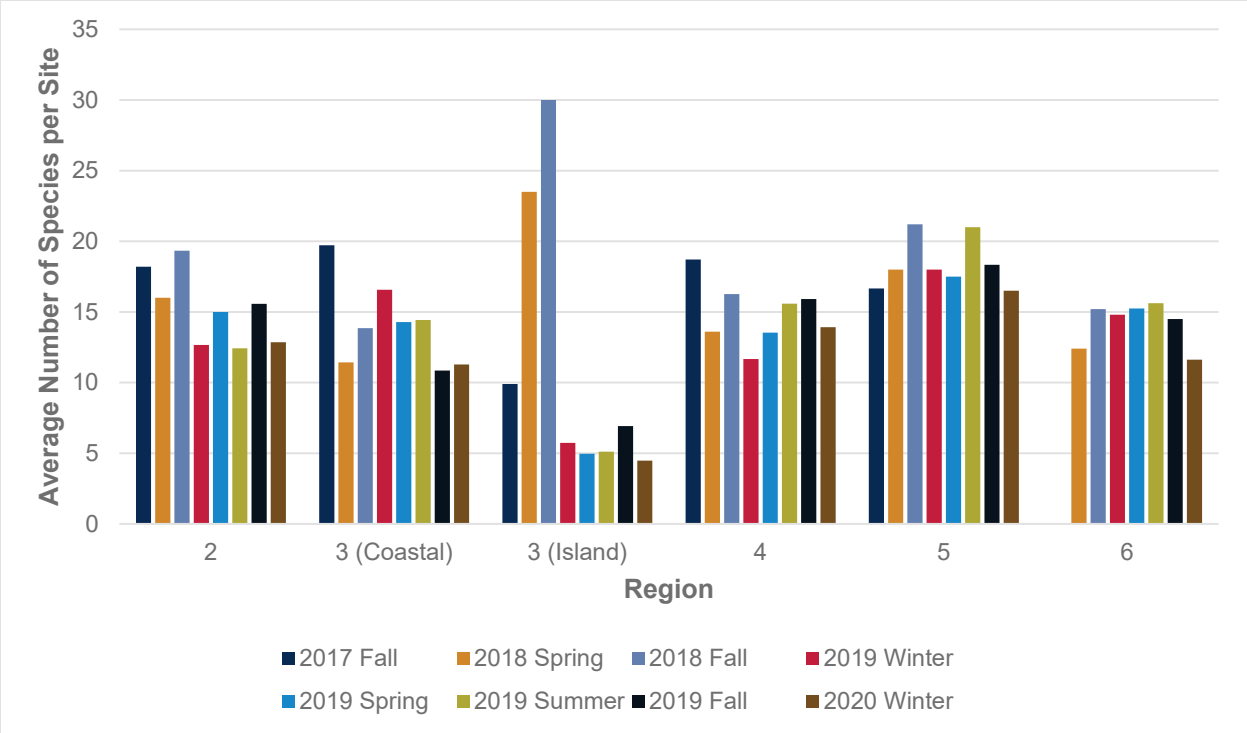


Figure does not include Region 1, which was surveyed in only Spring 2018.

Figure 4-3: Average Bird Species Richness across Regions and Survey Periods 2017–2020

4.2.2.1 Speces Richness by Life History Category

The non-migratory landbird category had by far the highest number of species observed across all surveys (Figure 4-4). This was expected because non-migratory landbirds (resident species) make up the vast majority of all bird species known to occur in Guyana. The migratory landbird category had the lowest number of species observed across all surveys. This is likely because most of the migratory landbirds that come to Guyana use inland (non-coastal) habitats or only occur as transients during migration.

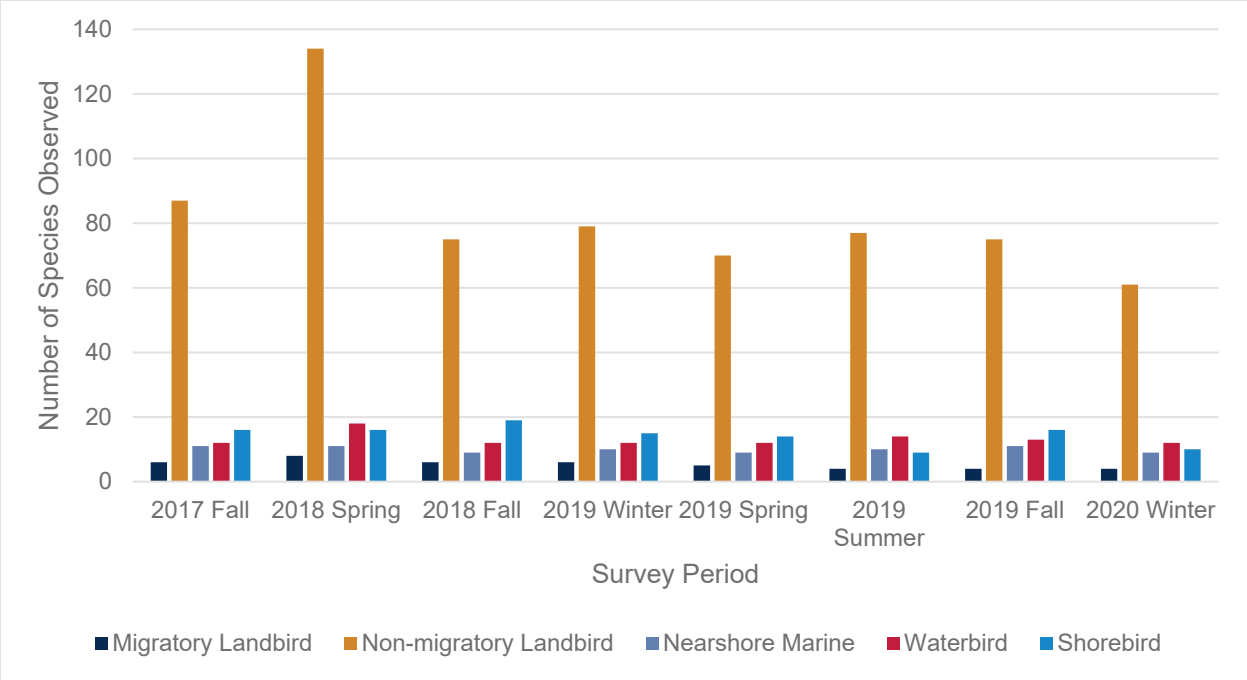


Figure does not include Region 1, which was surveyed in only Spring 2018.

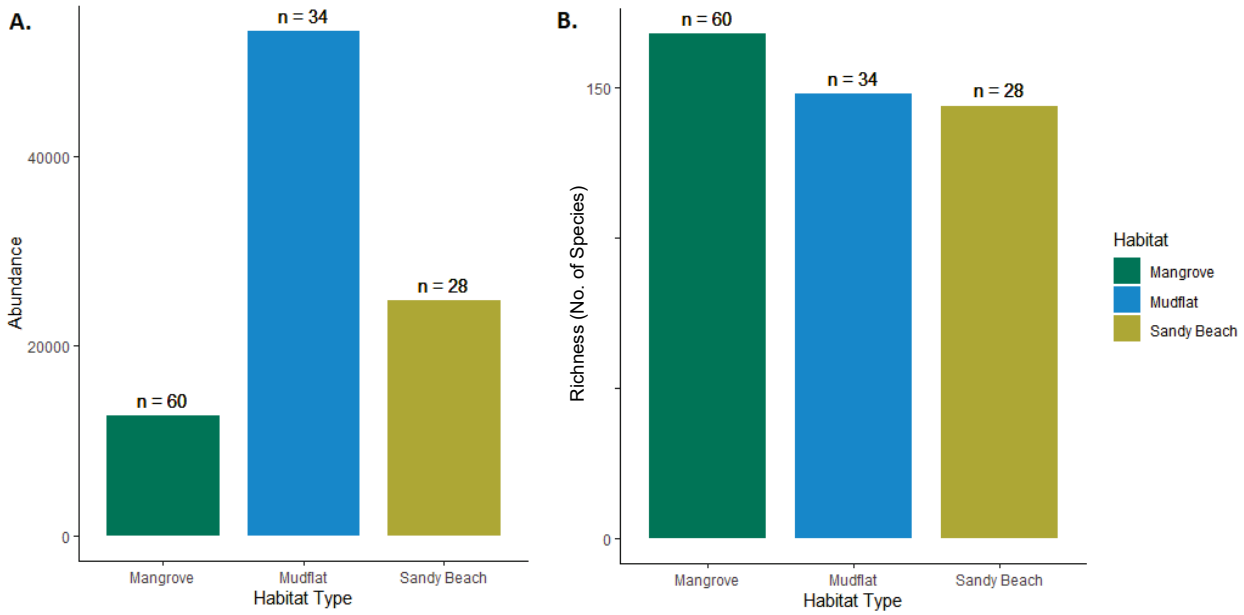
Figure 4-4: Bird Species Richness by Bird Category per Survey Period 2017–2020

4.3 Species-Habitat Associations

Habitat use documented during the surveys was similar across survey periods and years. However, several survey sites contain multiple habitat types, so abundance and richness estimates are not completely exclusive between habitats.

Overall, mudflats had the highest bird abundance (more than three times as many individuals per site as compared to mangrove habitats). Sites with mangrove habitat had the highest average richness (12 species per site), followed by mudflat and sandy beach habitats. These comparisons reflect the abundance of colonial (i.e., occurring in large groups or colonies) shorebirds at mudflat sites and the high diversity of species at mangrove sites (Figure 4-5).

The bird communities of the Essequibo Islands and the coast were quite different despite having significant overlap in species. Island sites were dominated by waterbirds and landbirds, and coastal sites were dominated by shorebirds, particularly during migration. The Essequibo Islands contain some unique habitat types not found along the coastline (agriculture, riverine mangrove), which support a different bird community year-round. Many of the species unique to the island sites are inland species such as hawks, woodpeckers, and flycatchers.



Number of sites with each habitat type is indicated above bars.

Figure 4-5: (A) Average Bird Abundance, and (B) Average Species Richness by Habitat Type, All Surveys 2017–2020

4.4 Conservation Status of Bird Species Documented during the Coastal Bird Study 2017–2020

Of the bird species documented during the Coastal Bird Study, most are currently listed on the IUCN Red List as Least Concern, which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation. Eight species documented during the study have elevated conservation status, classified as Vulnerable (VU) or Near Threatened (NT) per the IUCN Red List (Table 4-1).

In addition, three bird species of local conservation interest were recorded along the Guyana coast during this study. The Silvered Antbird (*Sclateria naevia*) was recorded in Fall 2017, Spring 2018, Winter/Summer/Fall 2019, and Winter 2020, while the Gray-headed Kite (*Leptodon cayennensis*) and the subspecies *fumosus* of Fuscous Flycatcher (*Cnemotriccus fuscatus*) were observed on the Essequibo Islands during the Fall 2017 / Spring 2018 surveys and Fall 2017 survey, respectively. Species of local conservation interest are species that are considered by Guyanese and international bird specialists to be rare and/or declining in Guyana or have very limited distribution in Guyana, but are not species of global conservation concern based on their IUCN Red List status.

Table 4-1: Coastal Bird Species with Elevated Global Conservation Status Documented to Occur in Coastal Guyana during the Coastal Bird Study 2017–2020

Species	IUCN Red List Status	Regions Observed	Time of Year (Season) Observed
Bicolored Conebill (*Conirostrum bicolor*)	NT	1, 2, 3 (coastal and island), 4, 5, 6	All Seasons
Harpy Eagle (*Harpia harpyja*)	NT	1	Spring 2018

Species	IUCN Red List Status	Regions Observed	Time of Year (Season) Observed
Red Knot (*Calidris canutus*)	NT	4, 5, 6	Fall 2018, Winter 2019
Semipalmated Sandpiper (*Calidris pusilla*)	NT	2, 3 (coastal and island), 4, 5, 6	All Seasons
Ruddy Pigeon (*Patagioenas subvinacea*)	VU	1	Spring 2018
Rufous Crab-hawk (*Buteogallus aequinoctialis*)	NT	1, 3 (coastal and island), 4, 5, 6	All Seasons
White-bellied Piculet (*Picumnus spilogaster*)	VU	3 (coastal and island), 4, 5, 6	All Seasons except Fall 2018
White-throated Toucan (*Ramphastos tucanus*)	VU	1, 3 (island)	Fall/Spring 2018, Fall/Summer/Winter 2019

4.5 Important Bird Habitats Identified during the Coastal Bird Study 2017–2020

BirdLife International (2016) has designated several Important Bird Areas (IBAs) in the neighboring countries of Suriname, Trinidad and Tobago, and Venezuela. These IBAs provide foraging, breeding, and nesting habitats similar to those found along Guyana's coastline. While no IBAs have been designated in Guyana, several areas along the Guyana coastline meet the definition of a 'threshold site' by BirdsCaribbean (www.birdscaribbean.org) for high abundance (criterion for threshold site is more than 3,000 individuals) that is consistent and predictable from year to year during coastal bird migration periods.

Based on the results of this study and other available data from historical or ongoing surveys and local bird specialists' knowledge, fourteen coastal sites of importance to birds, defined in this study as Important Bird Habitats (IBH), were identified in Regions 1 to 6 (Figure 4-6). While these sites are not formally classified or recognized, they are considered important to birds because they support one or more of the following: (1) predictable congregations of migratory shorebirds, including 'threshold sites'; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and/or (4) important nesting sites for regional endemic species of conservation interest.

All of these IBH sites consistently had higher average bird abundance and species richness per site than other survey locations. Coastal IBH sites had an average abundance of 890 birds and 21 species per site across all surveys conducted to date, more than double that of non-IBH sites. Appendix E contains a summary and photographs of the 14 IBH sites.

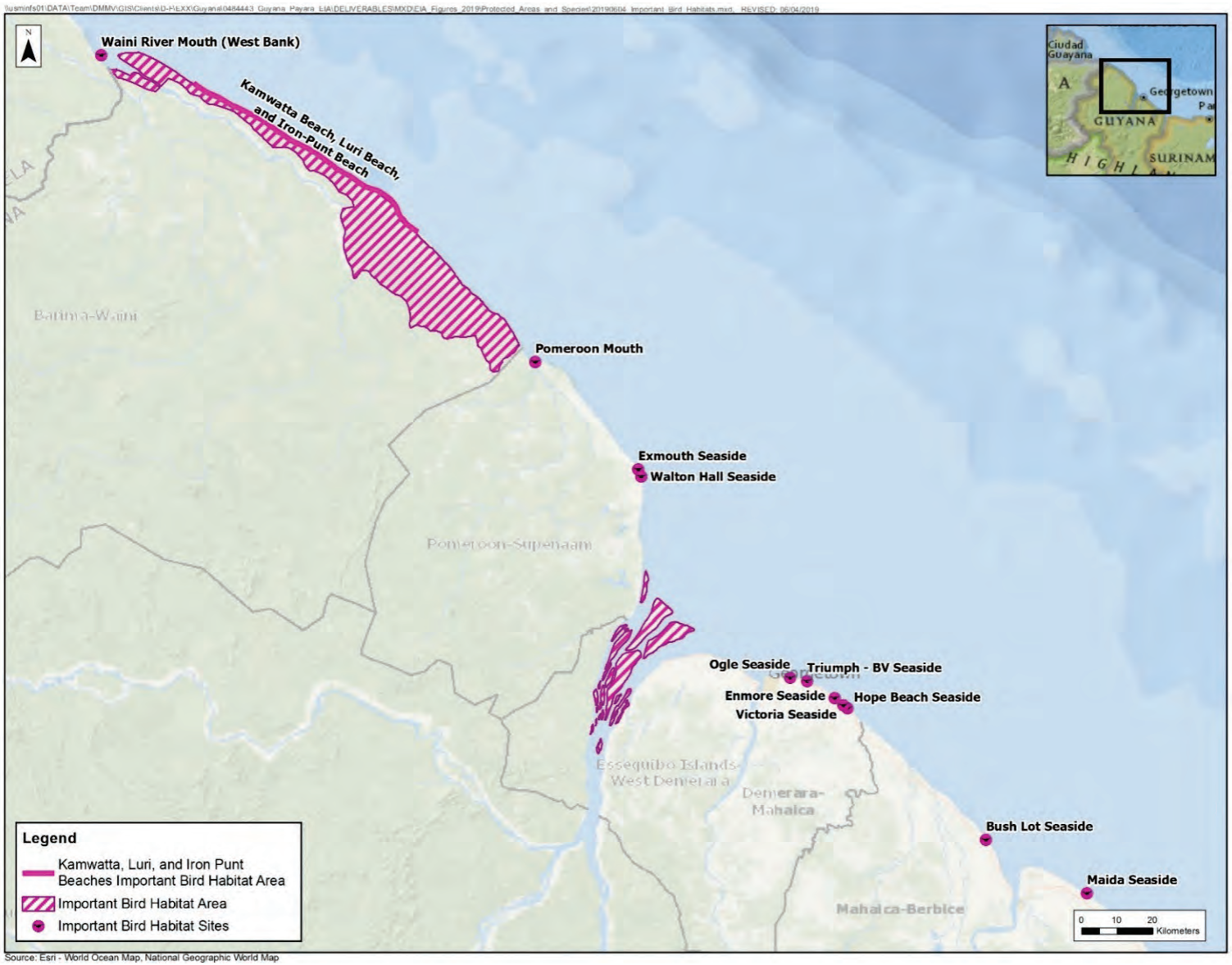


Figure 4-6: Locations of Important Bird Habitats—Regions 1 to 6

5. CONCLUSIONS AND NEXT STEP RECOMMENDATIONS

The Coastal Bird Study was the first comprehensive survey of Guyana's coastline outside the SBPA, and the first to systematically survey across all seasons (including migratory and non-migratory periods) and years, providing information on seasonal (migratory) species occurrence, as well as the species present year-round (i.e., resident species). This study constitutes a notable increase in the knowledge of Guyana's coastal bird community. Throughout the study, the surveys continued to document new findings, as is confirmed by the continued accumulation of bird species documented in Guyana's coastal habitats up through the last survey. The study also documented clear seasonal patterns in species assemblage and the timing of such, and confirmed overwintering activity by several species whose wintering range is poorly known. The results of the study make clear that Guyana's coastal avifauna is abundant and diverse and changes seasonally and across years. Understanding these patterns is important for impact assessment and emergency response planning as well as conservation and management.

ERM recommends continuing the EEPGL coastal bird survey program to further establish the coastal bird baseline in the region for use as a basis for future impact assessment and monitoring. Continuing the survey program would yield important information on the variability in seasonal and annual patterns of bird abundance and species composition, potentially document the presence of presumed present but yet-to-be-confirmed species, and likely confirm the presence of additional species, particularly during migration. A key unknown of relevance to EEPGL operations is the location and temporal stability (movement from year to year) of coastal bird breeding locations. This information is important for oil spill response planning since coastal birds are particularly vulnerable to oil spills during the breeding season. Data on coastal bird breeding locations could be collected in tandem with future suveys and through consultation with knowledgeable stakeholders (e.g., local community members, government staff, non-government entities).

The information gathered during additional surveys would further strengthen the coastal bird baseline and document the degree of variability in coastal bird use, which is particularly important in light of a rapidly changing regional and global environment. In addition, birds are well recognized as harbingers of environmental change and are used to monitor the health of the environment. EEPGL's coastal bird survey program is particularly well suited for use as a platform for future biodiversity monitoring, for which the Government of Guyana has indicated keen interest. Continuing the survey program would allow for training of additional Guyanese staff in program execution, including staff from relevant government agencies that have responsibilities involving coastal management, in preparation for a transition to a government-led monitoring program.

6. REFERENCES

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APPENDIX A COASTAL BIRD SURVEY SITE LIST AND MAPBOOK

Coastal Bird Survey Sites 2017-2020

Survey Site	Name	Region	Habitat Type
Coastal Sites			
FB-R1	Father's Beach	1	Tidal wetland, beach, mudflat, mangrove
MA-R1	Manawarin	1	Riverine mangrove
HA-R1	Haimaracabra	1	Riverine mangrove
WA-R1	Waramuri	1	Riverine mangrove
MO-R1	Moruca	1	Riverine mangrove
AS-R1	Asakata	1	Riverine mangrove
WP-R1	Warapoka	1	Riverine mangrove
TB-R1	Three Brothers	1	Riverine mangrove
AM-R1	Aruka Mouth	1	Riverine mangrove
MB-R1	Mabaruma	1	Riverine mangrove
MW-R1	Morawhanna	1	Riverine mangrove
SC-R1	Smith Creek	1	Riverine mangrove
IM-R1	Imbratero	1	Riverine mangrove
AB-R1	Almond Beach	1	Tidal wetland, beach, mudflat, mangrove
MR-R1	Moruca River	1	Riverine mangrove
LC-R1	Luri Creek	1	Riverine mangrove
BL-R1	Baramanni Lake	1	Riverine mangrove
PR-R1	Pomeroon River	1	Beach, mudflat, mangrove
DM-R2	Dartmouth	2	Sea wall, mudflat
EX-R2	Exmouth	2	Mudflat
WH-R2	Walton Hall	2	Mudflat and tidal wetland
AR-R2	Anna Regina	2	Mudflat
AF-R2	Affiance	2	Sea wall, mudflat, mangrove
SU-R2	Suddie	2	Sand beach, jetty
BH-R2	Better Hope	2	Sand beach
BP-R3	Bushy Park	3	Sand beach
FR-R3	Farm	3	Sea wall, mudflat
PH-R3	Philadelphia	3	Sea wall, mudflat
MM-R3	Meten-Meer-Zoor	3	Sea wall, mudflat
LN-R3	Lenora	3	Sea wall, mudflat
L J-R3	La Jalousie	3	Sea wall, mudflat
RZ-R3	Ruimzeight	3	Sea wall, mudflat
KS-R4	Kingston	4	Sand beach, jetty
TK- R4	Turkeyen	4	Sea wall, mudflat

Survey Site	Name	Region	Habitat Type
OG-R4	Ogle	4	Mudflat
LBI-R4	LBI Seawall	4	Mudflat, mangrove
BV-R4	BV-Triumph	4	Sea wall, intertidal wetland, mudflat
LU-R4	Lusignan	4	Mudflat
PA-R4	Paradise	4	Mangrove
EM-R4	Enmore	4	Mudflat
VT-R4	Victoria	4	Sea wall, intertidal wetland, mudflat, mangrove
NZ-R4	Nooten Zuil	4	Sea wall–open, some mangrove
HB-R4	Hope Beach	4	Mudflat, mangrove
HC-R4	Hope Canal	4	Mudflat, mangrove
Bee-R4	Bee Hive	4	Mangrove
UN-R4	Unity	4	Sand beach, jetty
MA-R4	Mahaica	4	Mudflat, mangrove
SS-R5	Sans Souci	5	Mangrove
AB-R5	Abary	5	Sand beach
MP-R5	Moor Park	5	Mangrove and mudflat
BL-R5	Bush Lot	5	Mudflat
HT-R5	Hopetown	5	Mangrove
WP-R5	Woodley Park	5	Mangrove
MS-R6	Maida Seaside	6	Sand beach
PS-R6	Phillipe Seaside	6	Sand beach
61B-R6	61-Beach Seaside	6	Sand beach
63B-R6	63-Beach Seaside	6	Sand beach
SL-R6	Springlands	6	Sand beach
AS-R6	Alness Seaside	6	Sand beach
EPS-R6	Bush Lot Village	6	Mudflat, mangrove
W61B-R6	No. 57 Village	6	Mudflat, vegetated low bank
Essequibo Island Sites			
Tig1-R3	Tiger Island 1	3	Sand beach, mangrove
Tig2-R3	Tiger Island 2	3	Sand beach, mangrove
Tig3-R3	Tiger Island 3	3	Sand beach, mangrove
Tig4-R3	Tiger Island 4	3	Mangrove
Tig5-R3	Tiger Island 5	3	Mangrove
Tig6-R3	Tiger Island 6	3	Sand beach, mangrove
Tig7-R3	Tiger Island 7	3	Sand beach, mangrove
Tig8-R3	Tiger Island 8	3	Sand beach, mangrove

Survey Site	Name	Region	Habitat Type
Tig9-R3	Tiger Island 9	3	Sand beach, mangrove
Wak1-R3	Wakenaam 1	3	Sand beach, mangrove
Wak2-R3	Wakenaam 2	3	Sand beach, mangrove
Wak3-R3	Wakenaam 3	3	Sand beach, mangrove
Wak4-R3	Wakenaam 4	3	Sand beach, mangrove
Wak5-R3	Wakenaam 5	3	Sand beach, mangrove
Wak6-R3	Wakenaam 6	3	Sand beach, mangrove
Wak7-R3	Wakenaam 7	3	Sand beach, mangrove
Wak8-R3	Wakenaam 8	3	Sand beach, mangrove
Wak9-R3	Wakenaam 9	3	Sand beach, mangrove
Wak10-R3	Wakenaam 10	3	Concrete wall, some mangrove
Wak11-R3	Wakenaam 11	3	Concrete wall, some mangrove
Wak12-R3	Wakenaam 12	3	Mangrove
Wak13-R3	Wakenaam 13	3	Mangrove
Wak14-R3	Wakenaam 14	3	Mangrove
Wak15-R3	Wakenaam 15	3	Mangrove
Wak16-R3	Wakenaam 16	3	Mangrove
Wak17-R3	Wakenaam 17	3	Mangrove
Wak18-R3	Wakenaam 18	3	Mangrove
Leg1-R3	Leguan 1	3	Concrete wall
Leg2-R3	Leguan 2	3	Concrete wall
Leg3-R3	Leguan 3	3	Concrete wall, mangrove
Leg4-R3	Leguan 4	3	Mangrove, plantation
Leg5-R3	Leguan 5	3	Sand beach, plantation
Leg6-R3	Leguan 6	3	Mudflat, mangrove
Leg7-R3	Leguan 7	3	Mudflat, mangrove
Leg8-R3	Leguan 8	3	Mudflat, mangrove
Leg9-R3	Leguan 9	3	Mudflat, mangrove
Leg10-R3	Leguan 10	3	Mudflat, mangrove
Leg11-R3	Leguan 11	3	Mangrove
Leg12-R3	Leguan 12	3	Mangrove
Leg13-R3	Leguan 13	3	Mangrove
Leg14-R3	Leguan 14	3	Mangrove
Leg15-R3	Leguan 15	3	Mangrove
Hog1-R3	Hog Island 1	3	Mudflat, mangrove
Hog2-R3	Hog Island 2	3	Mudflat, mangrove

Survey Site	Name	Region	Habitat Type
Hog3-R3	Hog Island 3	3	Mudflat, mangrove
Hog4-R3	Hog Island 4	3	Mudflat, mangrove
Hog5-R3	Hog Island 5	3	Mudflat, mangrove
Hog6-R3	Hog Island 6	3	Mudflat, mangrove
Hog7-R3	Hog Island 7	3	Mangrove
Hog8-R3	Hog Island 8	3	Mangrove
Hog9-R3	Hog Island 9	3	Mangrove

Almond Beach
Luri Beach
Imbratero
Smith Creek Village
Morawhanna
VENEZUELA
Aruka Mouth Village
GUYANA
Mabaruma
Three Brothers
I-2 Waini
I-1 Barima
Warapoka
Baramanni Lake
Asakata
Father's Beach
Moruca River Mouth
Moruca-Kumaka
Pomeroon Mouth
Waramuri
Haimaracabra
Manawarin
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Kilometers
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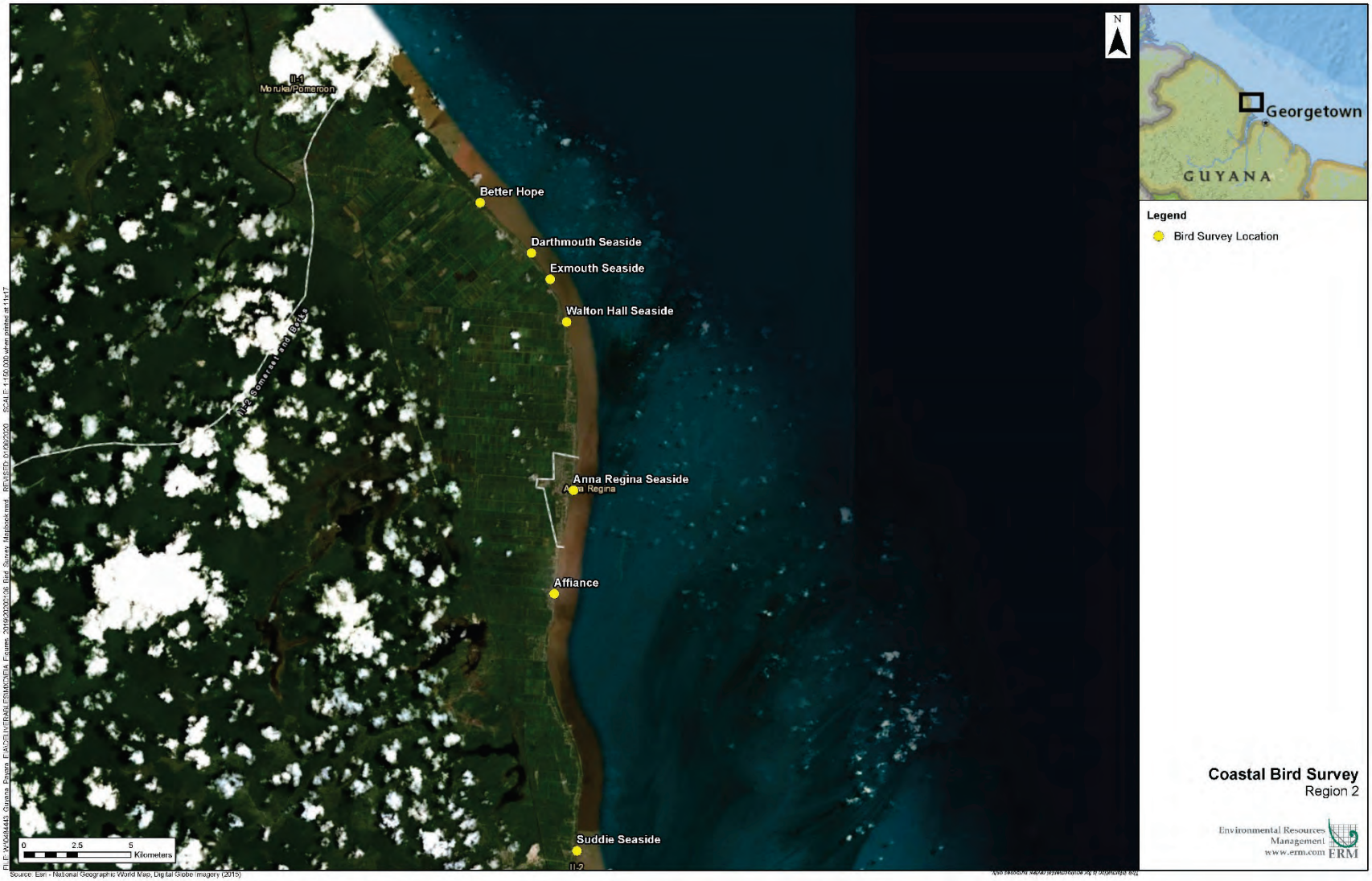
Georgetown
GUYANA
Legend
Bird Survey Location
Coastal Bird Survey
Region 1
Environmental Resources Management
www.erm.com
ERM
Source: Esri - National Geographic World Map, Digital Globe Imagery (2016)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Georgetown
GUYANA
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Bird Survey Location
Better Hope
Darthmouth Seaside
Exmouth Seaside
Walton Hall Seaside
Anna Regina Seaside
Affiance
Suddie Seaside
Moruka/Pomeroon
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2.5
5
Kilometers
Coastal Bird Survey
Region 2
Environmental Resources Management
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Legend
Bird Survey Location
Region 3 Essequibo Islands Survey Area
Coastal Bird Survey
Region 3
Environmental Resources Management
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Meten-Meer-Zorg Seaside
Farm Seaside
Philadelphia Seaside
Leonora Seaside
Bushy Park Seaside
La Jalousie Seaside
Ruimzeight Seaside
Parika
Leguan Island
Essequibo River
ESSEQUIBO ISLANDS-WEST DEMERARA
POMEROON-SUPENAAM
III-1 West Demerara
III-1 Essequibo Islands
III-2 Bonasika/Boerasirie
III-3 Lower West Demerara
Vreed en Hoop
0
2.5
5
Kilometers
Source: Esri - National Geographic World Map, Digital Globe Imagery (2015)

Ruimzeight Seaside
Kingston Seaside
Turkeyen Seaside
Ogle Seaside
LBI Seawall
Triumph - BV Seaside
Lusignan Seaside
Paradise
Enmore Seaside
Victoria Seaside
Nooten Zuil
Hope Beach Seaside
Hope Canal
Bee Hive
Unity
Mahaica River mouth
GEORGETOWN
Turkeyen
Vreed en Hoop
Lamaha Springs
Georgetown
Mobilissa/la Reconnai
III-3 Lower West Demerara
Vreed en Hoop
III-3 Lower West Demerara
N-1
Atlantic
Atlantisch
0 2.5 5 Kilometers
Source: Esri - National Geographic World Map, Digital Globe Imagery (2015)
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Georgetown
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Legend
Bird Survey Location
Coastal Bird Survey
Region 4
Environmental Resources Management
www.erm.com
ERM

Sans Souci
Abary
Moor Park
Bush Lot Seaside
Hopetown
Woodley Park
V.2 MahaiconyBerbice
Berbice River
V1.2 East Canje/E. C. Berb
New Amsterdam
Overwinning
EAST BERBICE
0 2.5 5 Kilometers
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Legend
Bird Survey Location
Coastal Bird Survey
Region 5
Environmental Resources Management
www.erm.com
ERM

N
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GUYANA
Legend
Bird Survey Location
Maida Seaside
Rose Hall
Rose Hall
Alness Seaside
Phillipe Seaside
Bush Lot Village
VI-2 East Canje/E. C. Berb
VI-3 Black Bush Polder
ERBICE-CORENTYNE
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Coastal Bird Survey
Region 6
Environmental Resources Management
www.erm.com
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Source: Esri - National Geographic World Map, Digital Globe Imagery (2015)

No. 57 Village
61-Beach Seaside
63-Beach Seaside
Boven Corantijn Rivier
SURINAME
GUYANA
Corriverton
Corriverton
VI-3 Black Bush Polder
VI-4 Lower Corentyne Rive
Oostelijke Polders
Westelijke Polders
Nieuw Nickerie
Westelijke Polders
Springlands
Nieuw Nickerie
VI-4 Lower Corentyne Rive
Oostelijk
0 2.5 5 Kilometers
N
Georgetown
GUYANA
Legend
Bird Survey Location
Coastal Bird Survey
Region 6
Environmental Resources Management
www.erm.com
ERM
Source: Esri - National Geographic World Map, Digital Globe Imagery (2015)

APPENDIX B ELECTRONIC DATA ENTRY TEMPLATE FOR THE COASTAL BIRD SURVEY

Bird Survey

Date *
Monday, April 08, 2019

Time *
5:38 PM

Location *

Survey Device Name

Survey Site Code

Survey Site Code

Observation ID *
1904081738

Method of Observation
- Visual
- Audio
- Other

Weather
- Sunny
- Partly Sunny
- Cloudy
- Light Rain
- Heavy Rain
- Other

Temperature C

Species Observed

Species Observed

Number of Individuals *

Unique Behaviour?
- Feeding
- Roosting
- Nesting
- None
- Other

Location/Habitat

Take or Insert Photo

External Camera IDs

1 of 1

General Description

Are you at the Site?
- (•) Yes
- ( ) No

APPENDIX C BIRD SPECIES PRESENT BY REGION DURING THE COASTAL BIRD STUDY (2017–2020)

Bird Species Present by Region during the Coastal Bird Study (2017-2020)

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*						X	
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	X		X	X	X	X	X
Accipitridae	Common Black Hawk	*Buteogallus anthracinus*				X			
Accipitridae	Crane Hawk	*Geranospiza caerulescens*				X			X
Accipitridae	Gray-headed Kite	*Leptodon cayanensis*	X			X			
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*				X	X		X
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	X	X	X	X	X		
Accipitridae	Harpy Eagle	*Harpia harpyja*	X						
Accipitridae	Long-winged Harrier	*Circus buffoni*	X	X			X	X	X
Accipitridae	Osprey	*Pandion haliaetus*	X	X	X	X	X	X	X
Accipitridae	Pearl Kite	*Gampsonyx swainsonii*			X				X
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	X			X			
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	X	X	X	X	X	X	X
Accipitridae	Rufous Crab-hawk	*Buteogallus aequinoctialis*	X		X	X	X	X	X
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*		X		X		X	X
Accipitridae	Slender-billed Kite	*Helicolestes hamatus*				X			
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	X	X	X	X	X	X	X
Accipitridae	Swallow-tailed Kite	*Elanoides forficatus*	X						
Accipitridae	White-tailed Hawk	*Geranoaetus albicaudatus*	X			X			
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	X	X		X	X		
Alcedinidae	Amazon Kingfisher	*Chloroceryle amazona*	X						
Alcedinidae	Green Kingfisher	*Chloroceryle americana*			X	X	X	X	X
Alcedinidae	Green-and-rufous Kingfisher	*Chloroceryle inda*	X						
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	X			X	X	X	X
Alcedinidae	Toco Toucan	*Ramphastos toco*				X			
Anatidae	Black-bellied Whistling Duck	*Dendrocygna autumnalis*	X			X		X	
Anatidae	Muscovy Duck	*Cairina moschata*	X						
Anhingidae	Anhinga	*Anhinga anhinga*	X						

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	X			X			
Apodidae	Band-rumped Swift	*Chaetura spinicaudus*			X	X			
Apodidae	Fork-tailed Palm-Swift	*Tachornis squamata*	X			X	X	X	
Apodidae	Gray-rumped Swift	*Chaetura cinereiventris*	X						
Aramidae	Limpkin	*Aramus guarauna*		X	X		X	X	
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	X	X	X	X	X	X	X
Ardeidae	Cattle Egret	*Bubulcus ibis*	X	X	X	X	X	X	
Ardeidae	Cocoi Heron	*Ardea cocoi*	X			X	X	X	X
Ardeidae	Great Egret	*Ardea alba*	X	X	X	X	X	X	X
Ardeidae	Little Blue Heron	*Egretta caerulea*	X	X	X	X	X	X	X
Ardeidae	Snowy Egret	*Egretta thula*	X	X	X	X	X	X	X
Ardeidae	Striated Heron	*Butorides striata*	X	X	X	X	X	X	X
Ardeidae	Tricolored Heron	*Egretta tricolor*	X	X	X	X	X	X	X
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*					X	X	X
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	X	X	X	X	X	X	X
Cathartidae	Black Vulture	*Coragyps atratus*	X	X	X	X	X	X	X
Cathartidae	Greater Yellow-headed Vulture	*Cathartes melambrotus*				X			
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	X	X				X	
Cathartidae	Turkey Vulture	*Cathartes aura*	X	X		X	X	X	X
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*		X			X	X	X
Charadriidae	Collared Plover	*Charadrius collaris*		X					X
Charadriidae	Hudsonian Godwit	*Limosa haemastica*					X		X
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*		X	X	X	X	X	X
Charadriidae	Southern Lapwing	*Vanellus chilensis*	X	X	X	X	X	X	
Ciconiidae	Wood Stork	*Mycteria americana*	X						
Columbidae	Common Ground-Dove	*Columbina passerina*	X	X	X	X	X	X	X
Columbidae	Gray-fronted Dove	*Leptotila rufaxilla*				X			

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	X		X	X	X	X	X
Columbidae	Rock Pigeon	*Columba livia*	X	X	X		X		X
Columbidae	Ruddy Ground-Dove	*Columba talpacoti*	X	X	X	X	X	X	X
Columbidae	Ruddy Pigeon	*Patagioenas subvinacea*	X						
Columbidae	White-tipped Dove	*Leptotila verreauxi*	X		X	X	X	X	X
Corvidae	Cayenne Jay	*Cyanocorax cayanus*	X						
Cotingidae	Screaming Piha	*Lipaugus vociferans*	X						
Cracidae	Variable Chachalaca	*Ortalis motmot*	X		X				
Cuculidae	Greater Ani	*Crotophaga major*	X			X	X	X	X
Cuculidae	Little Cuckoo	*Coccycua minuta*				X		X	
Cuculidae	Mangrove Cuckoo	*Coccyzus minor*							X
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	X	X	X	X	X	X	X
Cuculidae	Squirrel Cuckoo	*Piaya cayana*	X						
Cuculidae	Striped Cuckoo	*Tapera naevia*	X			X	X		X
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	X		X	X	X	X	X
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*				X		X	
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*		X					
Falconidae	Bat Falcon	*Falco rufigularis*				X	X		
Falconidae	Black Caracara	*Daptrius ater*	X						
Falconidae	Crested Caracara	*Caracara cheriway*	X	X		X	X	X	X
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	X			X			
Falconidae	Peregrine Falcon	*Falco peregrinus*		X			X		X
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	X	X	X	X	X	X	X
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	X	X	X	X	X	X	X
Fringillidae	Finsch's Euphonia	*Euphonia finschi*	X						
Fringillidae	Violaceous Euphonia	*Euphonia violacea*	X		X	X			
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	X	X	X	X	X	X	X

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Furnariidae	Buff-throated Woodcreeper	*Xiphorhynchus guttatus*	X						
Furnariidae	Pale-breasted Spinetail	*Synallaxis albescens*	X		X	X	X		X
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	X					X	
Hirundinidae	Barn Swallow	*Hirundo rustica*	X	X	X	X	X	X	X
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	X	X	X	X	X	X	X
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	X	X	X	X	X	X	X
Icteridae	Carib Grackle	*Quiscalus lugubris*		X	X	X			
Icteridae	Crested Oropendola	*Psarocolius decumanus*	X			X			
Icteridae	Epaulet Oriole	*Icterus cayanensis*	X						
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	X			X			
Icteridae	Red-breasted Meadowlark	*Leistes militaris*	X	X	X	X	X	X	
Icteridae	Red-rumped Cacique	*Cacicus haemorrhous*	X						
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	X	X	X	X	X	X	X
Icteridae	Yellow Oriole	*Icterus nigrogularis*	X	X	X	X	X	X	X
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	X	X	X	X	X		
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	X			X			
Jacanidae	Wattled Jacana	*Jacana jacana*	X	X	X	X	X	X	X
Laridae	Black Skimmer	*Rynchops niger*	X	X	X	X	X	X	X
Laridae	Common Tern	*Sterna hirundo*		X			X	X	X
Laridae	Gull-billed Tern	*Gelochelidon nilotica*		X	X		X	X	X
Laridae	Large-billed Tern	*Phaetusa simplex*	X	X	X	X	X	X	X
Laridae	Laughing Gull	*Leucophaeus atricilla*		X	X	X	X	X	X
Laridae	Least Tern	*Sternula antillarum*		X	X	X	X	X	X
Laridae	Lesser Black-backed Gull	*Larus fuscus*							X
Laridae	Royal Tern	*Thalasseus maximus*		X	X	X	X	X	X
Laridae	Royal/Sandwich Tern	*Thalasseus maximus/sandvicensis*				X			
Laridae	Sandwich Tern	*Thalasseus sandvicensis*				X			

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Laridae	Yellow-billed Tern	*Sternula superciliaris*		X			X	X	
Motmotidae	Amazonian Motmot	*Momotus momota*	X						
Parulidae	Masked Yellowthroat	*Geothlypis aequinoctialis*	X						
Parulidae	Northern Waterthrush	*Parkesia noveboracensis*				X	X		
Parulidae	Riverbank Warbler	*Myiothlypis rivularis*	X			X			
Parulidae	Yellow Warbler	*Setophaga petechia*	X	X	X	X	X		
Passerellidae	Pectoral Sparrow	*Arremon taciturnus*	X						
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*		X	X	X	X	X	X
Phalacrocidae	Neotropic Cormorant	*Phalacrocorax brasilianus*	X	X	X	X	X	X	X
Picidae	Blood-colored Woodpecker	*Veniliornis sanguineus*					X	X	
Picidae	Chestnut Woodpecker	*Celeus elegans*	X						
Picidae	Chestnut/Cream-colored Woodpecker	*Celeus elegans/flavus*				X			
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*				X			
Picidae	Lineated Woodpecker	*Dryocopus lineatus*	X	X		X			
Picidae	White-bellied Piculet	*Picumnus spilogaster*			X	X	X	X	X
Psittacidae	Blue-and-yellow Macaw	*Ara ararauna*	X						
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	X		X	X	X	X	X
Psittacidae	Green-rumped Parrotlet	*Forpus passerinus*							X
Psittacidae	Red-and-green Macaw	*Ara chloropterus*	X						
Psittacidae	Red-shouldered Macaw	*Diopsittaca nobilis*	X		X	X			
Psittacidae	Yellow-crowned Parrot	*Amazona ochrocephala*	X						
Psitticidae	Orange-winged Parrot	*Amazona amazonica*	X		X	X		X	
Psitticidae	Red-bellied Macaw	*Orthopsittaca manilatus*	X			X			

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Rallidae	Grey-cowled Wood-Rail	*Aramides cajaneus*	X			X			
Rallidae	Mangrove Rail	*Rallus longirostris*						X	
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*				X	X	X	
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	X			X			
Recurvirostridae	Black-necked Stilt	*Himantopus mexicanus*						X	X
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*		X			X	X	X
Scolopacidae	Least Sandpiper	*Calidris minutilla*		X	X		X	X	X
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*		X	X	X	X	X	X
Scolopacidae	Pectoral Sandpiper	*Calidris melanotos*					X		
Scolopacidae	Red Knot	*Calidris canutus*					X	X	X
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*		X	X		X	X	X
Scolopacidae	Sanderling	*Calidris alba*		X	X		X	X	X
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*		X	X	X	X	X	X
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*		X			X	X	
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*			X	X	X	X	
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	X	X	X	X	X	X	X
Scolopacidae	Western Sandpiper	*Calidris mauri*		X	X		X		
Scolopacidae	Whimbrel	*Numenius phaeopus*		X	X		X	X	X
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*		X			X	X	X
Scolopacidae	Willet	*Tringa semipalmata*		X	X	X	X	X	X
Strigidae	Great Horned Owl	*Bubo virginianus*				X		X	
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	X	X	X	X	X	X	
Thamnophilidae	Black-chinned Antbird	*Hypocnemoides melanopogon*	X			X			
Thamnophilidae	Black-crested Antshrike	*Sakesphorus canadensis*	X	X	X	X	X	X	X
Thamnophilidae	Black-throated Antbird	*Myrmophylax atrothorax*	X						

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Thamnophilidae	Dusky Antbird	*Cercomacroides tyrannina*	X						
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	X			X			
Thamnophilidae	White-browed Antbird	*Myrmoborus leucophrys*	X						
Thamnophilidae	White-flanked Antwren	*Myrmotherula axillaris*	X						
Thraupidae	Bananaquit	*Coereba flaveola*	X	X	X	X	X		
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	X	X	X	X	X	X	X
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	X	X	X	X	X	X	
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	X	X	X	X	X	X	X
Thraupidae	Burnished-buff Tanager	*Tangara cayana*		X	X	X	X		
Thraupidae	Chestnut-bellied Seedeater	*Sporophila castaneiventris*	X			X			
Thraupidae	Lined Seedeater	*Sporophila lineola*	X						
Thraupidae	Palm Tanager	*Thraupis palmarum*	X	X	X	X	X		
Thraupidae	Red-capped Cardinal	*Paroaria gularis*			X	X	X	X	
Thraupidae	Ruddy-breasted Seedeater	*Sporophila minuta*	X						
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	X		X	X			
Thraupidae	Turquoise Tanager	*Tangara mexicana*	X			X			
Thraupidae	White-lined Tanager	*Tachyphonus rufus*			X				
Thraupidae	White-shouldered Tanager	*Tachyphonus luctuosus*	X						
Thraupidae	Wing-barred Seedeater	*Sporophila americana*		X	X	X			
Threskiornithidae	Green Ibis	*Mesembrinibis cayennensis*	X						
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	X	X	X	X	X	X	X
Tityridae	Black-tailed Tityra	*Tityra cayana*	X						
Tityridae	Cinereous Becard	*Pachyramphus rufus*				X			
Tityridae	White-winged Becard	*Pachyramphus polychopterus*				X			

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Trochilidae	Black-throated Mango	*Anthracothorax nigricollis*			X				
Trochilidae	Blue-chinned Sapphire	*Chlorestes notata*				X			X
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	X			X			
Trochilidae	Glittering-throated Emerald	*Amazilia fimbriata*	X		X	X	X		
Trochilidae	Little Hermit	*Phaethornis longuemareus*				X			
Trochilidae	Plain-bellied Emerald	*Amazilia leucogaster*		X	X	X			
Trochilidae	Reddish Hermit	*Phaethornis ruber*	X						
Trochilidae	Tufted Cocquette	*Lophornis ornatus*	X						
Trochilidae	White-chested Emerald	*Amazilia brevirostris*			X	X		X	X
Troglodytidae	House-wren	*Troglodytes aedon*	X	X	X	X	X	X	X
Trogonidae	Green-backed Trogon	*Trogon viridis*	X						
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	X		X	X	X		
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	X	X	X	X	X		
Tyrannidae	Brown-crested Flycatcher	*Myiarchus tyrannulus*	X	X	X	X	X	X	X
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	X			X			
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	X		X	X	X	X	X
Tyrannidae	Fork-tailed Flycatcher	*Tyrannus savana*		X			X	X	
Tyrannidae	Fuscous Flycatcher	*Cnemotriccus fuscatus*				X			
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	X	X	X	X	X	X	
Tyrannidae	Grayish Mourner	*Rhytipterna simplex*	X						
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	X	X	X	X	X	X	X
Tyrannidae	Guianan Tyrannulet	*Zimmerius acer*	X						
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	X			X			
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	X	X	X	X	X	X	
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	X		X	X		X	X

Family	Common Name	Scientific Name	Region 1 (Coastal)	Region 2 (Coastal)	Region 3 (Coastal)	Region 3 (Island)	Region 4 (Coastal)	Region 5 (Coastal)	Region 6 (Coastal)
Tyrannidae	Pale-eyed Pygmy-Tyrant	*Atalotriccus pilaris*	X						
Tyrannidae	Pale-tipped Tyrannulet	*Inezia caudata*						X	
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	X	X	X	X	X	X	X
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	X		X				
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	X	X	X	X	X	X	X
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	-		X	X	X	X	
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	X		X	X	X	X	X
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	X	X	X	X	X	X	X
Tyrannidae	Sulphury Flycatcher	*Tyrannopsis sulphurea*				X			
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	X	X	X	X	X	X	X
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	X	X	X	X	X	X	
Tyrannidae	White-headed Marsh-Tyrant	*Arundinicola leucocephala*	X	X					
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*				X			
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	X		X	X	X	X	X
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*				X		X	
Tyrannidae	Yellow-breasted Flycatcher	*Tolmomyias flaviventris*				X		X	
Tyrannidae	Yellow-crowned Tyrannulet	*Tyrannulus elatus*	X		X				
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	X		X	X	X	X	X
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	X					X	
Vireonidae	Red-eyed Vireo	*Vireo olivaceus*	X						
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*				X			

APPENDIX D PHOTOGRAPH LOG—BIRDS PHOTOGRAPHED DURING EEPGL-COMMISSIONED COASTAL BIRD SURVEYS 2017–2020

Photograph Log Index

Photo No.	Photo Caption
Survey Team	
1	ERM staff Jenny Leon and Wally Prince—field observation and data entry
2	Bird observer Philip Odwin at the Darthmouth site—Region 2
3	Bird observers Garey Sway and Wally Prince at Ogle seaside—Region 4
4	Bird observer Jeffrey McCrary at Ruimzeight shoreline—Region 3
Waterbirds	
5	Scarlet Ibis *(Eudocimus ruber)* at Leguan mudflats—Region 3
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APPENDIX E IMPORTANT BIRD HABITATS IDENTIFIED IN REGIONS 1 THROUGH 6

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Shell Beach Protected Area (SBPA)	1	Sandy beach, mudflat, mangrove	SBPA contains critically important nesting and foraging habitats for over 200 species of waterbirds and land birds, including several globally threatened species.	
Pomeroon River Mouth	1	Mudflat, mangrove	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds. Thousands of wading birds roost in the mangroves in this area.	
Kamwatta Beach, Iron Punt Beach, and Luri Beach	1	Sandy beach, mudflat, mangrove	These beaches host hundreds of flamingos (multiple species) and thousands of other colonial waterbirds (ERM Personal Communication 26) for nesting and feeding. The photo depicts Luri Creek, which is located just inland from Luri Beach and is the location of the colonial waterbird roosting and nesting site.	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Waini River Mouth (west bank)	1	Mangrove	Pristine mangrove forest supporting large congregations of colonially roosting and nesting wading birds (herons, egrets, ibis, etc.).	
Exmouth Seaside	2	Mudflat	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds, including over 3,000 shorebirds (*Calidris* sp.) at a time, qualifying it as a Threshold Site[4] during the migratory season.	
Walton Hall Seaside	2	Mudflats and mangrove	Tidal mudflats and mangroves supporting large congregations of shorebirds and wading birds.	

[4] BirdLife International's definition of a Threshold Site for migratory birds is one that is known or thought to hold congregations that are equal to or more than 1 percent of the global population of one or more species (including species group or family) on a regular or predictable basis (BirdLife International 2011).

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Essequibo Island Complex	3	Mangrove	Unique transition zone between riverine forest and mangrove ecosystems that provides important roosting and nesting habitat for riverine birds and wading birds.	
Ogle Seaside	4	Mudflat	Extensive mudflat that is heavily populated with foraging shorebirds (over 3,000 individuals at a time, qualifying it as a Threshold Site for *Calidris* sp.) during the migratory season.	
Triumph-BV Seaside	4	Mudflat and mangrove	Extensive mudflat and natural revegetation of mangroves that supports large numbers of migratory shorebirds and waterbirds and is also considered very important as a nesting site for Snail Kite (*Rostrhamus sociabilis*).	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Enmore Seaside	4	Mudflat and mangrove	Tidal mudflats and mangroves that host large congregations of shorebirds and wading birds, and serve as nesting site for Snail Kite (*Rostrhamus sociabilis*) and other mangrove-dependent species, including conebills.	
Hope Beach Seaside	4	Vegetated sand flat	Fine sand flats overlain with compact mud at low tide that host large congregations of shorebirds and wading birds (including Scarlet Ibis [*Eudocimus ruber*]) and mangroves that support large numbers of nesting and roosting wading birds.	
Victoria Seaside	4	Mangrove and brackish marsh	Extensive mangrove and brackish marsh along the shoreline and inland that provides important roosting and breeding site for shorebirds and waterbirds, particularly Scarlet Ibis (*Eudocimus ruber*) and mangrove-dependent species.	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Bush Lot Seaside	5	Mudflat and mangrove	Extensive mudflats used by thousands of shorebirds during migration (threshold site for *Calidris* sp.) and waterbirds throughout the year.	
Mangroves between Maida and Phillipe	6	Mangrove	Important roosting and breeding area for thousands of colonial waterbirds.	

Sources:

BirdLife International. 2011. Marine Important Bird Areas toolkit: Standardized Techniques for Identifying Priority Sites for the Conservation of Seabirds at Sea. BirdLife International, Cambridge UK. Version 1.2: February 2011. Accessed: May 2018. Retrieved from: http://datazone.birdlife.org/userfiles/file/Marine/Marinetoolkitnew.pdf

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APPENDIX M

Nearshore and Offshore Fisheries Study Summary

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Nearshore and Offshore Fisheries Study

Year 2 Report

October 2021

Project No.: 0484443

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October 2021

Nearshore and Offshore Fisheries Study

Year 2 Report

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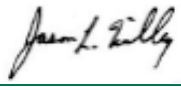
Senior Consultant



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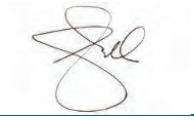

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Acronyms and Abbreviations

Acronym	Description
°C	degrees Celsius
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental Impact Assessment
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
g	gram
FAO	Food and Agriculture Organization of the United Nations
FPSO	Floating Production, Storage, and Offloading vessel
m	meter
UTM	Universal Transverse Mercator
WGS	World Geodetic System

EXECUTIVE SUMMARY

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for approval of the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. The EPA approved both the Application and the Environmental Impact Assessment on 1 June 2017, and issued an Environmental Permit for the Liza Phase 1 Development Project. As a condition of the permit, the EPA required EEPGL to conduct a study of the marine fish community offshore Guyana (referred to hereafter as the Marine Fish Study). In 2017-2018, Environmental Resources Management (ERM), EEPGL's environmental consultant, developed and implemented a study approach that included two seasonal surveys (one in the dry season and one in the wet season) in the deepwater, continental shelf, and nearshore zones, as well as a fish landing study at the major landing sites across the coast ("the Year 1 Study"). EEPGL elected to add an estuarine/riverine component to the EPA-required components during the second seasonal survey in April 2018. The results of the Year 1 Study were reported to the EPA in May 2018 (ERM 2018).

EEPGL subsequently elected to voluntarily repeat the study for a second year in 2018–2019 ("the Year 2 Study"). The study scope was modified in the second year to include a plankton component and the fish landing study was expanded into a standalone participatory fishing study, the results of which were reported separately (ERM 2020). This report describes the second year of the Marine Fish Study (not including the participatory fishing study) and is organized as follows:

1. Deepwater Component—conducted aboard Trinidad and Tobago-flagged *Captain Grady* (an offshore utility/cargo ship) using deep sea traps;
2. Continental Shelf Component—conducted aboard Guyanese-flagged vessels using trawls and longlines;
3. Nearshore Component—conducted from small boats at or near the shore in the shallow subtidal zone using gillnets and cast nets;
4. Estuarine/Riverine Component—conducted from small boats using electrofishing equipment; and
5. Plankton Component—conducted concurrently with the deepwater, continental shelf, and nearshore components.

All of the Year 2 components listed above were completed once in the wet season and once in the dry season except for the deepwater trap component, which was only completed in the wet season. A total of 203 species were captured across all the study components. The trap component of the deepwater assessment was not conducted during the dry season because of rough sea conditions in the Stabroek Block. The wet season deepwater survey yielded no captured nekton.

Ninety-two species of fish (49 families) were captured within the continental shelf transect stations. The wet season produced the most diverse catch for all continental shelf transects. The "A" Stations (closest to shore) tended to be the most species-rich stations on the continental shelf during the wet season, but during the dry season the "C" Stations (furthest from shore) were the most species-rich. The trawl samples from the continental shelf transects also produced a variety of benthic bycatch. Although not the focus of this assessment, the benthic bycatch data are noteworthy because of the diversity of species captured and the distribution of the bycatch. Numerous benthic species that are not targeted by the commercial fisheries in Guyana were captured. Benthic bycatch was widespread across the continental shelf transect stations and included live corals at several locations.

Sixty-two species of fish (23 families) were captured at the nearshore stations, many of which were also captured on the continental shelf. With 17 species, the Scianidae was the most diverse family captured in the nearshore zone. The Ariidae family was the second most diverse family captured in the nearshore

zone, with nine species. Most of the species captured during the wet season were either anadromous and likely entered the coastal area from the sea in response to increased freshwater discharge to the coastal zone, or were euryhaline species that entered the study area from further up the rivers.

Twenty-one species of fish (14 families) were captured at the estuarine/riverine stations. Most of the fish captured at the estuarine/riverine stations were juvenile marine species. The results of the estuarine/riverine component illustrate the importance of the estuaries, and particularly the mangroves, as nursery habitat for many marine species, as well as the key supporting role that estuaries (and mangroves in particular) play in sustaining Guyana's marine ichthyofauna and marine fisheries.

One hundred eleven species of fish (51 families) were represented in the plankton samples, accounting for 55 percent of the total number of species captured in the study. Nearly all the ichthyoplankton captured were obtained from the dry season samples. The extent of the seasonal differences in ichthyoplankton densities was consistent with traditional ecological knowledge concerning seasonal patterns in marine fish abundance and spawning behavior.

1. INTRODUCTION

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for approval of the company's initial offshore oilfield development in the Stabroek Block (referred to as the Liza Phase 1 Development Project). The Liza Phase 1 Development consists of 17 subsea development wells and a Floating Production, Storage, and Offloading vessel (FPSO). EEPGL submitted an Environmental Impact Assessment (EIA), prepared by Environmental Resources Management (ERM) to support its Application for Environmental Authorisation for the Liza Phase 1 Development Project. The Guyana EPA approved both the Application and the EIA on 1 June 2017, and issued an Environmental Permit for the Liza Phase 1 Development Project. The Liza Phase 1 Development is located approximately 120 miles offshore of Georgetown, Guyana. The Liza Phase 1 Development began operations in December 2019.

1.1 Year 1 (2017–2018) Marine Fish Study Activities

The Environmental Permit issued by the EPA for the Liza Phase 1 Development included the following requirement to complete fishery studies within a year of permit issuance:

> "[C]onduct fishery dependent studies in the nearshore zone, augmented by fishery-independent studies in the nearshore and offshore zones. Field methods shall include a sufficient variety of survey techniques to capture surface, mid-water, and bottom-oriented fish. The objective of the study shall be to develop a more complete understanding of the marine fish community outside the Liza Area of Interest. The study shall include at least one wet and one dry season (notionally several weeks duration each) to enable comparison of data across seasons."

In accordance with the above permit condition, EEPGL engaged ERM to complete a Marine Fish Study in 2017-2018 ("the Year 1 Study") that included industrial[1] and small-scale[2] fishery techniques to develop a more complete understanding of the marine fish community outside the Liza Area of Interest. The study included four direct sampling components and one interview-based component. The direct sampling components included:

1. Deepwater fish sampling
2. Continental shelf fish sampling
3. Nearshore fish sampling
4. Estuarine/riverine juvenile fish sampling

The interview-based component consisted of an observational and interview-based assessment of fish landings at several fish landing sites throughout Regions 1–6.

A Year 1 Study report was prepared, and the results of the Year 1 Study were used to inform an update of the Liza Phase 1 Development Project Environmental Impact Statement and the Liza Phase 1 Development Project Environmental and Socioeconomic Management Plan. EEPGL submitted these documents to the EPA in May 2018.

1.2 Year 2 (2018–2019) Marine Fish Study Activities

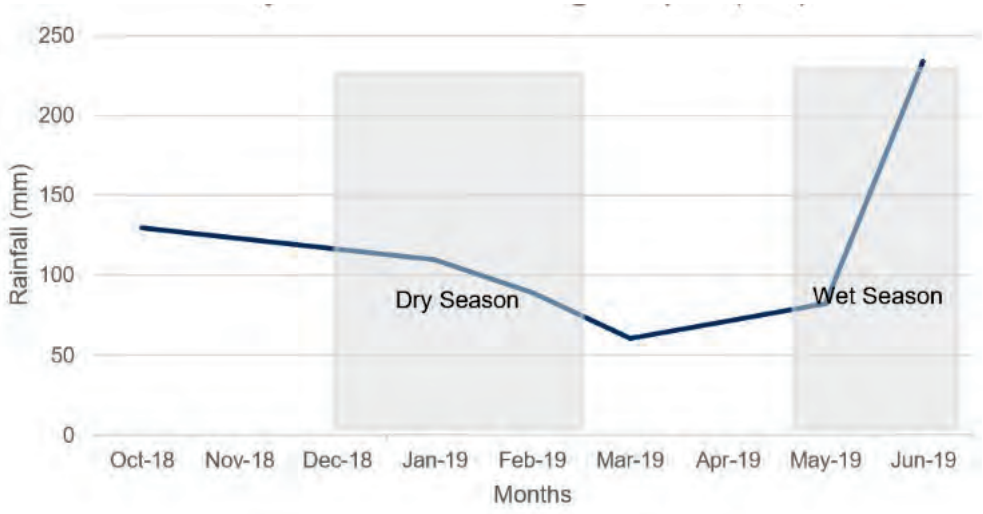
After completing the initial year of fish surveys required by the Environmental Permit for the Liza Phase 1 Development Project, EEPGL elected to continue the study for another year, extending the field

[1] Primarily for sale, typically larger volume than small-scale fisheries

[2] Typically small volume, and often using traditional techniques and little technology; sometimes referred to as "artisanal" fisheries

component of the study through the second quarter of 2019 (“the Year 2 Study”). Analysis of the samples collected during the second year of study continued through June 2020. The Year 2 Study included the same major components as the Year 1 Study, but in Year 2 EEPGL elected to add plankton sampling to the field program and expanded the fish landing study into a standalone participatory fishing study. Plankton sampling was carried out concurrently with the deepwater, continental shelf, and nearshore elements.

Coastal Guyana has a humid tropical climate characterized by two wet and two dry seasons. The Year 2 field activities were conducted from December 2018 through early February 2019 for the dry season, and from May to June 2019 for the wet season. As Figure 1-1 shows, rainfall data from Ogle Airport in Georgetown indicate that Guyana’s coastal region was transitioning into the dry season during the initial portion of the first Year 2 survey period, and was near the 9-month minimum for total monthly rainfall by the end of this survey period in February 2019. Rainfall increased sharply during the second Year 2 survey period. The results discussed herein therefore encompass conditions characteristic of both dry and wet season conditions.



Source: Guyana Hydrometeorological Service, 2020.

Figure 1-1: Coastal Rainfall Data, October 2018 to June 2019

2. OBJECTIVES

The goal of the second year of the Marine Fish Study was to continue to characterize Guyana's marine and estuarine fish communities. The primary objectives underpinning this goal were:

- Continue to develop the species lists that were initially developed during the Year 1 Study;
- Identify the main fish taxa occurring within each targeted zone (e.g., continental shelf, nearshore zone, etc.);
- Describe any important life history or ecological characteristics (such as reproductive status or gut contents) of the main species caught; and
- Collect information on benthic biological communities on an opportunistic basis (primarily on the continental shelf).

In addition to these primary objectives, the Year 2 Study had the following secondary objectives:

- Collect information on water quality conditions in the estuarine, nearshore, continental shelf, and deepwater marine zones; and
- Develop local capacity in marine survey techniques among government regulatory staff as well as local Guyanese contractors.

3. DISTRIBUTION OF SAMPLING STATIONS

Sampling stations were distributed from the estuaries to the outer continental slope in areas between the Stabroek Block and the Guyana coast. The following subsections describe the locations of sampling stations within the four hydrographic zones included in the Marine Fish Study (i.e., deepwater, continental shelf, nearshore, and estuarine zones).

3.1 Deepwater Sampling Stations

Deepwater sampling was carried out using a set of four traps (cylindrical in shape, with a mesh size of ½ inch and each weighing approximately 20 kilograms) on the seafloor at two different depths: ~1,000 meters (in the vicinity of the Liza field) and ~2,000 meters (in the vicinity of the Payara field). Four traps in total were deployed at each depth.

The sample locations were selected based on bathymetry and were intended to help sample and analyze a cross-section of different water depths, benthic habitats, and known fishing areas and zones. The currents were so strong during the dry season that deepwater sampling was not conducted. Table 3.1 shows the release coordinates (when traps were lowered into the water), and retrieval coordinates (when the traps were retrieved) for the deepwater traps. Figure 3.1 depicts the locations where the traps were released and retrieved.

Table 3.1: Year 2 Deepwater Sampling Locations (Wet Season Only)

Location	Trap Numbers	Release/Recovery	UTM—WGS 84 Coordinates	Depth (m)
Location Liza ~ 1,000 m depth				
Location A	NAS-1 and NAS-2	Release	500039.67 m E, 889422.51 m N	1,050
	NAS-3 and NAS-4	Release	500005.74 m E, 889472.69 m N	
Location B	NAS-1 and NAS-2	Recovery	483697.63 m E, 899282.66 m N	
	NAS-3 and NAS-4	Recovery	483240.89 m E, 899570.75 m N	
Location Payara ~ 2,000 m depth				
Location C	NAS-1 and NAS-2	Release	499678.26 m E, 910029.50 m N	2,010
	NAS-3 and NAS-4	Release	499533.38 m E, 910023.97 m N	
Location D	NAS-1 and NAS-2	Recovery	464965.47 m E, 934255.55 m N	2,005
	NAS-3 and NAS-4	Recovery	464894.85 m E, 934306.33 m N	

E = east; m = meter; N = north; UTM = Universal Transverse Mercator; WGS = World Geodetic System

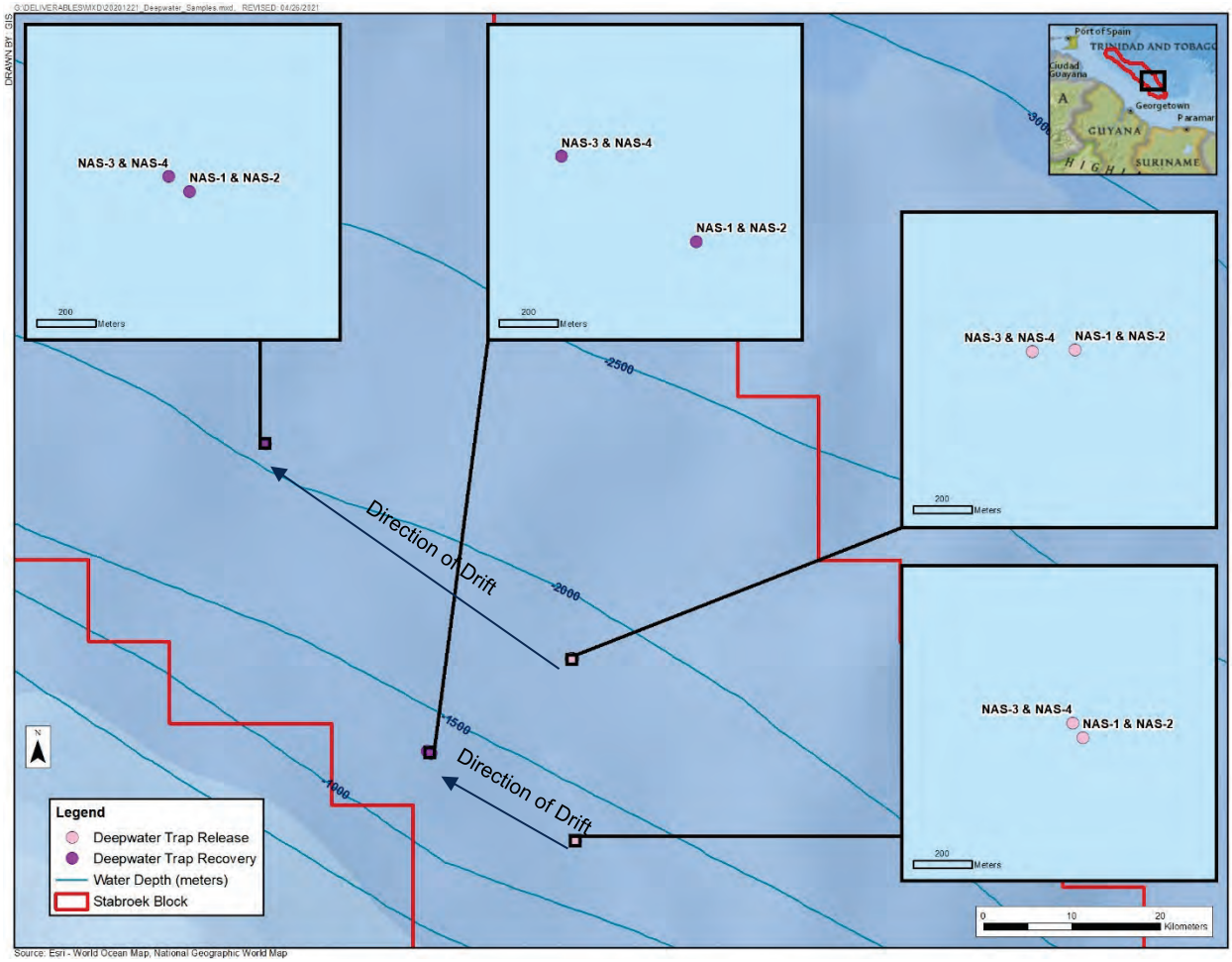


Figure 3-1: Locations of Year 2 Deepwater Trap Releases and Recoveries

3.2 Continental Shelf Sampling Stations

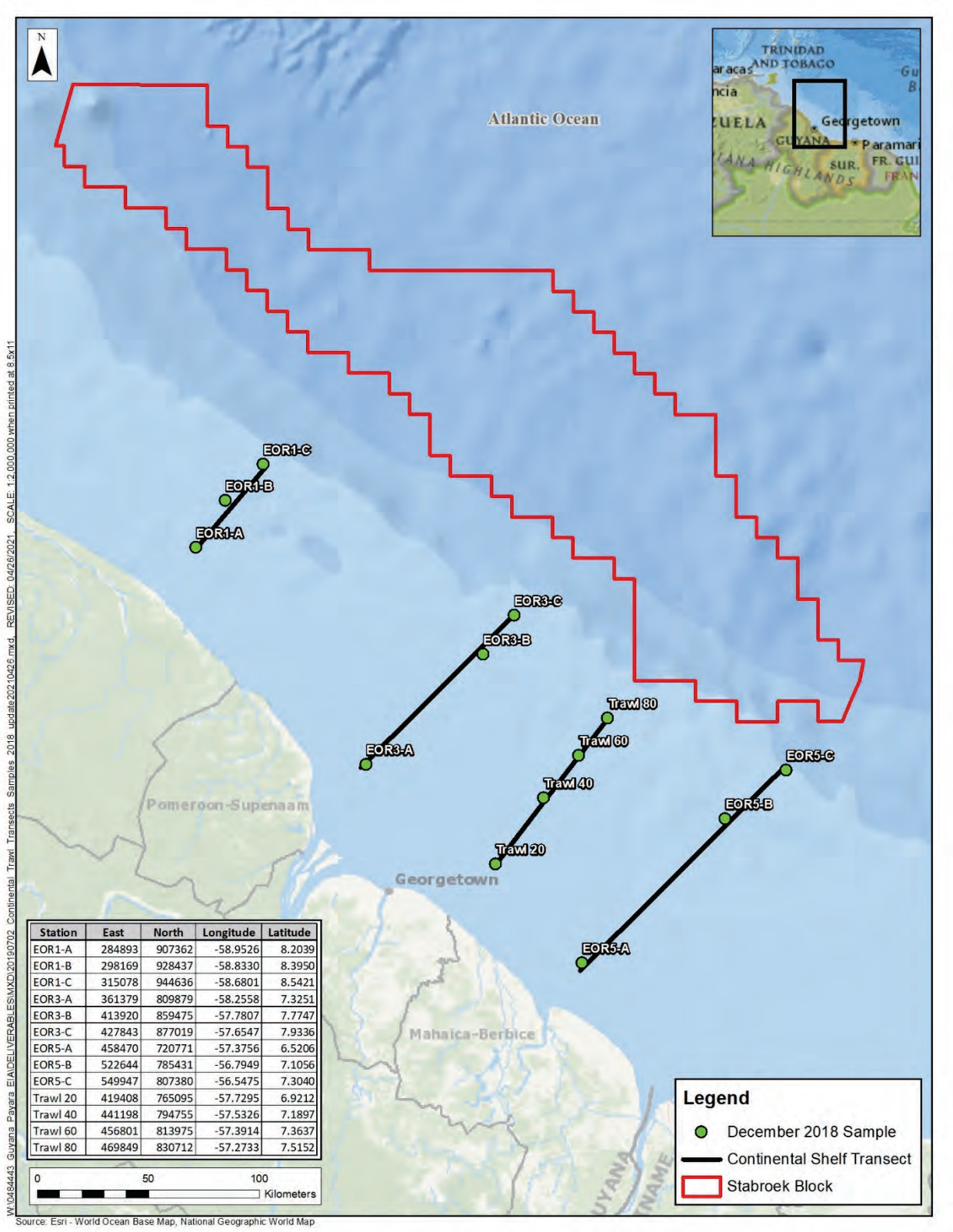
Thirteen continental shelf stations were arranged along four transects roughly perpendicular to the coast. The four transects were established with reference to the coastal regions: near the Shell Beach Protected Area in Region 1 (transect EOR1), Region 3 (transect EOR3), Region 4 (transect TRAWL), and Region 5 (transect EOR5). Transects EOR1, EOR3, and EOR5 were arranged approximately equidistant from one another with a northeasterly orientation, and the fourth transect (TRAWL) was established exclusively for trawl sampling and was located between the EOR3 and EOR5 transects. During the wet season, the fourth transect (TRAWL) was not sampled.

Three stations were established on each transect, and were labeled “A,” “B,” and “C,” in order of increasing depth. Four stations were established on the TRAWL transect at approximately 20-meter depth intervals between the coast and the 80 m isobath. The coordinates of the continental shelf stations are provided in Table 3.2. Table 3.2 shows the locations of the continental shelf sampling stations.

Table 3.2: Year 2 Continental Shelf Sampling Stations

Station	Depth (meters)	Location (UTM-WGS 84 Coordinates)	
		East	North
EOR1-A	35	284893	907362
EOR1-B	126	298169	928437
EOR1-C	200	315078	944636
EOR3-A	60	361379	809879
EOR3-B	160	423920	859475
EOR3-C	250	427843	877019
EOR5-A	60	458470	720771
EOR5-B	110	522644	785431
EOR5-C	250	549947	807380
TRAWL 20	20	419408	765095
TRAWL 40	40	441198	794755
TRAWL 60	60	456801	813975
TRAWL 80	80	469849	830712

UTM = Universal Transverse Mercator; WGS = World Geodetic System



Station	East	North	Longitude	Latitude
EOR1-A	284893	907362	-58.9526	8.2039
EOR1-B	298169	928437	-58.8330	8.3950
EOR1-C	315078	944636	-58.6801	8.5421
EOR3-A	361379	809879	-58.2558	7.3251
EOR3-B	413920	859475	-57.7807	7.7747
EOR3-C	427843	877019	-57.6547	7.9336
EOR5-A	458470	720771	-57.3756	6.5206
EOR5-B	522644	785431	-56.7949	7.1056
EOR5-C	549947	807380	-56.5475	7.3040
Trawl 20	419408	765095	-57.7295	6.9212
Trawl 40	441198	794755	-57.5326	7.1897
Trawl 60	456801	813975	-57.3914	7.3637
Trawl 80	469849	830712	-57.2733	7.5152

Figure 3-2: Locations of Year 2 Continental Shelf Sampling Stations

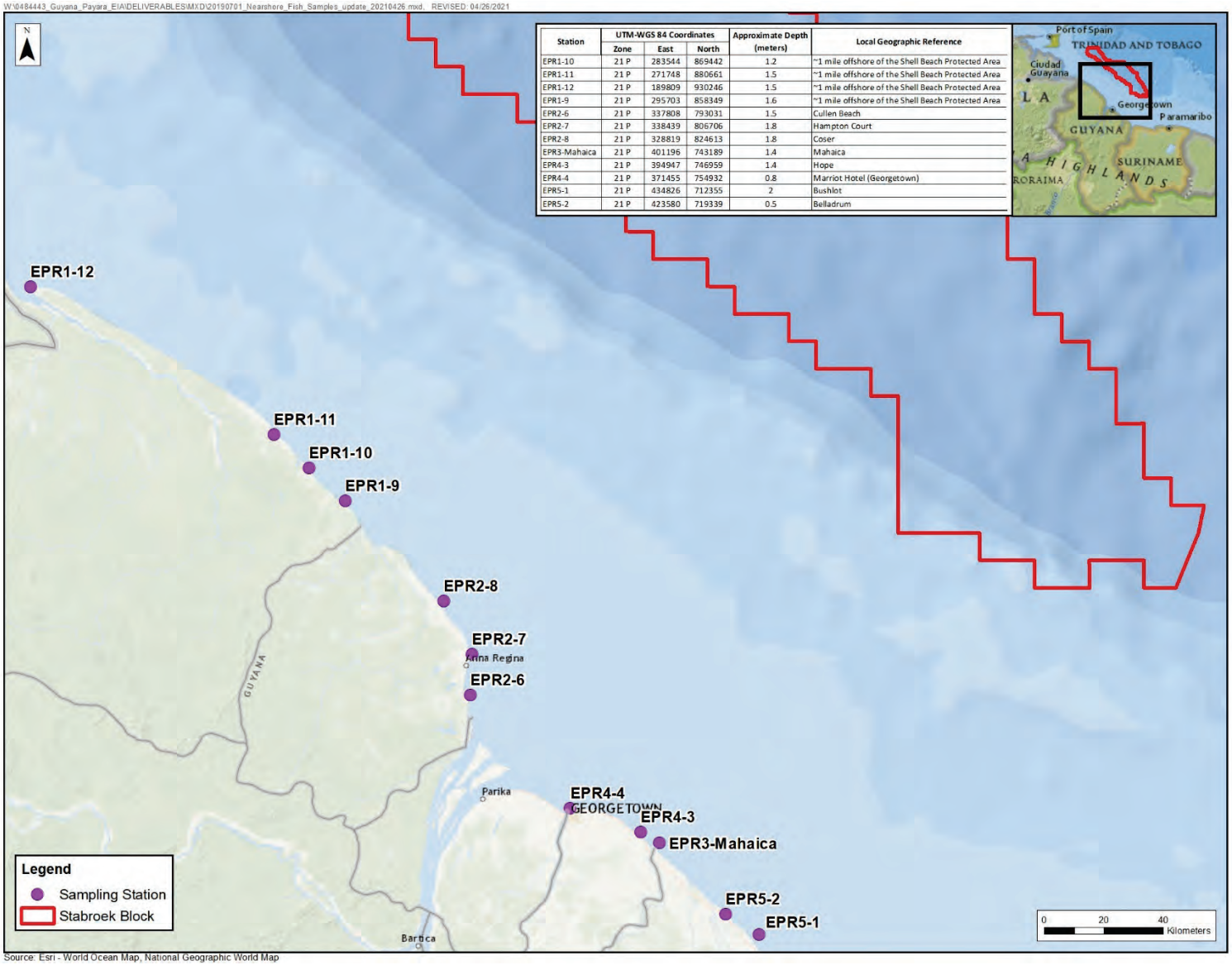
3.3 Nearshore Sampling Stations

Nearshore sampling stations were located based on observations of fishing activity, habitat characteristics, and input received during the first year of the Marine Fish Study from former fisheries officers and from local community members that were knowledgeable about fishing activities. The nearshore sampling stations were generally located near main fish landing sites along the coast or near the mouths of rivers or canals where small-scale fishing captains moor their vessels. The coordinates of the nearshore sampling stations are provided in Table 3.3. Figure 3.3 shows the locations of the nearshore sampling stations.

Table 3.3: Year 2 Nearshore Sampling Stations

Station	Location		Approximate Depth (meters)	Local Geographic Reference
	UTM-WGS 84 Coordinates			
	East	North		
EPR1-12	189809	930246	1.5	~1 mile offshore of the Shell Beach Protected Area
EPR1-11	271748	880661	1.5	~1 mile offshore of the Shell Beach Protected Area
EPR1-10	283544	869442	1.2	~1 mile offshore of the Shell Beach Protected Area
EPR1-9	295703	858349	1.6	~1 mile offshore of the Shell Beach Protected Area
EPR2-8	328819	824613	1.8	Coser
EPR2-7	338439	806706	1.8	Hampton Court
EPR2-6	337808	793031	1.5	Cullen Beach
EPR4-4	371455	754932	0.8	Marriott Hotel (Georgetown)
EPR4-3	394947	746959	1.4	Hope
EPR3-Mahaica	401196	743189	1.4	Mahaica
EPR5-2	423580	719339	0.5	Belladrum
EPR5-1	434826	712355	2	Bushlot

UTM = Universal Transverse Mercator; WGS = World Geodetic System



Station	UTM-WGS 84 Coordinates			Approximate Depth (meters)	Local Geographic Reference
	Zone	East	North		
EPR1-10	21 P	283544	869442	1.2	~1 mile offshore of the Shell Beach Protected Area
EPR1-11	21 P	271748	880661	1.5	~1 mile offshore of the Shell Beach Protected Area
EPR1-12	21 P	189809	930246	1.5	~1 mile offshore of the Shell Beach Protected Area
EPR1-9	21 P	295703	858349	1.6	~1 mile offshore of the Shell Beach Protected Area
EPR2-6	21 P	337808	793031	1.5	Cullen Beach
EPR2-7	21 P	338439	806706	1.8	Hampton Court
EPR2-8	21 P	328819	824613	1.8	Coser
EPR3-Mahaica	21 P	401196	743189	1.4	Mahaica
EPR4-3	21 P	394947	746959	1.4	Hope
EPR4-4	21 P	371455	754932	0.8	Marriot Hotel (Georgetown)
EPR5-1	21 P	434826	712355	2	Bushlot
EPR5-2	21 P	423580	719339	0.5	Belladrum

Figure 3-3: Locations of Year 2 Nearshore Sampling Stations

3.4 Estuarine/Riverine Sampling Stations

Estuarine/riverine sampling stations were located within the estuarine portions of the main rivers draining Guyana's coastal plain to assess the species composition of the estuarine fish community and evaluate the continuity between the estuarine and marine fish communities. Five major rivers (Pomeroon, Essequibo, Demerara, Mahaica, and Berbice) were sampled during the dry season; these same rivers were sampled and a sampling station on the Waini River was added in the wet season. The coordinates of the estuarine sampling stations are provided in Table 3.4. Figure 3.4 shows the locations of the estuarine sampling stations.

Table 3.4: Year 2 Estuarine/Riverine Sampling Locations

Station	UTM—WGS 84 Coordinates		River
	East	North	
EPE-RB	441009	696398	Berbice
EPE-RM	398686	740680	Mahaica
EPE-RD	371078	751795	Demerara
EPE-RE	336146	774007	Essequibo
EPE-RP	308778	840460	Pomeroon
EPE-RW	195099	925168	Waini

UTM = Universal Transverse Mercator; WGS = World Geodetic System

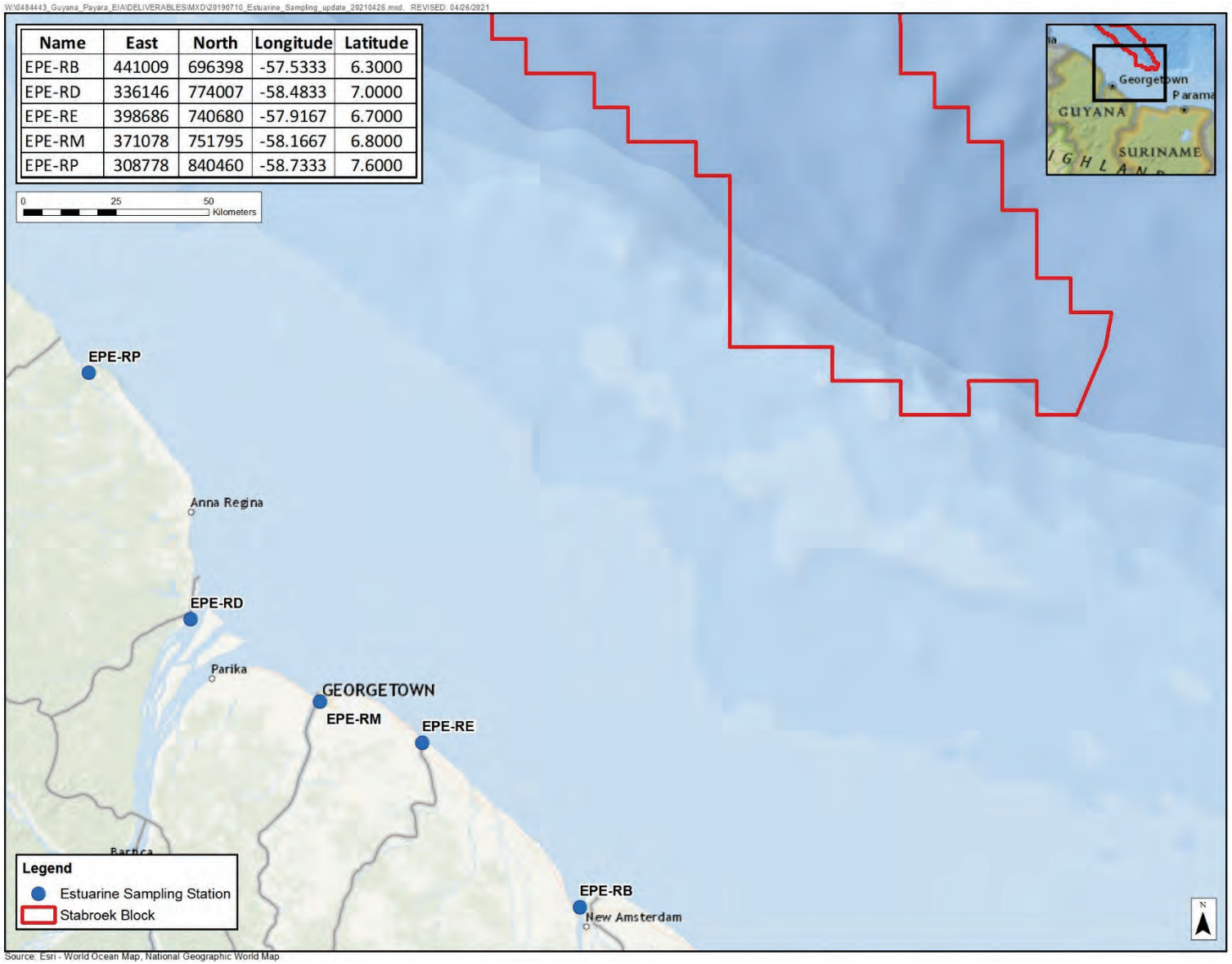


Figure 3-4: Locations of Year 2 Estuarine/Riverine Assessment Sampling Stations

3.5 Plankton Sampling Stations

The study area for the plankton component was defined using a transect approach that extended from the nearshore zone to the 2,000-meter (6,561.7-foot) isobath in the Stabroek Block. The study area was surveyed once during the dry season, and once during the wet season. During the dry season, samples were taken along five parallel transects that extended from nearshore to offshore waters. Five stations were established per transect. Additionally, another four stations were established at specific locations of interest, including one each near the Payara and Liza Phase 2 Project Development Areas, one station at the mouth of the Waini River, and one station at the mouth of the Essequibo River.

The wet season plankton survey was performed on three transects on the continental shelf. The wet season plankton survey included a smaller number of stations than the dry season for the following reasons:

- The coastal stations generally produced few species samples during the dry season. No eggs were captured at any of the coastal stations, and the zooplankton and ichthyoplankton samples at these stations contained far fewer species than the stations further out on the continental shelf. The coastal stations were therefore eliminated from the wet season sampling;
- As noted above, the TRAWL transect was eliminated entirely in the wet season;
- No other sampling was planned in the far northwestern and southern portions of the Stabroek Block, and the sea conditions and capabilities of the vessel combined would have required several additional days to reach these areas; accordingly, these sample stations were abandoned in favor of collecting samples in the Liza and Payara Project Development Areas.

The coordinates of the plankton sampling stations are provided in Table 3.5. The locations of the plankton sampling stations are depicted on Figure 3.5.

Table 3.5: Year 2 Plankton Sampling Locations

Station	UTM—WGS 84 Coordinates		Season
	East	North	
ECP-R0-A	189814	930288	Dry
ECP-R1-A	266418	887999	Dry
ECP-R2-A	306074	847920	Dry
ECP-R3-A	338747	792156	Dry
ECP-R3.5-A	339694	808261	Dry
ECP-R4-A	398250	741370	Dry
ECP-R5-A	448183	702932	Dry
EOP-R1-B	283903	906916	Both
EOP-R1-C	309542	934707	Both
EOP-R1-D	335252	962668	Both
EOP-R1-E	363095	992000	Dry
EOP-R2-B	318160	859500	Dry
EOP-R2-C	347451	888371	Dry
EOP-R2-D	376109	916963	Dry
EOP-R2-E	404344	944547	Dry
EOP-R3-B	358031	809641	Both

Station	UTM—WGS 84 Coordinates		Season
	East	North	
EOP-R3-C	391955	842955	Both
EOP-R3-D	426342	875124	Both
EOP-R3-E	459746	907687	Dry
EOP-R4-B	410679	752421	Dry
EOP-R4-C	446547	788624	Dry
EOP-R4-D	482572	823450	Dry
EOP-R4-E	459746	907687	Dry
EOP-R5-B	461265	715796	Both
EOP-R5-C	499491	755153	Both
EOP-R5-D	537791	794228	Both
EOP-R5-E	574533	832017	Dry
Liza Location	505225	886539	Both
Payara Location	503234	908943	Both

UTM = Universal Transverse Mercator; WGS = World Geodetic System

Figure 3-5: Locations of Year 2 Ichthyoplankton Sampling Stations

4. METHODS AND EQUIPMENT

The methodologies and equipment used in the second year of the Marine Fish Study were generally similar to the methods used in the first year of the study, as described in Sections 2 and 3 of this report. The methodologies and equipment used to sample the fish community were selected based on their expected effectiveness for the species of fish that are known to occur in the region, and have been proven effective in other fishery assessments in the northern South America/ Caribbean region. Equipment and instruments used to sample fish in the field included: trawl nets, longlines, gillnets, cast nets, seines, and fish traps. Descriptions of the methods used to sample the deepwater, continental shelf, nearshore, and estuarine zones are provided in the following subsections.

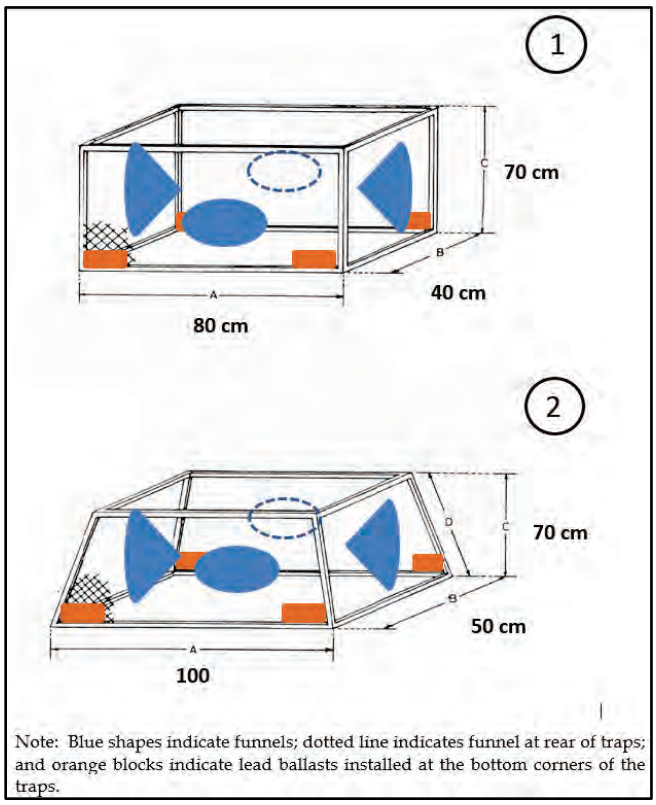
4.1 Deepwater Fish Sampling Methods

Due to the extreme depths within the Stabroek Block, net- and hook-based sampling technologies were not practical for sampling demersal species at the deepest sample stations. Accordingly, ERM constructed purpose-built deep-sea traps in Guyana in order to sample demersal biota on the continental slope and within the Stabroek Block. Sea trap frames were constructed of welded rebar that was treated with a rustproof coating. Each trap was then fitted with an outer mesh, and four mesh cones were sewn into the outer mesh to allow organisms to enter the traps. Traps were constructed in rectangular or trapezoidal shapes. Figure 5-1 illustrates the two types of traps and Figure 4-2 shows a photograph of the traps. Traps were baited with two King weakfish (also known as Bangamary; *Macrodon ancylodon*) and 1 kilogram (kg) of pork chop per trap.

Sampling locations are provided in Section 3.1. Pairs of rectangular and trapezoidal traps were deployed at each sampling station and each pair of traps was connected to a pair of buoys that remained at the surface with a line between them to aid in retrieval (Figure 4-3). Traps were deployed and left overnight before being retrieved the following day.

The different sizes of nets and hooks described below were selected to target specific sizes of fish and because they are known to be effective for a type or size of fish that was anticipated to occur in the study area. By deploying a variety of types and sizes of fishing gear, the study sought to increase the likelihood of catching specimens of different species and sizes, targeting a more complete representation of the fish community in the study area. In addition to the nets described below, supplemental sampling was completed using lines with hooks (hand lines) and luminescent “lures” targeting squid and to be able to cover a larger portion of the water column at each station.

Figure 4-1: Rectangular and Trapezoidal Traps



Note: 1 = rectangular trap; 2 = trapezoidal trap

Figure 4-2: Photograph of Traps

Figure 4-3: Deep Sea Trap Buoy System

4.2 Continental Shelf Fish Sampling Methods

4.2.1 Trawl Sampling Procedure

Trawling consists of dragging one or more nets over the seafloor. The net has a chain on its lower end, a line of buoys at the top, and large wooden planks called “doors” at each side. As the vessel tows the trawl through the water, pressure exerted on the doors by water passing over their leading surface causes the mouth of the net to open and catch marine organisms. This fishing gear is typically used to target shrimp and demersal fish.

Doors were comprised of four planks of 8-foot length and 36-inch width – each with five vertical and four horizontal wood planks with 2-inch slots between them. The cable securing system was composed of ½-inch chains that allow easy attack angle adjustment. To accommodate the desired trawl depth (which varied between 10 m and 80 m), the amount of towing cable per reel was approximately 400 m. The ballast system was made up of 30 sets of 3/8-inch chain with 6 links, for a total weight of approximately 50 kg per net. The trawl net panels consisted of N° 21 green polyethylene (PE) with a 2-inch mesh.

The trawl nets used in the study were fitted with turtle excluder devices (TEDs). The devices were constructed of solid galvanized aluminum bars with an oval frame approximately 40 inches high by 35 inches wide, with a ¾-inch diameter. The frame contained parallel bars with 4.5 inches of space between each bar. The TEDs were located on the cod end[3] of the trawl nets and each TED was fitted with two 200-mm diameter buoys to maintain proper position while deployed. In order to standardize sampling effort, soak time for the trawls was limited to 30 minutes per station. In commercial situations, the Guyana shrimp fishing fleet typically trawls for longer periods. Trawling was carried out at Stations A, B, and C alongthe EOR-1, EOR-3, and EOR-5 transects and at 20m, 40m, 60m, and 80m depths on the TRAWL transect.

4.2.2 Gillnet Sampling Procedure

Gillnets are designed to entangle fish and other organisms, and can be used alone or in groups (set of nets). Depending on design, ballast, and buoyancy, they may be used at the surface, in the middle of the water column, or near the seafloor. Gillnets are generally constructed of monofilament nylon, and may have one or more panels, each with a variable length (typically between 100 m and 180 m) and a height between 1.5 m and 2.4 m. The net openings are known as the “mesh”, and are generally measured in inches when stretched corner to corner. The size of the mesh is proportional to the gauge of the monofilament, with larger mesh nets using heavier gauge monofilaments. Heavier-gauge lines form the upper and lower edges of the net, holding the edges of the mesh in place and helping to give the net its shape. Buoys are attached to the upper line and weights to the lower one in order to keep the net extended through the water column and prevent it from collapsing.

Gillnets used in this study were made of green nylon monofilament. Each panel was 100 m long by 2 m wide (i.e., for a total net set length of 300 m). Each net set was allowed to soak for 2.5 hours excluding time to deploy and retrieve each set. Gillnets were deployed at the surface and on the bottom at each station and contained up to three panels of different mesh sizes (mesh sizes of ¼ inch, 1 inch and 2½ inch – collectively a “set of nets”) at each of the surface and bottom (30 m) strata.

Three sets of nets were deployed at the surface at each station. Buoys were affixed at the ends of each surface set to maintain adequate positive buoyancy. Bottom net sets were arranged similarly, but additional ballast was added to the bottom net sets to keep them on the sea floor. A halyard connected the bottom net set to a buoy to mark the location of the net set and maintain the net set at the desired depth. Surface and bottom net sets were deployed from the vessel side in the direction of the current; after releasing the last buoy, the end was attached to the ship’s bow and the engines were shut down for the 2.5-hour standard soak time.

4.2.3 Longline Sampling Procedure

Longlines consist of a series of baited hooks and can be fished at the surface or lower in the water column. Longlines were deployed at two depths in the survey: one at the surface and the other at a depth of 50 m. Each line was composed of 35 hooks in three sizes (Mustang scale: 01, 04 and 06), including 15 hooks of size 01, 10 hooks of size 04, and 10 hooks of size 06. These were separated along the main line at a spacing of 5 m, with 2-m snoods[4]. Each longline had a total length of 200 m. The physical characteristics of the longlines used in this assessment are presented in Table 4.1.

[3] Rear portion of a trawl net, which retains the catch.

[4] A “snood” is a short line that connects the hook to the main longline. It is often abrasion-resistant and made of a smaller diameter line and provides some separation between the bait and the main line to help prevent fish from detecting the main line.

Table 4.1: Characteristics of Longlines Used to Sample on the Continental Shelf

Characteristics	Deep Longline (50 m depth)	Surface Longline (1 m depth)
Length of line	200 m	200 m
Number of hooks	35	35
Type of steel hook (Mustang Number/Size)	N° 10 (15 hooks)	N° 10 (15 hooks)
	N° 04 (10 hooks)	N° 04 (10 hooks)
	N° 06 (10 hooks)	N° 06 (10 hooks)
Line material	Monofilament nylon (3.5 mm)	Monofilament nylon (3.5 mm)

Each longline was deployed into the water at a constant speed from one of the vessel sides in order to keep the fishing gear oriented in the direction of the current, and to avoid entanglement with the vessel. Prior to deployment, a signal buoy was tied to each end of the longline. Once in the water, the longline was secured to the vessel using a 50-m cord to ensure the fishing gear was deployed correctly and to avoid it being carried away by the current. The location where each longline was deployed was recorded on the vessel's Global Positioning System (GPS) unit.

4.3 Nearshore Fish Sampling Methods

All nearshore sampling was done in the morning. Vessel-based sampling was performed with gillnets which were deployed from shallow-draft small-scale fishing vessels smaller than 30 feet in length, with outboard motors of 40 to 60 horsepower. Nearshore gillnets were deployed at the surface and at the bottom in 7 to 8 feet of water at each station. Each net contained up to three panels of mesh sizes (mesh sizes of 0.25 inch, 1 inch, and 2.5 inches). The gillnets used in this study were made of nylon monofilament. Each panel was 50 meters long by 2 meters wide (i.e., for a total net set length of 100 square meters). Buoys were affixed at the ends of each surface multipanel net to maintain adequate positive buoyancy. Bottom nets were arranged similarly, but additional ballast was added to the bottom net sets to keep them on the sea floor. A halyard connected the bottom net set to a buoy to mark the location of the net set and maintain the net set at the desired depth. Surface and bottom net sets were deployed from the vessel side in the direction of the current. After the last buoy was released, the end was attached to the ship's bow and the engines were shut down to allow the net to soak. Each multipanel net was allowed to soak for 2 hours, excluding time to deploy and retrieve.

Land-based sampling was performed using cast nets in shallow water (1-2 m depth). Cast nets were thrown 10 times at each station (Table 4.2). Seines were pulled in wadeable waters at each sampling station. Three seine passes were completed at each station (Table 4.2).

Table 4.2: Characteristics of Gear Used to Sample Nearshore Stations

Gear	Mesh Size (Inches)	Panel Length/ Weight	Effort per Station
Gillnet	1	100 meters	2.5 hours
Seine net	0.25	12 meters	3 passes
Cast net	1	8 kg	10 throws

4.4 Estuarine Fish Sampling Methods

Estuarine sampling stations were established at the mouths of large rivers. Habitats that appeared likely to aggregate fish (especially juvenile fish) were selected based on physical habitat complexity, water velocity, type of substrate, depth, and type of riparian vegetation. At each station, an area of approximately 25 m^2 was sampled using electrofishing equipment. The position of each sampling station

was determined by marking the coordinates with a GPS unit, navigator, and by means of visual references.

Sampling was carried out during daylight and to the extent possible during high tides to allow navigational access to riparian vegetation, mangrove areas, and other shallow riparian habitat features that are known to attract juvenile fish.

Safety considerations specific to electrofishing included:

- Adjusting the output based on the salinity of the water, such that the minimum voltage required to achieve the desired effect was used;
- Recognizing that sampling activities would occur in shallow water and would require the operation of sampling equipment of the sides of the vessels, selection of vessels with shallow draft and wide beams to enhance lateral stability;
- Placing the electric generator as near as possible to the center of the vessel's hull to minimize the risk of destabilizing the vessel; and
- Using tarps to cover the equipment during rainy weather.

Electrofishing operations were carried out from a vessel with capacity for five people that was prepared for electrofishing activities. This vessel allowed the containment of the electrofishing equipment (generator, battery, power converter, anode and cathode cables) and personnel and other sampling equipment (including safety equipment).

In slow waters, the movement of the boat was controlled by the use of a rope attached to an anchor on the shore. Specimens captured were placed in labeled plastic containers and the containers were stored on ice in order to preserve the diagnostic characteristics of the fish, and to improve the ability to identify them taxonomically and perform the necessary biometrics measurements.

4.5 Ichthyoplankton Sampling Procedure

The ichthyoplankton component was added as a new study component in the second year of the Marine Fish Study. Plankton were collected at three different depths using conical-cylindrical double Bongo nets towed behind a vessel. The Bongo net was put into the water after being connected to a towrope. The boat traveled at a speed of 2 knots[5] for 15 to 20 minutes. The start and end time of each sampling period was recorded. The nets were towed at an oblique orientation through the water column; see Figure 4-4). Plankton samples were collected at the surface in the offshore stations, at mid-depths (50 to 150 meters [164 to 492.1 feet]) on the continental shelf, and near the bottom in the nearshore stations. A double Bongo net (0.7-meter mouth diameter) with a 500-micrometer mesh was used for offshore and continental shelf samples (see Figure 4-4). In the nearshore environment, a smaller Bongo net was used (0.25-meter [2.3-foot] mouth diameter). Each mesh was attached to a collection container. A calibrated flowmeter was mounted in the center of each net mouth for determination of the volume of water filtered through the net.

Once brought on board, the net was carefully rinsed and the collection containers were removed from the meshes and emptied into pre-marked jars labeled with date, time, and location. The biological material captured in the collection container was preserved in formaldehyde solution, and buffered with sodium tetraborate diluted in seawater to effect an approximate final concentration of 4 percent.[6] Ichthyoplankton species were identified in a laboratory setting to the lowest taxonomic level practicable using keys and

[5] Measured with Global Positioning System, towed against the current

[6] All materials were purchased locally, to the extent that they were available.

references. The filtered volume was calculated from the flowmeter readings and used to calculate the abundance of fish eggs and larvae per 100 cubic meters of filtered water.

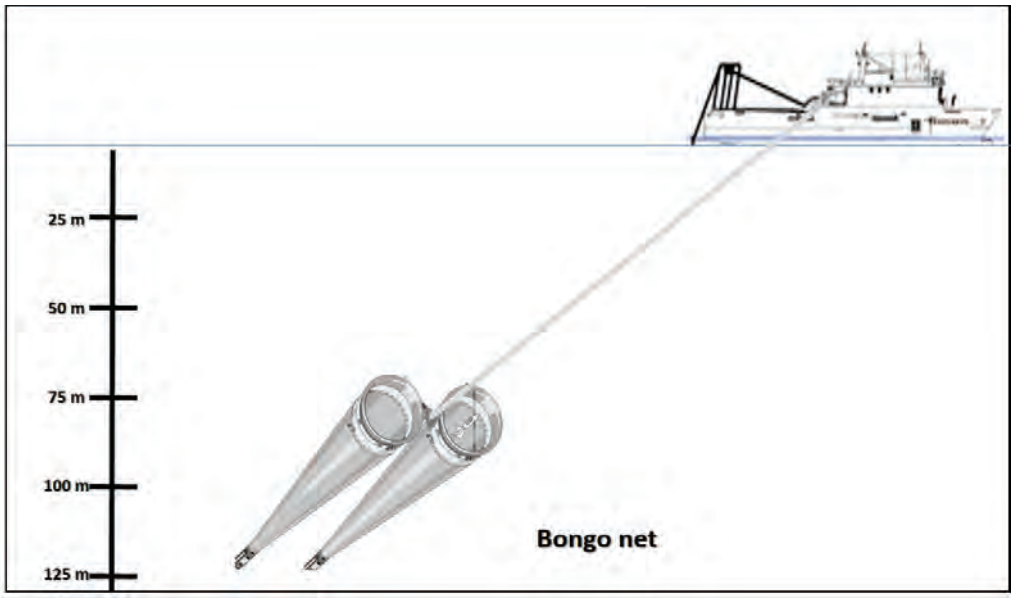


Figure 4-4: View of Oblique Plankton Trawl Using a Bongo Net

4.6 Sampling Abiotic Parameters

A Van Dorn sampling bottle was used to collect water samples at each continental shelf and nearshore sampling station[7]. The following abiotic measurements were taken using a multi-parameter water quality sampler, turbidimeter, and Secchi disk:

- Ambient air temperature (°C)
- Surface temperature (°C)
- pH (standard pH units)
- Dissolved oxygen (mg/L)
- Salinity (ppm)
- Conductivity (mS/cm)
- Turbidity (NTU)

[7] Abiotic data were not collected at the deepwater stations because EEPGL has conducted multiple environmental baseline surveys that include water quality data collection.

5. RESULTS

5.1 Deepwater Sampling Results

The deepwater zone was not sampled with the deepwater traps in the dry season due to rough sea conditions in the Stabroek Block that made it impossible to deploy the traps safely. Although deepwater traps were deployed during the wet season, no species were captured during the deepwater sampling effort. Please see Attachment A for photographs of field activities during the deepwater assessment.

5.2 Continental Shelf Sampling Results

5.2.1 Species Richness

Thirteen stations were sampled across four transects on the continental shelf during the Year 2 surveys. These stations produced 92 species belonging to 49 families (see Table 5.1). The most diverse families in the continental shelf samples were the Sciaenidae (drums and croakers, 13 species), Haemulidae (grunts, seven species), Ariidae (sea catfishes, four species), Triglidae (sea robins, four species) and Lutjanidae (snappers, four species). These five families accounted for approximately 35 percent of the species captured on the continental shelf, exclusive of plankton[8].

The dry season catch included 41 species distributed across 25 families. The wet season catch included 78 species distributed across 45 families. Unidentified flying fish (*Exocetus* sp.*)* were observed regularly at the deeper stations, while dolphinfish and triggerfish (probably *Balistes capriscus*) were observed sporadically in these areas. Squid were often observed in these areas at night, likely because they were attracted to the vessel lights. These species were not caught, likely because they were not attracted to the bait used or because the individuals were too small for the fishing gear being used. The C stations accounted for the highest numbers of species across all transects during the dry season. During the wet season, the A stations accounted for the highest number of species caught.

[8] Plankton are analyzed separately from nekton in this report because the distribution of plankton is driven almost entirely by environmental factors, whereas the distribution of nekton results from a combination of environmental and behavioral factors.

Table 5.1: Continental Shelf Assessment Results – Year 2

Family	Species	Common Name [a,b]	Dry Season				Wet Season			
			No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass	No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass
Achiridae	*Achirus achirus*	Drab sole	—	—	—	—	4	0.66	117.00	0.17
	Achirus declivis	Plainfin sole	—	—	—	—	1	0.17	29.00	0.04
	Apionichthys dumerili	Longtail sole	—	—	—	—	12	1.99	126.00	0.19
Antennariidae	*Antennarius* sp.	Striated frogfish	—	—	—	—	1	0.17	8.00	0.01
Ariidae	*Amphiarius rugispinis*	Softhead sea catfish	—	—	—	—	10	1.66	680.30	1.00
	Bagre bagre	Coco sea catfish	—	—	—	—	20	3.32	482.20	0.71
	Bagre marinus	Gafftopsail sea catfish	1	0.49	0.80	0.00	—	—	—	—
	Sciades herzbergii	Pemecou sea catfish	2	0.98	4,400.00	9.51	5	0.83	173.00	0.25
Aspredinidae	*Aspredo aspredo*	Banjo	—	—	—	—	13	2.16	135.00	0.20
Balistidae	*Balistes capriscus*	Grey triggerfish	21	10.29	9,390.00	20.29	6	1.00	3,087.00	4.54
Batrachoididae	*Batrachoides surinamensis*	Pacuma toadfish	—	—	—	—	3	0.50	530.00	0.78
	Porichthys plectrodon	Atlantic midshipman	—	—	—	—	5	0.83	103.00	0.15
Bothidae	*Bothus robinsi*	Twospot flounder	—	—	—	—	23	3.81	401.60	0.59
Carangidae	*Chloroscombrus chrysurus*	Atlantic bumper	—	—	—	—	12	1.99	300.00	0.44
	Oligophites saurus	Leatherjacket	5	2.45	1,840.00	3.98	—	—	—	—
	Selene vomer	Lookdown	—	—	—	—	7	1.16	78.00	0.11
Carcharhinidae	*Carcharhinus brevipinna*	Spinner shark	7	3.43	23.50	0.05	—	—	—	—
	Negaprion brevirostris	Lemon shark	—	—	—	—	1	0.17	6,000.00	8.82
Centropomidae	*Centropomus undecimalis*	Common snook	—	—	—	—	3	0.50	950.00	1.40
Clupeidae	*Harengula clupeola*	False herring	11	5.39	1,130.00	2.44	—	—	—	—
	Odontognatus mucronatus	Guiana longfin herring	1	0.49	10.00	0.02	11	1.82	153.50	0.23
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	5	2.45	14.00	0.03	—	—	—	—
Cynoglossidae	*Symphurus plagusia*	Duskycheek tonguefish	1	0.49	150.00	0.32	—	—	—	—
Dasyatidae	*Hypanus guttatus*	Longnose stingray	—	—	—	—	2	0.33	3,100.00	4.56
Diodontidae	*Chilomycterus antillarum*	Web burrfish	4	1.96	410.00	0.89	3	0.50	71.00	0.10
Echeneidae	*Echeneis naucrates*	Live sharksucker	13	6.37	10.35	0.02	2	0.33	600.00	0.88
Elopidae	*Elops saurus*	Ladyfish	—	—	—	—	1	0.17	2,130.00	3.13
Engraulidae	*Anchoa spinifer*	Spicule anchovy	—	—	—	—	3	0.50	77.00	0.11
	Anchovia surinamensis	Surinam anchovy	—	—	—	—	6	1.00	39.00	0.06
	Anchoviella lepidentostole	Broadband anchovy	—	—	—	—	1	0.17	9.00	0.01
Ephippidae	*Chaetodipterus faber*	Atlantic spadefish	2	0.98	360.00	0.78	7	1.16	1,273.00	1.87
Exocoetidae	*Exocoetus sp*	Unidentified flying fish	—	—	—	—	2	0.33	24.00	0.04
Gereidae	*Eucinostomus gula*	Jenny mojarra	—	—	—	—	10	1.66	349.20	0.51
Gymnuridae	*Gymnura micrura*	Smooth butterfly ray	—	—	—	—	3	0.50	641.00	0.94

Family	Species	Common Name [a,b]	Dry Season				Wet Season			
			No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass	No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass
Haemulidae	*Anisotremus virginicus*	Porkfish	—	—	—	—	1	0.17	204.00	0.30
	Genyatremus luteus	Annafolk	—	—	—	—	6	1.00	423.00	0.62
	Haemulon carbonarium	Caesar grunt	2	0.98	220.00	0.48	10	1.66	407.00	0.60
	Haemulon sp.	Unidentified grunt	—	—	—	—	2	0.33	16.00	0.02
	Haemulon aurolineatum	Tomtate grunt	—	—	—	—	1	0.17	60.00	0.09
	Haemulopsis corvinaeformis	Roughneck Grunt	—	—	—	—	3	0.50	398.00	0.59
	Orthopristis ruber	Corocoro grunt	—	—	—	—	5	0.83	654.00	0.96
Lutjanidae	*Lutjanus analis*	Mutton snapper	3	1.47	550.00	1.19	7	1.16	63.00	0.09
	Lutjanus purpureus	Southern red snapper	2	0.98	270.00	0.58	15	2.49	336.60	0.49
	Lutjanus synagris	Lane snapper	13	6.37	4,370.00	9.44	—	—	—	—
	Pristipomoides aquilonaris	Wenchman	19	9.31	1,438.00	3.11	14	2.32	194.70	0.29
Monacanthidae	*Aluterus monoceros*	Leatherjacket	—	—	—	—	2	0.33	1,500.00	2.21
	Monacanthus ciliatus	Fringed filefish	—	—	—	—	5	0.83	54.00	0.08
Mugiliidae	*Mugil curema*	White mullet	1	0.49	540.00	1.17	—	—	—	—
Mullidae	*Upeneus parvus*	Dwarf goatfish	5	2.45	580.00	1.25	10	1.66	115.50	0.17
Muraenesocidae	*Cynoponticus savanna*	Guyana pike-conger	—	—	—	—	4	0.66	725.00	1.07
Narcinidae	*Narcine bancroftii*	Lesser electric ray	—	—	—	—	1	0.17	133.00	0.20
Ogcocephalidae	*Halieutichthys aculeatus*	Pancake batfish	—	—	—	—	1	0.17	2.00	0.00
	Ogcocephalus vespertilio	Seadevil	—	—	—	—	1	0.17	3.00	0.00
Ophichthidae	*Aplatophis chauliodus*	Fangtooth snake-eel	—	—	—	—	1	0.17	450.00	0.66
Ophidiidae	*Lepophidium brevibarbe*	Shortbeard cusk-eel	—	—	—	—	3	0.50	51.00	0.07
Ostraciidae	*Acanthostracion quadricornis*	Scrawled cowfish	4	1.96	610.00	1.32	24	3.98	3,958.00	5.82
Paralichthyidae	*Syacium papillosum*	Dusky flounder	5	2.45	775.00	1.68	14	2.32	655.70	0.96
Perciformes	*Caranx hippos*	Crevalle jack	—	—	—	—	1	0.17	4,800.00	7.06
	Coryphaena hippurus	Dolphinfish	—	—	—	—	1	0.17	12,300.00	18.08
Polynemidae	*Polydactylus virginicus*	Barbu	—	—	—	—	8	1.33	339.00	0.50
Priacanthidae	*Priacanthus arenatus*	Atlantic bigeye	—	—	—	—	9	1.49	883.00	1.30
Rachycentridae	*Rachycentron canadum*	Cobia	3	1.47	2,680.00	5.79	—	—	—	—
Sciaenidae	*Cynoscion acoupa*	White bashaw	1	0.49	270.00	0.58	10	1.66	212.50	0.31
	Cynoscion virescens	Sea trout	4	1.96	1,250.00	2.70	—	—	—	—
	Larimus breviceps	Shorthead drum	5	2.45	440.00	0.95	9	1.49	149.50	0.22
	Lonchurus elegans	Blackfin croaker	—	—	—	—	10	1.66	395.00	0.58
	Lonchurus lanceolatus	Longtail croaker	—	—	—	—	3	0.50	334.00	0.49
	Macrodon ancylodon	Bangamary	9	4.41	980.00	2.12	39	6.47	1,812.00	2.66
	Menticirrhus americanus	Southern kingcroaker	—	—	—	—	7	1.16	1,563.00	2.30
	Micropogonias furnieri	Bashaw	5	2.45	2,240.00	4.84	8	1.33	1,677.00	2.47

Family	Species	Common Name [a,b]	Dry Season				Wet Season			
			No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass	No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass
	Nebris microps	Smalleye croaker	13	6.37	3,800.00	8.21	23	3.81	2,986.50	4.39
	Paralonchurus brasiliensis	Banded croaker	1	0.49	200.00	0.43	21	3.48	1,942.00	2.86
	Plagioscion squamosissimus	White basha	1	0.49	300.00	0.65	—	—	—	—
	Stellifer microps	Smalleye stardrum	—	—	—	—	21	3.48	738.00	1.09
	Stellifer rastrifer	Rake stardrum	4	1.96	355.00	0.77	4	0.66	70.00	0.10
Scombridae	*Scomberomorus brasiliensis*	Serra Spanish mackerel	4	1.96	1,090.00	2.36	—	—	—	—
Scorpaenidae	*Scorpaena agassizii*	Longfin scorpionfish	2	0.98	430.00	0.93	2	0.33	133.00	0.20
	Scorpaena brasiliensis	Barbfish	—	—	—	—	16	2.65	174.00	0.26
Serranidae	*Diplectrum formosum*	Sand perch	—	—	—	—	21	3.48	675.30	0.99
Sparidae	*Calamus pennatula*	Pluma porgy	2	0.98	470.00	1.02	2	0.33	476.00	0.70
Stromateidae	*Peprilus paru*	American harvestfish	—	—	—	—	5	0.83	57.00	0.08
Synodontidae	*Saurida normani*	Shortjaw lizardfish	8	3.92	1,540.00	3.33	13	2.16	1,410.00	2.07
	Trachinocephalus myops	Snakefish	—	—	—	—	4	0.66	102.00	0.15
Tetraodontidae	*Colomesus psittacus*	Banded puffer	—	—	—	—	9	1.49	180.00	0.26
	Lagocephalus laevigatus	Smooth pufferfish	1	0.49	1.40	0.00	—	—	—	—
	Sphoeroides testudineus	Checkered puffer	6	2.94	880.00	1.90	8	1.33	330.00	0.49
Trichiuridae	*Trichiurus lepturus*	Largehead hairtail	1	0.49	60.00	0.13	10	1.66	605.00	0.89
Triglidae	*Prionotus beanii*	Bean's searobin	4	1.96	1,440.00	3.11	2	0.33	43.30	0.06
	Prionotus ophyras	Bandtail searobin	1	0.49	300.00	0.65	—	—	—	—
	Prionotus punctatus	Bluewing searobin	2	0.98	450.00	0.97	24	3.98	1,273.00	1.87
	Prionotus stearnsi	Shortwing	—	—	—	—	2	0.33	8.80	0.01
Urotrygonidae	*Urotrygon microphthalmum*	Stingray	—	—	—	—	4	0.66	277.00	0.41
49 families	**92 species**	**Total**	**204**	100.00	**46,268.05**	100.00	**603**	100.00	**68,016.2**	100.00

— = species was not observed during the survey; g = gram
[a] For most species, the common name used by the Food and Agriculture Organization of the United Nations (FAO) (as reported by Fishbase) is used in this report.
[b] For species that have a single Guyanese common name that is (1) different from the FAO common name and (2) is in general use throughout the country, the Guyanese common name is used in place of the FAO common name.

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As summarized in Table 5.2, the TRAWL transect accounted for the highest number of species caught in the dry season, with 24 species, or 30 percent of the total species caught. The EOR3 transect, located offshore of the Essequibo River, accounted for the second highest number of species in the dry season (21 species or 26 percent), followed closely by the EOR1 transect, located off Region 1, with 20 species (or 25 percent of all species). EOR5, located near the Berbice River, had the fewest species of all transects, with 16 species (20 percent). During the wet season, transects EOR1 and EOR5 tied for the highest number of species (45 species each, or 34 percent each). EOR3 had slightly fewer species (42 species or 32 percent).

Table 5.2: Continental Shelf Total Species Richness by Transect

Transect	Dry Season		Wet Season	
	No. of Species	Percent of Total Dry Season Species	No. of Species	Percent of Total Wet Season Species
EOR1	20	25	45	34
EOR3	21	26	42	32
EOR5	16	20	45	34
TRAWL	24	30	—	—

The combined catch from the continental shelf stations was richer in terms of species during the wet season than the dry season. Over half of all the species documented on the continental shelf occurred in only the wet season samples. Table 5.3 summarizes diversity in the continental shelf samples by season and station. During the dry season, the C stations accounted for the highest numbers of species across all transects, with 17 species, or 38.6 percent of all species caught in the continental shelf. The B stations accounted for approximately 36.4 percent of the species (16 species) caught in the dry season in the continental shelf, and A stations accounted for 11 species (25 percent). During the wet season, the A stations accounted for the highest number of species caught (42 species, or 42.4 percent), followed by the B stations with 38 species (38.4 percent), and then the C stations with only 19 species (19.2 percent). Attachment B contains photographs of the Year 2 continental shelf assessment.

Table 5.3: Continental Shelf Total Species Richness by Station Group

Transect	Dry Season		Wet Season	
	No. of Species	Percent of Total Dry Season Species	No. of Species	Percent of Total Wet Season Species
A Stations	11	25	42	42.4
B Stations	16	36.4	38	38.4
C Stations	17	38.6	19	19.2

5.2.2 Abundance

Fish were more abundant in the wet season samples than in the dry season continental shelf samples by nearly a factor of three (603 individuals captured in the wet season compared to 204 individuals captured in the dry season). Bangamary (*Macrodon ancylodon*) was the only species that accounted for more than five percent of the total individuals in the wet season samples. Grey triggerfish (*Balistes capriscus*), wenchman (*Pristipomoides aquilonaris*), smalleye croaker (*Nebris microps*), lane snapper (*Lutjanus synagris*), live sharksucker (*Echeneis naucrates*), and false herring (*Harengula clupeola*) all accounted for more than five percent of the total individuals in the dry season samples.

5.2.3 Biomass

There were marked differences in the continental shelf samples between the dry and wet seasons in terms of biomass, abundance, and diversity. Slightly more than 46 kilograms of fish were caught in the dry season, composed of 204 individuals. Approximately 68 kilograms of fish were caught in the wet season, composed of 603 individuals. Although the wet season samples contained a higher number of species and more individual fish than the dry season samples, the mean mass of individual fish captured in the wet season (113 grams per individual) was almost exactly half the mean mass of individual fish captured in the dry season (225 grams per individual). Several relatively large fishes (lemon shark, ladyfish, longnose stingray, crevalle jack, and dolphinfish), were captured only in the wet season. These species were encountered very rarely; together, they were represented by a total of six individual specimens, but they accounted for approximately 42 percent of the total biomass of fish caught in the wet season. All of these fishes with the exception of the ladyfish are considered predatory species. When these uncommon large predator fishes are removed from the wet season dataset, the mean mass of individual fish captured during the wet season decreases to 66 grams per individual. These results suggest that during the Year 2 surveys, the wet season fish community on the continental shelf was comprised of a relatively large number of abundant, small-bodied species with a few large predatory species mixed in, but that the medium-sized bottom fish that are the mainstay of the trawl fishery on the continental shelf were largely absent. Fewer species were present and the large pelagic predators were scarcer during the dry season than in the wet season, but the medium-sized bottom fishes were more abundant during the dry season.

5.2.4 Gut Contents of Species Captured Using Gillnets, Longline, and Trawl

Analysis of stomach contents demonstrated that shrimp were a primary food item for coastal fish, particularly at the A and B stations. This is consistent with the habitat preferences of crustaceans, such as seabob and prawns, which are typically abundant in shallow coastal waters. Shrimp comprised nearly 80 percent of Siluriformes' (catfishes') stomach contents, especially white spring cariss (*Cathorops arenatus*).

Several species of Sciaenids, including white basha (*Plagioscion squamosissimus*), bangamary (*Macrodon ancylodon*), shorthead drum (*Larimus breviceps*), rake stardrum (*Stellifer rastrifer*), smalltooth weakfish (*Cynoscion steindachneri*), and sea trout (*Cynoscion virescens*), also had large numbers of shrimp in their digestive tracts, but small fish (probably anchovies) were more common in the gut contents of drum than in those of catfish.

Most specimens captured with the longline had empty stomachs; the only species captured via longline that had identifiable stomach contents were dolphinfish (*Coryphaena hippurus*) and bashaw (*Micropogonias furnieri*). Stomach contents in dolphinfish consisted entirely of fish (probably anchovies), while bashaw stomach contents consisted of unidentifiable crustacean remains.

5.2.5 Benthic Incidental Take in Trawl Samples

Several non-target (incidental catch or bycatch) species were captured with trawl gear at various continental shelf stations. Bycatch included sea cucumbers (*Holothuroidea* sp.), sea urchins (*Eucidaris tribuloides*, *Hygrosoma* sp.), various sea stars (*Astropecten americanus, Astropecten marginatus*, *Anthenoides guyanensis, Luidia clathrata*), and several crustacean taxa including mantis shrimp (*Squilla empusa*) and crabs *(Hepatus gronovii, Callinectes* sp.). Several mollluscan taxa were also represented including marine snails (*Distorsio clathrata*, *Turritella variegata*, *Tonna galea),* bivalves (*Euvola chazaliei*, *Arcinella sp.*), and squid *(Loligo* sp.). Non-reef-building coral (*Madrepora oculata*) and reef-building coral (*Solenosmilia variabilis*) also appeared in several samples, similar to the results of the first year of the

Marine Fish Study. Attachment C provides representative photographs of some of the non-target benthic species captured on the continental shelf.

5.2.6 Water Quality Conditions at the Continental Shelf Sampling Stations

Water quality data collected during the continental shelf survey are reported in Attachment D.

5.3 Nearshore Sampling Results

5.3.1 Species Richness

Twelve stations were sampled across the nearshore zone. These stations produced 62 species (23 families; Table 5.4). Thirty-four of these species were captured in both seasons. Most species that were only captured in one season were found in low numbers. The most diverse families in the nearshore samples were the Sciaenidae (drums and croakers, 17 species), Ariidae (sea catfishes, nine species), and Engraulidae (anchovies, seven species). Together, these three families accounted for over 53 percent of the total species diversity in the nearshore samples. Abundance in the nearshore zone was the highest of any of the four sampling zones, with 1,429 individuals collected.

Approximately 55 kilograms of fish were caught in the dry season, while approximately 44 kilograms were caught in the wet season. Slightly more fish were captured in the dry season than in the wet season (726 individuals and 704 individuals, respectively). The mean mass of individual fish caught in the dry season was slightly higher than the mean mass caught in the wet season (75 grams and 63 grams, respectively).

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Table 5.4: Nearshore Assessment Results – Year 2

Family	Species	Common Name [a,b]	Dry Season				Wet Season			
			No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass	No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass
Albulidae	*Albula vulpes*	Bonefish	1	0.14	290.00	0.66	—	0.00	0.00	0.00
Anablepidae	*Anableps anableps*	Four-eyes	9	1.24	27.80	0.06	16	2.28	37.60	0.07
Ariidae	*Amphiarius phrygiatus*	Kukwari sea catfish	—	0.00	—	0.00	2	0.28	204.00	0.37
	Amphiarius rugispinis	Softhead sea catfish	15	2.07	2,916.30	6.61	27	3.84	6,384.10	11.51
	Arius quadriscutis	—	—	0.00	—	0.00	45	6.40	274.60	0.50
	Bagre bagre	Coco sea catfish	16	2.20	14,170.10	32.10	44	6.26	9,117.80	16.44
	Cathorops arenatus	White spring cariss	101	13.91	195.00	0.44	156	22.19	996.50	1.80
	Cathorops spixii	Cuirass	1	0.14	109.00	0.25	30	4.27	993.40	1.79
	Potamarius sp.	Lacandon sea catfish	1	0.14	377.60	0.86	1	0.14	2,608.80	4.70
	Sciades herzbergii	Pemecou sea catfish	81	11.16	2,068.00	4.68	30	4.27	2,610.00	4.71
	Sciades couma	Couma sea catfish	12	1.65	3,821.30	8.66	1	0.14	5,972.70	10.77
Aspredinidae	*Aspredinichthys filamentosus*	Banyaman	5	0.69	94.80	0.21	—	0.00	0.00	0.00
	Aspredo aspredo	Banjo	1	0.14	16.00	0.04	—	0.00	0.00	0.00
	Aspredinichthys tibicen	Tenbarbed banjo	—	0.00	—	0.00	1	0.14	8.00	0.01
Auchenipteridae	*Pseudauchenipterus nodosus*	Cocosoda catfish	27	3.72	3,446.50	7.81	19	2.70	1,749.80	3.16
Batrachoididae	*Batrachoides surinamensis*	Pacuma toadfish	—	0.00	—	0.00	1	0.14	300.00	0.54
Carangidae	*Caranx* sp.	Unidentified jack	2	0.28	0.30	0.00	—	0.00	0.00	0.00
	Trachinotus carolinus	Florida pompano	2	0.28	4.40	0.01	—	0.00	0.00	0.00
	Trachinotus cayennensis	Cayenne pompano	—	0.00	—	0.00	5	0.71	20.40	0.04
	Ogligopites palometa	Leatherjacket	—	0.00	—	0.00	2	0.28	10.60	0.02
Centropomidae	*Centropomus ensiferus*	Swordspine snook	3	0.41	730.80	1.66	3	0.43	237.00	0.43
Dasyatidae	*Fontitrygon geijskesi*	Sharpsnout stingray	—	0.00	—	0.00	1	0.14	600.00	1.08
Elopidae	*Elops saurus*	Ladyfish	—	0.00	—	0.00	2	0.28	0.00	0.00
	Elops sp.	Alevin transparent	—	0.00	—	0.00	5	0.71	18.20	0.03
Engraulidae	*Anchoa* sp.	Unidentified anchovy	1	0.14	75.00	0.17	—	0.00	0.00	0.00
	Anchoa spinifer	Spicule anchovy	12	1.65	541.70	1.23	27	3.84	1,199.90	2.16
	Anchovia surinamensis	Surinam anchovy	3	0.41	228.00	0.52	1	0.14	17.90	0.03
	Anchoviella sp.	Unidentified anchovy	7	0.96	828.00	1.88	7	1.00	13.70	0.02
	Lycengraulis batesii	Bates' sabretooth anchovy	42	5.79	828.70	1.88	4	0.57	36.20	0.07
	Lycengraulis grossidens	Atlantic sabretooth anchovy	—	0.00	—	0.00	25	3.56	292.00	0.53
	Pterengraulis atherinoides	Wingfin anchovy	1	0.14	21.30	0.05	11	1.56	922.10	1.66
Ephippida	*Chaetodipterus faber*	Atlantic spadefish	9	1.24	7.70	0.02	5	0.71	0.60	0.00
Gerreidae	*Diapterus rhombeus*	Caitipa mojarra	1	0.14	10.90	0.02	—	0.00	0.00	0.00
Gobiidae	*Bollmannia* sp.	Unidentified goby	1	0.14	0.60	0.00	—	0.00	0.00	0.00
	Gobionellus sp.	Unidentified goby	—	0.00	—	0.00	2	0.28	2.30	0.00
Haemulidae	*Genyatremus luteus*	Annafolk	1	0.14	270.00	0.61	—	0.00	0.00	0.00

Family	Species	Common Name [a,b]	Dry Season				Wet Season			
			No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass	No. of Individuals	Percent of Total Individuals	Biomass (g)	Percent of Total Biomass
Lobotidae	*Lobotes surinamensis*	Atlantic tripletail	1	0.14	40.00	0.09	—	0.00	0.00	0.00
Mugilidae	*Mugil incilis*	Parassi mullet	96	13.22	1,180.20	2.67	1	0.14	0.00	0.00
Pimelodidae	*Brachyplatystoma filamentosum*	Piraíba	1	0.14	249.30	0.56	3	0.43	256.10	0.46
	Hypophthalmus edentatus	Highwaterman catfish	90	12.40	101.00	0.23	81	11.52	11,854.70	21.38
	Pimelodus blochii	Bloch's catfish	1	0.14	390.00	0.88	—	0.00	0.00	0.00
Polynemidae	*Polydactylus virginicus*	Barbu	8	1.10	49.50	0.11	3	0.43	6.70	0.01
Pristigasteridae	*Odontognathus mucronatus*	Guiana longfin herring	1	0.14	7.60	0.02	—	0.00	0.00	0.00
Sciaenidae	*Cynoscion acoupa*	White bashaw	23	3.17	5,010.20	11.35	12	1.71	2,458.80	4.43
	Cynoscion microlepidotus	Smallscale weakfish	—	0.00	—	0.00	8	1.14	1,027.10	1.85
	Cynoscion steindachneri	Smalltooth weakfish	7	0.96	1,411.50	3.20	3	0.43	1,752.50	3.16
	Cynoscion virescens	Sea trout	4	0.55	98.00	0.22	2	0.28	230.40	0.42
	Larimus breviceps	Shorthead drum	12	1.65	56.60	0.13	3	0.43	48.80	0.09
	Lonchurus lanceolatus	Longtail croaker	1	0.14	317.00	0.72	1	0.14	891.80	1.61
	Lonchurus elegans	Blackfin croaker	1	0.14	311.30	0.71	6	0.85	304.20	0.55
	Macrodon ancylodon	Bangamary	—	0.00	—	0.00	16	2.28	425.00	0.77
	Micropogonias furnieri	Bashaw	2	0.28	272.40	0.62	2	0.28	275.60	0.50
	Nebris microps	Smalleye croaker	1	0.14	166.00	0.38	—	0.00	0.00	0.00
	Paralonchurus brasiliensis	Banded croaker	1	0.14	81.70	0.19	5	0.71	11.40	0.02
	Plagioscion squamosissimus	White basha	2	0.28	280.00	0.63	4	0.57	519.00	0.94
	Sciades sp.	Unidentified sea catfish	3	0.41	1,176.00	2.66	—	0.00	0.00	0.00
	Stellifer microps	Smalleye stardrum	1	0.14	110.00	0.25	6	0.85	34.50	0.06
	Stellifer rastrifer	Rake stardrum	—	0.00	—	0.00	13	1.85	3.40	0.01
	Stellifer brasiliensis	Rockhead	93	12.81	1,099.80	2.49	47	6.69	375.40	0.68
	Stellifer chaoi	Chaoi's rockhead	6	0.83	402.50	0.91	1	0.14	8.40	0.02
Tetraodontidae	*Colomesus psittacus*	Banded puffer	15	2.07	68.30	0.15	12	1.71	99.80	0.18
Trichiuridae	*Trichiurus lepturus*	Largehead hairtail	1	0.14	190.00	0.43	1	0.14	236.00	0.43
23 families	**62 species**	**Total**	**726**	**100.00**	**44,148.70**	**100.00**	**703**	**100.00**	**55,447.80**	**100.00**

— = species was not observed during the survey; g = gram
[a] For most species, the common name used by the Food and Agriculture Organization of the United Nations (FAO) (as reported by Fishbase) is used in this report.
[b] For species that have a single Guyanese common name that is (1) different from the FAO common name and (2) is in general use throughout the country, the Guyanese common name is used in place of the FAO common name.

Region 2 had the highest species richness out of the five regions sampled. Its proximity to the largest river in Guyana (the Essequibo) most likely contributed to the relatively high number of species captured in that region, although it is notable that stations in closest proximity to river mouths (e.g., EPR2-6, EPR1-12, EPR4-4) often produced fewer species than stations in the same region but further away from river mouths (see Table 5.5). Attachment E includes photographs of species caught during the nearshore assessment.

Table 5.5: Nearshore Stations Total Species Richness

Station	Dry Season		Wet Season	
	Species Richness	Percent of Total Species Richness	Species Richness	Percent of Total Species Richness
EPR1-9	10	9.4	7	6.1
EPR1-10	5	4.7	7	6.1
EPR1-11	6	5.7	4	3.5
EPR1-12	4	3.8	8	7.0
EPR2-6	8	7.5	--	--
EPR2-7	17	16.0	23	20.2
EPR2-8	16	15.1	12	10.5
EPR4-3 Hope	16	15.1	10	8.8
EPR4-3 Mahaica	7	6.6	5	4.4
EPR4-4	10	9.4	12	10.5
EPR5-1	4	3.8	9	7.9
EPR5-2	3	2.8	17	14.9

5.3.2 Abundance

Unlike the individual counts from the continental shelf, samples from the nearshore zone had very similar numbers of individuals in both seasons (703 individuals in the wet season and 726 individuals in the dry season). There was less seasonal variation in terms of the taxonomic distribution of the catch in the nearshore zone than on the continental shelf. Five species individually accounted for more than five percent of the total individuals captured in the wet season: white spring cariss (*Cathorops arenatus*), highwaterman catfish (*Hypoptahlamus edentatus*) rockhead (*Stellifer brasiliensis*), Bressou sea catfish (*Arius quadriscutis*), and coco sea catfish (*Bagre bagre*). Three of these species (white spring cariss, highwaterman catfish, and rockhead) also individually accounted for more than five percent of the total individuals captured in the dry season. Parassi mullet (*Mugil incilis*), Pemecou sea catfish (*Sciades herzbergii*), and Bates sabretooth anchovy (*Lycengraulis batesii*) also individually accounted for more than five percent of the total individuals captured in the dry season.

5.3.3 Biomass

Biomass data from the nearshore zone were similar to the biomass data from the continental shelf in terms of differences between the dry and wet seasons and the disproportionate effects of large individuals on total biomass during the wet season. Slightly more than 44 kilograms of fish were caught in the dry season, compared to 55 kilograms of fish caught in the wet season. The mean mass of individual fish captured was 61 grams per individual in the dry season and 79 grams in the wet season. Two particularly large individual predatory fish captured in the wet season, a lacandon sea catfish (*Potamarius sp.*) and a couma sea catfish (*Sciades couma*) together accounted for 7.5 kilograms of the entire wet

season biomass. When these individuals are removed from the wet season dataset, the mean mass of individual fish captured during the wet season decreases by 14 percent to 68 grams per individual. These results suggest that, similar to the continental shelf surveys, during the Year 2 nearshore surveys the wet season fish community was comprised of a large number of abundant, small-bodied species with a few larger individuals mixed in. Unlike the dry season data from the continental shelf, which showed a decrease in abundance and a modest increase in mean size of individuals, the dry season catch in the nearshore zone was also dominated by small fishes. Most of the individuals captured in both seasons were either small-bodied coastal species or immature forms of larger species whose adult life stages are more prevalent on the continental shelf.

5.3.4 Water Quality Conditions at the Nearshore Sampling Stations

Water quality data collected during the nearshore survey are reported in Attachment F.

5.4 Estuarine/Riverine Assessment

5.4.1 Species Richness

Six stations were sampled across the estuarine/riverine zone. Twenty-one fish species were captured during the survey (see Table 5.7). No more than six species were found at any one location during the wet or dry seasons. During the dry season, six species were observed at each of the Pomeroon, Demerara, and Berbice river stations, four species were observed at the Mahaica River station, and three species were observed at the Essequibo River station. Despite overall species richness across all the river stations combined being slightly higher in the wet season than in the dry season (16 species versus 13 species, respectively), wet season species richness was equivalent to or slightly lower than dry season species richness at most of the river stations (Table 5.6). This indicates a more uniform species composition between estuaries in the wet season than in the dry season.

5.4.2 Abundance

Unlike the continental shelf and nearshore zone, fish were more abundant in the dry season than the wet season in the estuaries (Table 5.6). Parassi mullet (*Mugil incilis*) dominated the dry season samples, accounting for over 38 percent of the total dry season catches across all estuarine/riverine stations. Rockhead (*Stellifer brasiliensis*), banded puffer (*Colomesus psittacus*), zabaleta anchovy (*Anchovia clupeoides*), and false herring (*Harengula clupeola*) were the only other species that individually accounted for more than five percent of the total catch during the wet season. Whereas the dry season samples were dominated by mullet, the wet season samples were dominated by anchovies. The most common species caught in the wet season were broadband anchovy (*Anchoviella lepidentostole*) and zabaleta anchovy (*Anchovia clupeoides*), followed by rockhead (*Stellifer brasiliensis*), unidentified elopids (*Elops sp.*), banded puffer (*Colomesus psittacus*), leatherjacket (*Oligoplites palometa*) and pemecou sea catfish (*Sciades herzbergii*). All other species each accounted for less than five percent of the total abundance in the wet season. The results of the estuarine survey clearly indicate a fish community with a coastal-marine affinity; in fact, only one species captured in either the wet or dry season - suckermouth catfish (*Hypostomus plecostomus*) - is typically considered a freshwater species (Table 5-7).

5.4.3 Biomass

Biomass was not measured in the estuarine/riverine samples because most of the individuals caught were juvenile and the biomass of individual fishes was not reliably measureable with the equipment on board the sampling vessel. See Attachment G for photographs of species caught during the estuarine/riverine assessment.

5.4.4 Water Quality Conditions at the Estuarine/Riverine Sampling Stations

Water quality data collected during the estuarine/riverine survey are reported in Attachment H.

Table 5.6: Estuarine/Riverine Stations Species Richness by River

Station	River	Dry Season (January)			Wet Season (May)		
		Species Richness	No. of Individuals	Percent of Total Species Richness	Species Richness	No. of Individuals	Percent of Total Species Richness
EPE-RP	Pomeroon	6	62	46.15	4	21	25.00
EPE-RE	Essequibo	3	94	23.08	4	29	25.00
EPE-RD	Demerara	6	62	46.15	5	27	31.25
EPE-RM	Mahaica	4	188	30.77	4	19	25.00
EPE-RB	Berbice	6	19	46.15	6	19	37.50
EPE-RW	Waini	*Not Surveyed*			3	22	18.75

Table 5.7: Estuarine/Riverine Assessment Species Abundance

Family	Species	Common Name [a,b]	Dry Season (January)		Wet Season (May)	
			No. of Individuals	Percent of Total Individuals	No. of Individuals	Percent of Total Individuals
Achiridae	*Anableps anableps*	Four eyes	1	0.24	1	0.73
	Apionichthys dumerili	Longtail sole	2	0.47	0	—
Ariidae	*Sciades herzbergii*	Pemecou sea catfish	9	2.12	7	5.11
	Cathorops arenatus	White spring cariss	2	0.47	0	—
Auchenipteridae	*Pseudauchenipterus nodosus*	Cocosoda catfish	—	—	1	0.73
Belonidae	*Belone* sp.	Garfish	—	0.00	1	0.73
Carangidae	*Caranx* sp.	Unidentified jack	10	2.35	0	—
	Oligoplites palometa	Leatherjacket	—	—	10	7.30
	Trachinotus cayennensis	Cayenne pompano	—	—	1	0.73
Clupeidae	*Harengula clupeola*	False Herring	34	8.00	0	—
Elopidae	*Elops* sp.	Unidentified larvae	18	4.24	20	14.60
	Leptocephalus spp.	Unidentified larvae	4	0.94	2	1.46
Engraulidae	*Anchovia clupeoides*	Zabaleta anchovy	48	11.29	24	17.52
	Anchoviella lepidentostole	Broadband anchovy	—	—	27	19.71
Gobiidae	*Gobionellus* sp.	Unidentified goby	—	—	1	0.73
Loricariidae	*Hypostomus plecostomus*	Suckermouth catfish	16	3.76	—	—
Mugilidae	*Mugil incilis*	Parassi mullet	164	38.59	2	1.46
Poeciliidae	*Poecilia reticulata*	Guppy	—	—	1	0.73

Family	Species	Common Name [a,b]	Dry Season (January)		Wet Season (May)	
			No. of Individuals	Percent of Total Individuals	No. of Individuals	Percent of Total Individuals
Sciaenidae	*Cynoscion acoupa*	White bashaw	—	—	6	4.38
	Stellifer sp.	Rockhead	60	14.12	22	16.06
Tetraodontidae	*Colomesus psittacus*	Banded puffer	57	13.41	11	8.03
14 families	**21 species**	**Total**	**425**	**100.00**	**137**	**100.00**

[a] For most species, the common name used by the Food and Agriculture Organization of the United Nations (FAO) (as reported by Fishbase) is used in this report.
[b] For species that have a single Guyanese common name that is (1) different from the FAO common name and (2) is in general use throughout the country, the Guyanese common name is used in place of the FAO common name.

5.5 Ichthyoplankton Assessment

5.5.1 Deepwater Zone

For the purposes of the ichthyoplankton assessment, the deepwater zone consisted of the “E”, “Payara” and “Liza” sample locations depicted on Figure 3-5. Forty-seven species of fish in twenty-nine families were identified in the ichthyoplankton samples taken from the deepwater zone (Table 5.8). Most of the ichthyoplankton collected from the deepwater zone were eggs, with comparatively small numbers of post-yolk sac larvae. No yolk sac larvae were collected. The most common and most diverse family was Scombridae (mackerels and tunas), which accounted for 37 percent of the entire number of individual planktonic fishes collected, and eight species (approximately 20 percent of the species collected). The second- and third-most abundant families were the Dactylopteridae (round herrings) and Nomeidae (snappers). The second- and third-most diverse families were Myctophidae (lanternfish, five species) and Carangidae (jacks), Serranidae (seabasses and groupers), and Sphyraenidae (barracudas) (three species each). All ichthyoplankton in the deepwater zone was captured in the dry season; the deepwater zone was sampled in the wet season, but no plankton were recovered from the wet season samples.

5.5.2 Continental Shelf Zone

The continental shelf zone included the “B”, “C”, and “D” sample locations, as depicted on Figure 3-5. Seventy-two species of fish in thirty-six families were identified from the plankton samples taken from the continental shelf zone (Table 5.9). Small numbers of sailfin flyingfish (*Parexocoetus brachypterus*) eggs were collected in the wet season; all other species were captured in the dry season only. No eggs were collected in the dry season; most of the ichthyoplankton captured on the continental shelf in the dry season were post-yolk sac larvae with small numbers of yolk sac larvae and leptocephalus larvae mixed in. The most abundant family was Sciaenidae, followed by Carangidae and Scombridae, which together accounted for slightly more than 50 percent of the entire number of individual planktonic fishes collected. The most diverse ichthyoplankton families on the continental shelf were Scombridae (10 species), Myctophidae (eight species), and Sciaenidae (six species). Together, these species accounted for 33 percent of the species collected.

5.5.3 Nearshore Shelf Zone

The nearshore zone included the “A” sample locations as depicted on Figure 3-5. Twenty-two species of fish in eleven families were identified from the plankton samples from the nearshore zone (Table 5.10). No eggs were collected in the nearshore zone; most of the ichthyoplankton captured in the nearshore zone were post-yolk sac larvae with small numbers of yolk sac larvae and early juveniles mixed in. The

most abundant family was Engraulidae (anchovies), followed by Sciaenidae and Gobiidae (gobies), which together accounted for 97 percent of the entire number of individual planktonic fishes collected. The dominance of these three families was primarily due to the overwhelming abundance of two species in particular, broadband anchovy (*Anchoviella lepidentstole*) and acoupa weakfish (*Cynoscion acoupa*), which together accounted for over 76 percent of all ichthyoplankton collected in the zone. The most diverse ichthyoplankton families in the nearshore zone were Sciaenidae and Engraulidae. Together, these two families accounted for 50 percent of the species collected. All ichthyoplankton in the nearshore zone was captured in the dry season; none was captured in the wet season.

Table 5.8: Ichthyoplankton Data from the Deepwater Zone

Family	Species	Common Name	Number of Individuals	Percent of Individuals
Achiridae	*Aulostomus maculatus*	Trumpetfish	1	0.16
Anguillidae	*Engyophrys senta*	American spiny flounder	10	1.62
Aulostomidae	*Brama dussumieri*	Lowfin pomfret	1	0.16
Bothidae	*Antigonia capros*	Deepbody boarfish	1	0.16
Bramidae	*Caranx crysos*	Blue runner	1	0.16
Caproidae	*Caranx latus*	Horse eye jack	3	0.48
Carangidae	*Chloroscombrus chrysurus*	Atlantic bumper	11	1.78
Chaetodontidae	*Seriola rivoliana*	Longfin yellowtail	2	0.32
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	3	0.48
Cynoglossidae	*Dactylopterus volitans*	Flying gurnard	1	0.16
Dactylopteridae	*Etrumeus teres*	Round herring	192	31.02
Dussumieridae	*Gempylus serpens*	Snake mackerel	2	0.32
Engraulidae	*Nealotus tripes*	Black snake mackerel	4	0.65
Gempylidae	*Nesiarchus nusutus*	Black gemfish	4	0.65
Gobiidae	*Ptereleotris helenae*	Hovering dartfish	1	0.16
Hemiramphidae	*Oxyporhamphus micropterus*	Smallwing flyingfish	4	0.65
Paralepididae	*Lestidiops mirabilis*	Strange pike smelt	6	0.97
	Lutjanus synagris	Lane snapper	6	0.97
Lutjanidae	*Pristipomoides aquilonaris*	Wenchman	10	1.62
Moringuidae	*Neoconger mucronatus*	Ridged eel	1	0.16
	Diaphus brachycephalus	Short-headed lanternfish	5	0.81
	Diaphus mollis	Soft lanternfish	2	0.32
	Lampadena urophaos atlantica	Sunbeam lampfish	2	0.32
	Lampanyctus nobilis	Noble lampfish	6	0.97
Myctophidae	*Myctophum obtusirostris*	Bluntsnout lanternfish	2	0.32
Nomeidae	*Cubiceps pauciradiatus*	Bigeye cigarfish	46	7.43
	Ahlia egmontis	Key worm eel	2	0.32
Ophichthidae	*Ichthyapus ophioneus*	Surf eel	7	1.13
Ostraciidae	*Acanthostracion quadricornis*	Scrawled cowfish	1	0.16
Scombridae	*Auxis rochei*	Bullet mackerel	52	8.40

Family	Species	Common Name	Number of Individuals	Percent of Individuals
	Auxis thazard	Frigate mackerel	75	12.12
	Katsuwonus pelamis	Skipjack	77	12.44
	Scomberomorus cavalla	King mackerel	1	0.16
	Euthynnus alletteratus	Little tunny	15	2.42
	Thunnus alalunga	Longfinned albacore	1	0.16
	Thunnus albacares	Yellowfin tuna	1	0.16
	Scombrolabrax heterolepis	Longfin escolar	9	1.45
	Decapterus macarellus	Mackerel scad	5	0.81
	Decapterus punctatus	Round scad	1	0.16
Carangidae	*Selar crumenophthalmus*	Bigeye scad	2	0.32
	Anthias asperilinguis	Jeweled gemfish	2	0.32
	Anthias nicholsi	Yellowfin bass	5	0.81
Serranidae	*Epinephelus morio*	Red grouper	1	0.16
	Sphyraena barracuda	Great barracuda	2	0.32
	Sphyraena borealis	Northern sennet	13	2.10
Sphyraenidae	*Sphyraena guachancho*	Guaguanche	19	3.07
Synodontidae	*Saurida normani*	Shortjaw lizardfish	1	0.16
29 families	**47 species**	**Total**	**619**	**100**

Table 5.9: Ichthyoplankton Data from the Continental Shelf

Family	Species	Common Name [a,b]	Number of Individuals	Percent of Individuals
Achiridae	*Achirus lineatus*	Lined sole	4	0.32%
Caproidae	*Antigonia capros*	Deepbody boarfish	1	0.08%
	Antigonia combatia	Shortspine boarfish	2	0.16%
Carangidae	*Caranx hippos/latus complex*	Jack	113	9.11%
	Chloroscombrus chrysurus	Atlantic bumper	63	5.08%
	Naucrates ductor	Pilotfish	23	1.85%
	Pseudocaranx dentex	White trevally	5	0.40%
	Selene setapinnis	Atlantic moonfish	5	0.40%
Clupeidae	*Anchoa spinifer*	Spicule anchovy	27	2.18%
	Anchoviella brevirostris	Snubnose anchovy	44	3.55%
	Anchoviella cayennensis	Cayenne anchovy	6	0.48%
	Opisthonema oglinum	Atlantic thread herring	1	0.08%
Congridae	*Ariosoma balearicum*	Bandtooth conger	1	0.08%
	Heteroconger longissimus	Brown garden eel	3	0.24%
	Rhynchoconger flavus	Yellow conger	5	0.40%
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	1	0.08%

Family	Species	Common Name [a,b]	Number of Individuals	Percent of Individuals
Dussumieriidae	*Etrumeus teres*	Round herring	109	8.78%
Eleotridae	*Eleotris pisonis*	Spinycheek sleeper	4	0.64%
Engraulidae	*Pterengraulis atherinoides*	Wingfin anchovy	1	0.32%
Ephippidae	*Chaetodipterus faber*	Atlantic spadefish	75	0.08%
Exocoetidae	*Parexocoetus brachypterus*	Sailfin flyingfish	8	6.04%
Gempylidae	*Gempylus serpens*	Snake mackerel	1	0.08%
	Nesiarchus nusutus	Violet sanke mackerel	1	0.08%
Gobiidae	*Gobioides broussonnetii*	Violet goby	2	0.16%
	Gobionellus oceanicus	Highfin goby	4	0.32%
Haemulidae	*Anisotremus surinamensis*	Balck margate	3	0.24%
	Orthopristis ruber	Corocoro grunt	15	1.21%
Hemiramphidae	*Oxyporhamphus micropterus similis*	False halfbeak	1	0.08%
Kyphosidae	*Kyphosus incisor*	Yellow chub	2	0.16%
Lutjanidae	*Pristipomoides aquilonaris*	Wenchman	93	7.49%
Monacanthidae	*Aluterus scriptus*	Scrawled filefish	2	0.16%
Mugilidae	*Mugil cephalus*	Striped mullet	10	0.81%
Muraenidae	*Anarchias similis*	Pygmy moray	2	0.16%
Myctophidae	*Ceratoscopelus maderensis*	Horned lanternfish	13	1.05%
	Diaphus brachycephalus	Lanternfishes	2	0.16%
	Lampadena anomala	Anomalous lanternfish	2	0.16%
	Lampadena luminosa	Lanternfishes	4	0.32%
	Lampadena urophaos atlantica	Lanternfishes	3	0.24%
	Lampanyctus alatus	Lanternfishes	2	0.16%
	Lampanyctus nobilis	Lanternfishes	1	0.08%
	Lepidophanes guentheri	Günther's lanternfish	12	0.97%
Nettastomatidae	*Hoplunnis macrura*	Freckeled pike-conger	1	0.08%
Nomeidae	*Cubiceps pauciradiatus*	Bigeye cigarfish	24	1.93%
Ophichthidae	*Myrophis punctatus*	Speckeled worm eel	2	0.16%
	Ophichthus puncticeps	Palespotted eel	1	0.08%
Oreosomatidae	*Allocyttus verrucosus*	Warty dory	1	0.08%
Ostraciidae	*Acanthostracion quadricornis*	Scrawled cowfish	3	0.24%
Paralychthidae	*Syacium gunteri*	Shoal flounder	1	0.08%
Rachycentridae	*Rachycentron canadum*	Cobia	1	0.08%
Sciaenidae	*Cynoscion jamaicensis/microlepidotus*	Weakfish	140	11.28%
	Cynoscion virescens	Green weakfish	1	0.08%
	Macrodon ancylodon	King weakfish	85	6.85%

Family	Species	Common Name [a,b]	Number of Individuals	Percent of Individuals
	Menticirrhus littoralis	Gulf kingfish	1	0.08%
	Micropogonias undulatus	Atlantic croaker	2	0.16%
	Nebris microps	Smalleye croaker	3	0.24%
Scombridae	*Acanthocybium solandri*	Wahoo	1	0.08%
	Auxis rochei	Bullet mackerel	120	9.67%
	Auxis thazard	Frigate makerel	17	1.37%
	Euthynnus alletteratus	Little tunny	5	0.40%
	Katsuwonus pelamis	Skipjack	5	0.40%
	Scomberomorus brasiliensis	Spanish mackerel	14	1.13%
	Scomberomorus cavalla	King mackerel	5	0.40%
	Scombrolabrax heterolepis	Longfin escolar	2	0.16%
	Selar crumenophthalmus	Bigeye scad	5	0.40%
	Thunnus atlanticus	Blackfin tuna	9	0.73%
Scorpaenidae	*Scorpaena bergii*	Goosehead scorpionfish	2	0.16%
Serranidae	*Anthias nicholsi*	Yellowfin bass	1	0.08%
Sparidae	*Archosargus probatocephalus*	Sheepshead	1	0.08%
Sphyraenidae	*Sphyraena borealis*	Northern sennett	20	1.61%
	Sphyraena guachancho	Guaguanche	84	6.77%
Stomateidae	*Peprilus paru*	Harvestfish	7	0.56%
Trichiuridae	*Trichiurus lepturus*	Cutlassfish	1	0.08%
36 families	**72 species**	**Total**	**1,241**	**100**

Table 5.10: Ichthyoplankton Data from the Nearshore Zone

Family	Species	Common Name	Number of Individuals	Percent of Individuals
Achiridae	*Achirus lineatus*	Lined sole	3	0.44%
Aspredinidae	*Aspredo aspredo*	Banjo	2	0.30%
Carangidae	*Hemicaranx amblyrhynchus*	Bluntnose jack	2	0.30%
	Trachinotus cayennensis	Cayenne pompano	1	0.15%
Clupeidae	*Odontognathus mucronatus*	Guiana longfin herring	1	0.15%
Elopidae	*Elops smithi*	Southern ladyfish	3	0.44%
Engraulidae	*Lycengraulis grossidens*	Atlantic sabretooth anchovy	5	0.74%
	Anchoviella lepidentostole	Broadband anchovy	371	54.96%
	Anchoa spinifer	Spicule anchovy	14	2.07%
Ephippidae	*Chaetodipterus faber*	Atlantic spadefish	1	0.15%
Gobiidae	*Gobionellus oceanicus*	Highfin goby	42	6.22%
	Gobioides broussonnetii	Violet goby	2	0.30%

Family	Species	Common Name	Number of Individuals	Percent of Individuals
Pimelodidae	*Brachyplatystoma vaillantii*	Laulou catfish	20	2.96%
Sciaenidae	*Cynoscion acoupa*	Acoupa weakfish	150	22.22%
	Cynoscion virescens	Green weakfish	7	1.04%
	Lonchurus lanceolatus	Longtail croaker	1	0.15%
	Stellifer microps	Smalleye stardrum	10	1.48%
	Cynoscion leiarchus	Smooth weakfish	4	0.59%
	Cynoscion steindachneri	Steindachner's weakfish	4	0.59%
	Cynoscion jamaicensis/microlepidotus	Weakfish	2	0.30%
	Micropogonias furnieri	Whitemouth croaker	23	3.41%
Tetraodontidae	*Colomesus psittacus*	Parrot pufferfish	7	1.04%
11 families	**22 species**	**Total**	**675**	**100**

6. DISCUSSION

A total of 203 species were captured during the 2018–2019 (Year 2) Marine Fish Survey. A total of 213.9 kilograms (471.6 pounds) of fish (not counting estuarine/riverine catches or plankton) were caught. Similar to the results of the first year of the Marine Fish Study, the continental shelf had the most diverse nektonic fish community, with 92 species (49 families), followed by the nearshore zone, with 62 species (23 families). The estuarine area was the least diverse, with only 21 species (14 families). The plankton community showed remarkable diversity in the deepwater zone (47 species) given the lack of adult fishes captured in this zone. Ichthyoplankton species richness in the continental shelf and nearshore zones (72 species and 22 species, respectively) followed the trends seen in the nektonic samples, which suggest that the fish community on the continental shelf is the most diverse of the four zones included in the study.

6.1 Continental Shelf Assessment

Seasonal influences on biomass and species composition across the continental shelf were markedly different between the first and second years of the Marine Fish Study in several respects. Total biomass was much higher during the first year than during the second year, in both seasons. Biomass was highest in the dry season during the first year, unlike in the second year. Large predatory species (e.g., sharks, mackerels, barracudas, dolphinfish, jacks) were also more commonly encountered during the first year (especially sharks) than in the second year, and most commonly encountered in the dry season. Water quality may have played a role in the differences between years. Maximum measured water temperatures in the dry season reached approximately 35 degrees Celsius (ºC) in the second year's dry season, approximately 5 ºC higher than in the first year. These temperatures may have been sufficiently high to cause some species to seek cooler water. While it is impossible to conclusively identify the cause of the warmer water temperatures in the second year, water quality on the continental shelf is subject to the influence of oscillations in the Guiana Current as well as fluctuations in freshwater inputs from coastal rivers. Mean temperatures at the continental shelf sites during the second years dry season were more than 2.5 ºC higher than at the coastal sites during the same period, so it seems unlikely that riverine influences caused the high temperatures on the shelf and more likely that the warm temperatures on the continental shelf were oceanic in origin. Very few marine fish prefer water temperatures above 32 ºC, so water temperatures during the second year's dry season probably had some effect on fish distributions; however, temperatures above 32 ºC did not occur frequently, so thermal effects on fish distribution were probably limited. Dissolved oxygen levels were also conspicuously low during the wet season in the second year, with concentrations at the seafloor below 2.0 milligrams per liter at four of the 13 sampling stations during the wet season in the second year. This is below the optimum range for most marine fishes, and may partially explain the apparent scarcity of large fishes during this period. Low dissolved oxygen concentrations were more widespread in the wet season than high temperatures were in the dry season, so dissolved oxygen concentrations likely had a more significant effect on fish distribution than temperature.

Although the overall catch data across the entire continental shelf differed in a number of ways between the first and second study years, seasonal and spatial distribution of fish species diversity within the continental shelf were remarkably consistent between years. During the second study year, fish diversity was uneven between the transects in the dry season, but relatively consistent in the wet season. The same pattern was observed in the first study year, which suggests that seasonal influxes of freshwater across the continental shelf may obscure the effects of localized differences in physical habitat on the fish community. Species richness also increased at the "A" sites in the wet season in both years, which provides further evidence of the seasonal influence of freshwater inputs on species richness, especially on the inner continental shelf. The "B" stations produced the highest number of species in both seasons

in the first study year and the "C" stations produced the highest number of species in the second year, indicating that despite seasonal increases in nearshore diversity in the wet season, the highest fish diversity is consistently found on the mid- to outer-continental shelf. Visual observations made by the field team during the second year of study indicate that the B zone is an area of transition from the mixture of "blackwater"[9]and highly turbid silt-laden water near shore to clearer waters more characteristic of offshore conditions, an observation that is supported by the turbidity data collected from the continental shelf stations (Attachment D).

Although benthic marine resources were not the primary target of the survey, the sampling team reported the presence of living hard corals (*Madrepora oculata* and *Solenosmilia variabilis*) in some of the trawl samples at the B stations on transects EOR1, EOR3, and EOR5. These tended to be most common at depths from 110-160 m, on the outer continental shelf. This corroborated similar findings from the first year of study, which was the first known scientific evidence of living corals on Guyana's continental shelf. As noted in the Year 1 report for the Marine Fish Study, it is unknown whether the corals represent the remnant of a long-established population or a nascent recovery.

6.2 Nearshore Assessment

Sixty-two species were captured at the nearshore stations. The most common species observed at the nearshore stations were white spring cariss, rockhead, highwaterman catfish (*Hypophthalmus edentatus*), parassi mullet (*Mugil incilis*), and Pemecou sea catfish (*Sciades herzbergii*). Nearshore catches consisted primarily of catfish, which were found in salinities from 3.5 to 34 parts per thousand. This variability is caused primarily by substantial freshwater inputs from rivers, which explains the dominance of estuarine species in all of the nearshore samples (even those located several kilometers away from river mouths) and the presence of freshwater species in some low salinity areas along the coast. Some species were observed in the nearshore zone, but were not captured due to limitations inherent in the selected sampling protocols and equipment. One example is the widely distributed four-eyes (*Anableps anableps*), which is common in extremely shallow water where cast nets are not effective. Most of the species captured during the wet season were anadromous species that had presumably entered the coastal area from the sea in response to increased freshwater discharge to the coastal zone, or euryhaline species that entered the study area from further up the rivers.

Similar to the continental shelf, seasonal influences on the nearshore fish community manifested differently in the first and second years of the Marine Fish Study. During the first study year, total diversity in the nearshore zone was comparatively low (48 total species captured across both seasons) and there was a marked difference in the total number of species captured between seasons (25 species in the dry season versus 42 species in the wet season). In the second year, the total number of species captured across both seasons was higher (62 species) and about 45 percent of the species were only found in one season, but the total number of species captured was the same for both seasons. Region 2 had the most diverse fish community in both years and in both seasons in the second study year, which illustrates the importance of the Essequibo River's freshwater inputs in shaping the nearshore fish community. Although freshwater inputs clearly influence fish distribution, proximity to rivers is not the only factor that influences nearshore fish diversity. A few nearshore stations that were located in close proximity to river mouths had lower than average species diversity. This phenomenon was exemplified at EPR2-6. No fish were captured at this station during the wet season in the second study year, when freshwater influence was

[9]The clarity of water flowing out of Guyana's rivers onto the continental shelf is limited by two types of influences. The first is so – called-"blackwater" contributions, which come from swamps and other wetlands that characteristically have deep accumulations of organic debris. Water flowing from these areas has a very dark color and low light transmissivity because of high tannin content, but typically has very low suspended solids. The second type of influence has very high suspended soilds content (i.e.; turbidity) but little if any tannin content. In the estuaries and near-shore marine environments where both of these types of water mix with oceanic water, water clarity is typically low.

presumably near its annual peak. It is possible that a moderate amount of freshwater increases fish diversity but that above a certain threshold diversity begins to decrease as large numbers of marine species are excluded, but the exact nature of the relationship between salinity and nearshore fish diversity in Guyana is currently unclear.

6.3 Estuarine/Riverine Assessment

Twenty-one species were captured at the estuarine/riverine stations. Parassi mullet, rockhead, zabaleta anchovy, and false herring (*Harengula clupeola*) were the most common species collected at the estuarine/riverine stations. The stations with the highest catches of juvenile fish were located near riparian vegetation such as aquatic plants, grass, submerged palm trees, and plants of small size with abundant foliage. Smaller catches were associated with areas among mangrove roots. The abundance of Leptocephalii (which are a larval form that is unique to elopomorphic fish, primarily the marine and diadromous eels) in the estuarine samples points to the value of the estuaries as nursery areas.

6.4 Plankton Assessment

The total diversity of the ichthyoplankton community across the study area was remarkably high. One hundred eleven species of fish were represented in the plankton samples, accounting for 55 percent of the total number of species represented in the study. The paucity of ichthyoplankton in the wet season samples was consistent with local traditional knowledge. As documented in ERM's Participatory Fishing Study, local fisherpeople generally believe that spawning activity for most marine fish peaks from July through September, which is just after the wet season portion of this study was conducted. This is consistent with the low numbers of ichthyoplankton that appeared in the wet season samples (ERM 2020). Although the traditional knowledge regarding the seasonal aspect of spawning behavior is widely accepted in Guyana, ERM had not expected our data to validate this phenomenon so strongly based on such a limited dataset. It is not known whether the comparatively high number of ichthyoplankton collected during the dry season is typical of this season, or if a late spawn in 2018 increased the numbers of plankton beyond the normal seasonal levels for this period. Although the degree of seasonal difference in ichthyoplankton concentrations was unexpected, the differences in species composition between the zones was expected and consistent with known habitat preferences for the various families of fishes represented in the samples.

7. REFERENCES

ERM (Environmental Resources Management). 2018. Nearshore and Offshore Fisheries Study Summary Report 2017-2018.

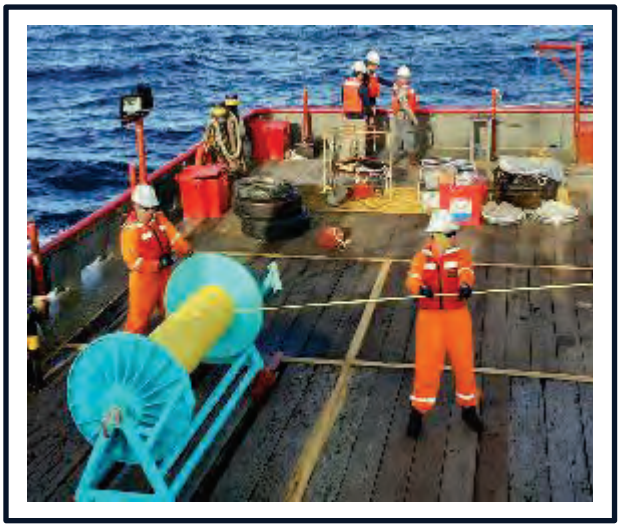
ERM (Environmental Resources Management). 2020. Participatory Fishing Study Final Report.

ATTACHMENT A DEEPWATER ASSESSMENT PHOTOS

Fishing Equipment Review

Bait for the Deepwater Traps

Joining the Traps to the Main Line

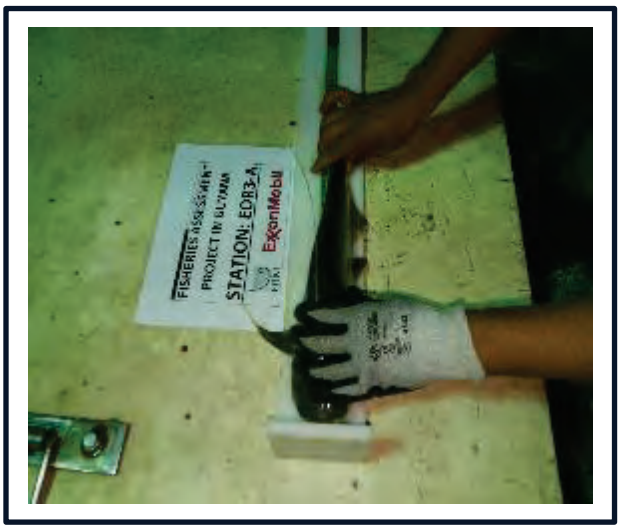


Raising the Traps with a Winch

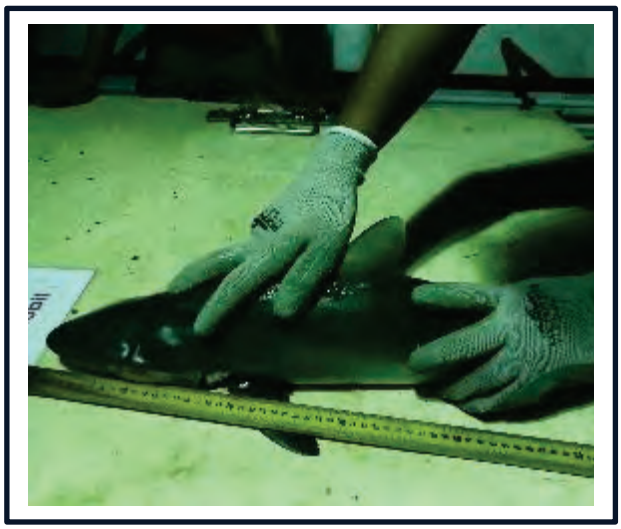
ATTACHMENT B CONTINENTAL SHELF ASSESSMENT PHOTOS

Species Caught at Station EOR3-C

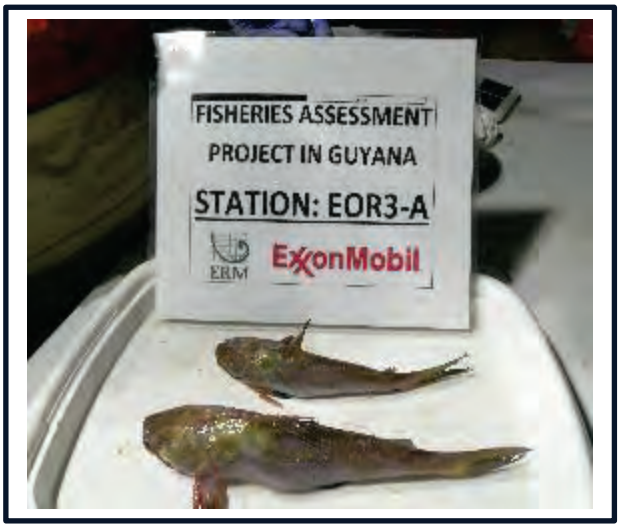
Species Caught at Station EOR3-B



Species Caught at Station EOR3-A

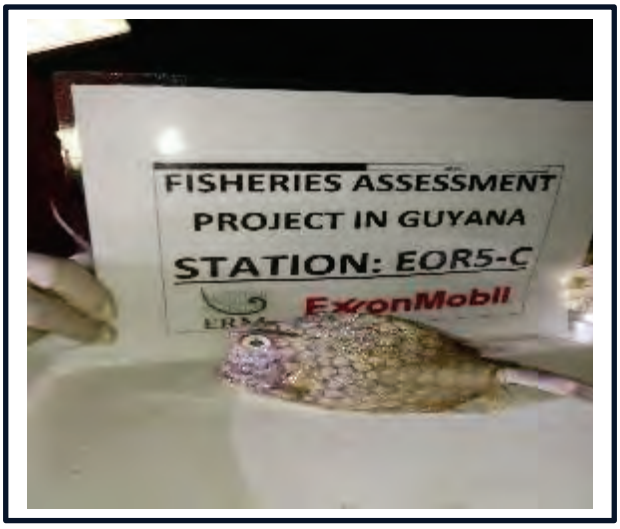


Recording Size of Captured Individual



Species Caught at Station EOR3-A

Species Caught at Station EOR1-A



Species Caught at Station EOR5-C

Species Caught at Station EOR5-A

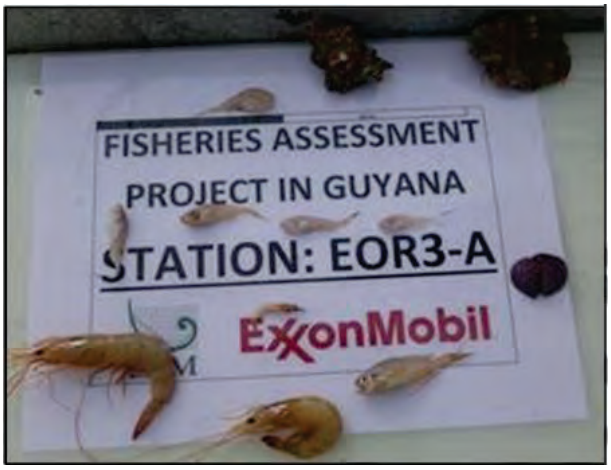
ATTACHMENT C INCIDENTAL BENTHIC BYCATCH FROM THE CONTINENTAL SHELF TRAWL SAMPLES

Benthic Crustacean and Asteroidea Species Caught at Station EOR1-B

Benthic Crustacean, Fish, and Mollusk Species Caught at Station EOR1-C

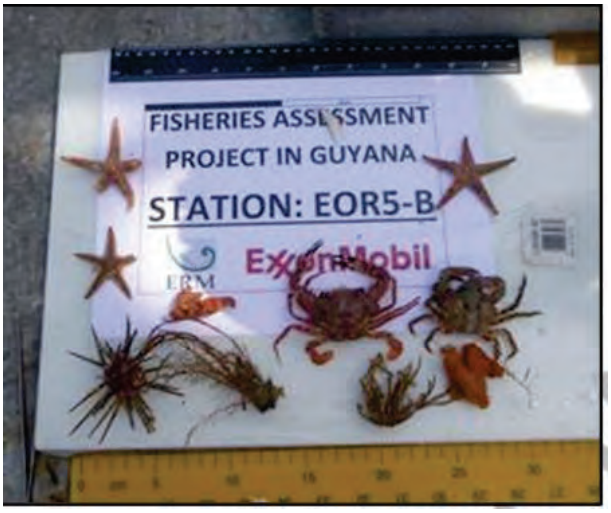
Benthic Fish, Crustacean, and Mollusk Species Caught at Station EOR3-C

Benthic Asteroidea, Fish, and Crustacean Species Caught at Station EOR3-B

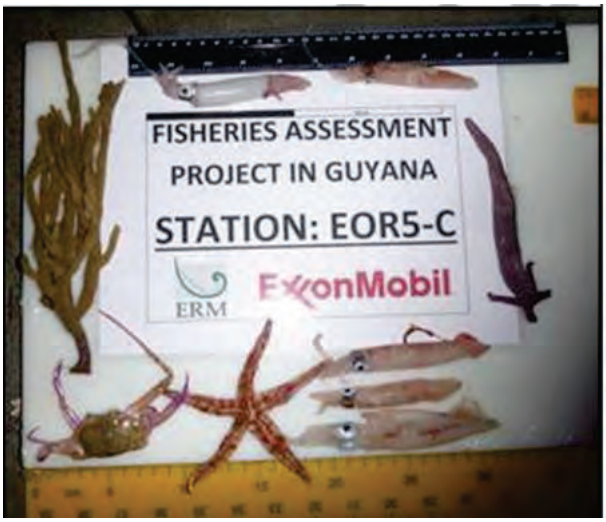


Benthic Crustacean, Mollusk, and Fish Species Caught at Station EOR3-A

Benthic Crustacean Species Caught at Station EOR5-A



Benthic Crustacean, Echinoidea, Asteroidea, and Haermatipic Coral Species Caught at Station EOR5-B

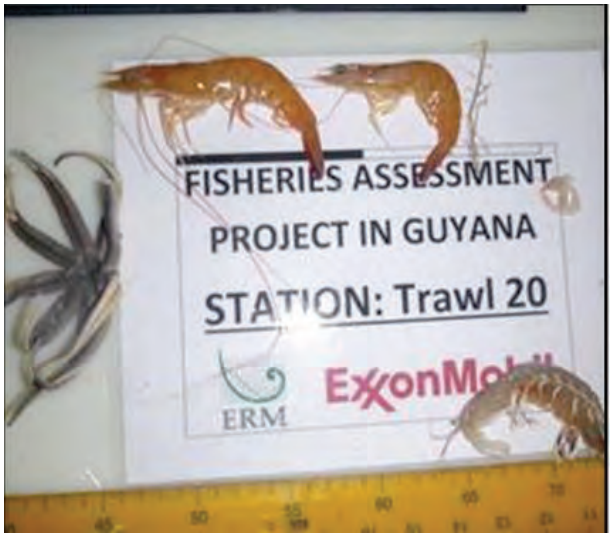


Benthic Crustacean, Asteroidea, Mollusk, Ahaermatipic Coral, and Haermatipic Coral Species Caught at Station EOR5-C

Benthic Crustacean, Mollusk, Ahaermatipic Corals and Haermatipic Corals Caught at Station TRAWL 80

Benthic Crustacean, Asteroidea, Mollusk, and Ahaermatipic Coral Species Caught at Station TRAWL 60

Benthic Crustacean, Asteroidea, Mollusk, and Haermatipic Coral Species Caught at Station TRAWL 40



Benthic Crustacean and Asteroidea, Mollusk Species Caught at Station TRAWL 20

ATTACHMENT D *IN SITU* WATER QUALITY DATA OBTAINED DURING THE CONTINENTAL SHELF ASSESSMENT

Dry Season Water Quality Data

Station	Stratum	Water Temp (ºC)	pH	DO (mg/L)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µS/cm)
EOR1-A	Surface	27.5	8.22	5.68	19.10	39.70	62,646
EOR1-B	Surface	28.7	8.20	5.84	3.11	39.50	63,249
	Bottom	28.9	8.24	5.74	2.71	38.80	62,566
EOR1-C	Surface	30.4	8.18	5.90	1.35	39.62	62,750
	Bottom	30.2	8.23	5.77	1.51	39.59	62,556
EOR3-C	Surface	28.8	8.19	6.23	0.91	39.49	62,351
	Bottom	28.5	8.24	5.54	0.82	39.48	62,303
EOR3-B	Surface	29.4	8.13	6.11	5.38	39.33	62,333
	Bottom	28.6	8.26	5.75	1.06	39.43	62,258
EOR3-A	Surface	30.7	8.08	5.49	12.30	38.46	60,573
EOR5-A	Surface	29.9	8.05	5.84	12.50	39.39	61,359
EOR5-B	Surface	34.2	8.18	5.72	5.55	39.84	61,562
	Bottom	34.5	8.20	5.68	1.78	39.88	61,414
EOR5-C	Surface	30.3	8.21	6.64	0.58	39.38	61,407
	Bottom	30.1	8.23	5.56	1.37	39.37	61,463
TRAWL 80	Surface	30.4	8.21	5.97	1.52	40.00	62,159
	Bottom	30.0	8.26	5.73	0.75	40.01	62,126
TRAWL 60	Surface	28.9	8.12	5.93	1.18	40.01	62,408
	Bottom	28.5	8.23	5.71	1.02	39.98	62,362
TRAWL 40	Surface	29.4	8.15	6.08	4.39	39.85	62,416
	Bottom	29.2	8.25	5.62	3.05	39.84	62,371
TRAWL 20	Surface	28.6	8.15	5.52	14.40	39.45	61,588

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; NTU = nephelometric turbidity unit; ppt = parts per thousand

Wet Season Water Quality Data

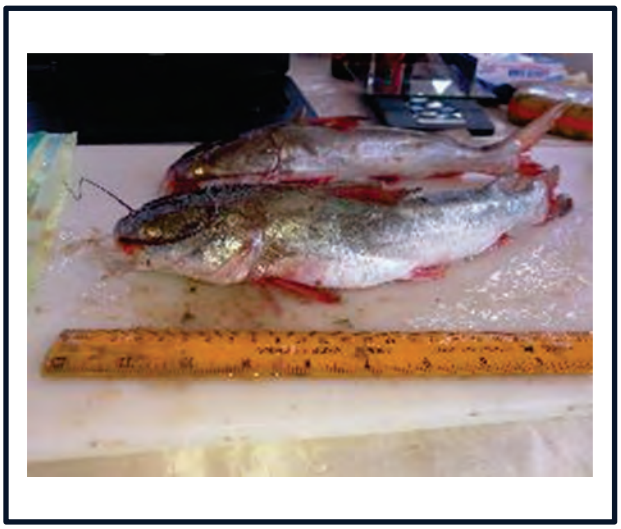
Station	Stratum	Water Temp (ºC)	pH	DO (mg/L)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µS/cm)
EOR1-A	Surface	29.5	10.6	4.66	2.74	31.33	50,601
EOR1-B	Surface	30.1	10.25	5.78	1.96	30.36	50,454
	Bottom	30.1	9.1	4.99	1.76	30.13	49,351
EOR1-C	Surface	28	10	3.82	1.76	32.33	52,039
	Bottom	28	9.87	3.06	4.45	32.79	43,016
EOR3-A	Surface	29.7	10.2	5.17	9.92	30.66	45,454
	Bottom	Not taken					
EOR3-B	Surface	29	10.14	5.10	2.54	32.23	52,466
	Bottom	29	9.89	3.51	1.81	32.5	32,370
EOR3-C	Surface	29.7	10.11	3.02	2.54	33.18	32,955
	Bottom	29.7	9.27	1.72	2.44	33.48	33,215
EOR5-A	Surface	29.3	10.04	2.12	8.66	34.45	55,326
EOR5-B	Surface	28.7	10.25	2.23	1.10	34,77	34,385
	Bottom	28.7	9.46	1.89	1.08	34.46	34,687
EOR5-C	Surface	28.7	9.33	2.34	1.91	34,39	33,546
	Bottom	28.8	9.13	1.89	1.88	34.12	33,679

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; NTU = nephelometric turbidity unit; ppt = parts per thousand

ATTACHMENT E NEARSHORE ASSESSMENT PHOTOS

Start of Fishing with Nets

Pick up from Nets



Recording Size and Weight of the Captured Individual

Determination of the Gonadal Stage of the Captured Species

Species Caught during Fishing

Pick up from Fishing Nets

Variety of Species Caught during Fishing

Registration of the Physical-Chemical Parameters of the Station

ATTACHMENT F *IN SITU* WATER QUALITY DATA OBTAINED DURING THE NEARSHORE ASSESSMENT

Dry Season Water Quality Data

Station	Stratum	Temp (°C)	pH	DO (mg/L)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µS/cm)
EPR1-12	Surface	26.2	8.04	5.72	517	30.45	48,018
EPR1-11	Surface	26.6	8.07	6.16	49.3	21.3	35,069
EPR1-10	Surface	26.7	8.19	6.81	20.2	19.95	33,125
EPR1-9	Surface	27.4	8.01	6.01	317	20.05	33,675
EPR2-8a	Surface	27.4	7.89	6.57	82.4	15.03	25,971
EPR2-8b	Surface	26.4	7.97	6.50	377	14.47	24,577
EPR2-7a	Surface	28.6	7.79	6.34	283	5.97	11,350
EPR2-7b	Surface	27.3	7.40	6.70	> 1000	8.14	14,748
EPR2-6a	Surface	28	7.01	7.01	661	0.58	12,45
EPR2-6b	Surface	27.6	7.62	7.08	> 1000	0.98	20,45
EPR4-4a	Surface	27.1	7.80	6.08	938	9.14	16,318
EPR4-4b	Surface	29.4	8.05	6.33	762	13.78	24,840
EPR3-3a	Surface	26.5	8.21	5.87	416	24.22	39,274
EPR3-3b	Surface	29.1	8.14	6.20	81.7	17.89	31,359
EPR3-Mahaica[(a)]	Surface	27.2	8.35	5.69	140	27.12	44,110
EPR3-Mahaica[(b)]	Surface	24.8	8.23	6.31	368	25.61	42,269
EPR5-2a	Surface	26.6	8.26	6.15	60.2	23.4	38,190
EPR5-2b	Surface	NM	NM	NM	NM	NM	NM
EPR5-1a	Surface	27.4	8.4	7.04	10.7	27.24	44,439
EPR5-1b	Surface	NM	NM	NM	NM	NM	NM

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; NM = not measured; NTU = nephelometric turbidity unit; ppt = parts per thousand

Wet Season Water Quality Data

Station	Stratum	Water Temp (°C)	Temp Sample (°C)	pH	DO (mg/L)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µS/cm)
EPR1-12	Surface	30	29.7	8.55	5.75	590	10.13	101,211
EPR1-11	Surface	33	32.4	8.76	6.95	550	11.73	11,221
EPR1-10	Surface	32	31.2	7.96	5.89	670	10.83	15,361
EPR1-09	Surface	30	29.1	8.77	4.66	656	11.56	12,991
EPR1-8a	Surface	29	28.77	8.95	5.24	800	13.24	24,207
EPR2-8b	Surface	29	28.77	8.88	5.74	789	12.24	26,208
EPR2-7a	Surface	30	28.77	8.91	6.80	776	8.72	15,975
EPR2-7b	Surface	30	27.67	8.81	6.78	787	8.72	16,965
EPR2-6a	Surface	28.9	27.57	9.40	6.89	800	3.44	15,781
EPR2-6b	Surface	29.9	28.57	9.70	6.80	800	3.34	15,781
EPR4-4b	Surface	29.2	30.9	7.94	6.89	438	28.3	45,572
EPR4-4a	Surface	NM	NM	NM	NM	NM	NM	NM
EPR4-3a (Hope)	Surface	29.7	28.67	8.33	4.67	439	17.47	31,515
EPR4-3b (Hope)	Surface	29.87	26.67	8.93	5.44	638	14.47	41,505
EPR-4a (Mahaica)	Surface	30.7	27.67	8.87	5.89	422	16.47	41,595
EPR-4b (Mahaica)	Surface	29.1	28.67	9.34	4.89	545	14.89	45,533
EPR5-2a	Surface	26.5	27	7.77	6.21	> 1000	28.34	46,688
EPR5-2b	Surface	29.5	31.8	7.76	5.80	601	27.88	49,150
EPR5-1a	Surface	26	27.9	7.99	6.95	799	27.46	45,244
EPR5-1b	Surface	NM	NM	NM	NM	NM	NM	NM

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; NM = not measured; NTU = nephelometric turbidity unit; ppt = parts per thousand

ATTACHMENT G ESTUARINE/RIVERINE ASSESSMENT PHOTOS

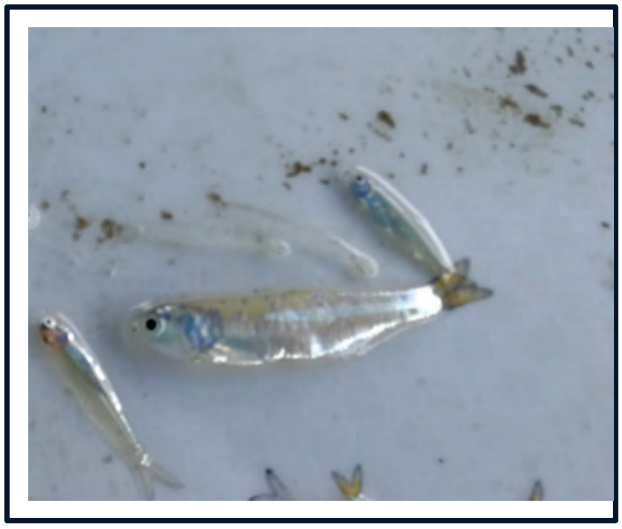
Trawling of the Net in the Estuarine Areas

Review of the Catch in the Estuarine Areas

Electro-Fishing in Estuarine Areas

Calibration of the Electrofishing Equipment

Fish Species Stunned by the Electrofishing Unit



Fish Larvae and Some Captured Juvenile Species, Arranged for Identification and Biometrics

ATTACHMENT H *IN SITU* WATER QUALITY DATA OBTAINED DURING THE ESTUARINE ASSESSMENT

Dry Season Water Quality Data

Sampling Station	Temperature (ºC)	DO (mg/L)	Salinity (ppt)	Conductivity (µS/cm)
Mahaica River	27.8	5.85	3.54	6,284
Berbice River	29.6	5.66	4.79	9,445
Pomeroon River	28.1	5.27	3.43	7,600
Essequibo River	28	5.40	3.60	600
Demerara River	27	6.16	0.30	2,500

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; ppt = parts per thousand

Wet Season Water Quality Data

Sampling Station	Temperature (ºC)	DO (mg/L)	Salinity (ppt)	Conductivity (µS/cm)
Mahaica River	28.5	4.70	18.47	31,515
Berbice River	27.7	4.65	18.49	31,515
Pomeroon River	29.7	6.75	16.79	71,415
Essequibo River	28.4	5.87	23.15	43,665
Demerara River	26.8	6.84	22.37	25,670
Waini River	26.6	6.77	14.28	46,668

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; ppt = parts per thousand

APPENDIX N

ExxonMobil Multi AUV Geophysical Survey Protected Species Observer Summary Report

Resubmitted without changes

March 2022

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EXXONMOBIL MULTI AUV GEOPHYSICAL SURVEY

Seabed Constructor and Normand Frontier

Final
July 22, 2020

rpsgroup.com

EXXONMOBIL MULTI AUV GEOPHYSICAL SURVEY

Seabed Constructor and Normand Frontier

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Appendices

APPENDIX A : WILDLIFE PHOTOS

1 EXECUTIVE SUMMARY

This report covers the protected species mitigation measures and efforts on board the Vessel Normand Frontier for the period of 14 December 2019 to 21 May 2020. This is a continuation report for the Multi AUV Operation, which was conducted by Ocean Infinity, on behalf of ExxonMobil. This Geophysical survey was equipped with five AUV's.

The AUV's operation testing commenced on 14 December at 14:59 UTC following one hour of pre-watch and concluded on 21 May 2020 at 21:34 UTC. The AUV's were launched on in accordance to mission assign on continuous operations, in shallow and deep waters ranging from 52 meters to 2099 meters with in the Southeast Stabroek Block.

In accordance with Environmental Permit Ref. No. 20161202-CSPEP Clauses 3.1-3.6 and industry best practices and in alignment with "JNCC guidelines for minimizing the risk of injury to marine mammals from geophysical surveys" the following protocols were to be observed during the program: one PSO would perform a 60-minute visual pre-search prior to any use of the acoustic source. If any protected species were observed within a 500 and 800-meter radius of the acoustic source, the ramp-up would be delayed. Once the acoustic source was activated the PSOs would monitor continuously.

The AUV's source was active for a total of 1612 hours 43 minutes during the survey. Full volume production was carried out for 1538 hours 29 minutes. There were 222 ramp ups.

There were 23 visual sightings; 13 detections of Common bottlenose dolphins, four detections of unidentified dolphins, two detections Short-finned pilot whale, one detection of Atlantic spotted dolphin, one detection of Pantropical spotted dolphin, one detection of green sea turtle, and one detection of loggerhead sea turtle.

2 INTRODUCTION

The Geophysical survey were conducted by Ocean Infinity on behalf of ExxonMobil aboard the M/V Normand Frontier and the M/V Seabed Constructor. During the Geophysical survey, AUVs were deployed. The AUVs would conduct a ramp up in both shallow and deeper zone before full power. The AUVs then dove to the assigned depth for production. The mitigation and monitoring procedures were used for these AUV deployments regardless of the number of AUVs deployed at the time.

The survey site is in the Southeast Stabroek block approximately 100 miles from Georgetown, Guyana.

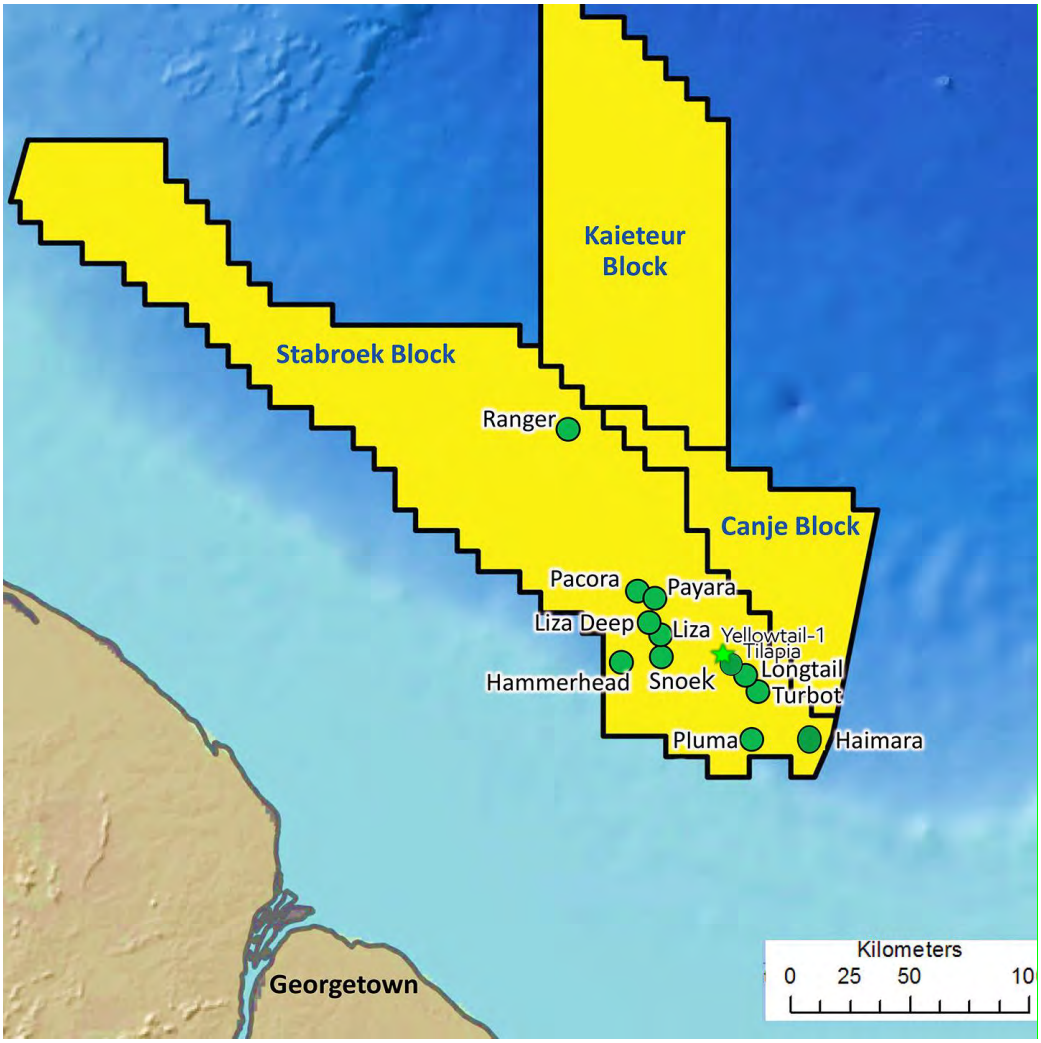

Figure 1: Guyana block map indicating the general location of the survey

2.1 Vessel Information

The Seabed Constructor was used for the first part of this survey (December 2019 to January 2020). The Seabed Constructor was the source vessel for the duration of the early part of the survey. The vessel is 115 m in length and carried the AUVs (Figure 2). The M/V Normand Frontier was used for the second part of this survey (February – May 2020). The Normand Frontier was the source vessel for the duration of the later part of the survey. The vessel is 121 m in length and carried the AUVs (Figure 3).See Table 1 with additional vessel information.

Figure 2: M/V Seabed Constructor

Figure 3: M/V Normand Frontier

Table 1: Acquisition Parameters Summary Table

General Specifications	
General Location:	Southeast Stabroek Block, Guyana
Vessel / Vessel Length (m):	M/V Seabed Constructor / 115 m M/V Normand Frontier / 121 m
Other Vessels Involved:	n/a
Support/Chase Vessels:	n/a
Vessel Configuration description:	The AUVs were deployed from the vessels

3 MITIGATION AND MONITORING METHODS

3.1 Visual Monitoring Survey Methodology

There were two trained and experienced PSOs on board the M/V Seabed Constructor and the M/V Normand Frontier to conduct monitoring for protected species, record and report on observations, and request mitigation actions accordingly. The PSOs were provided by RPS and have completed a BSEE approved PSO training program.

Observers scanned the sea surface with the naked eye and binoculars with a 10 x 42 magnification. Watches were held from the top deck of the vessel providing an optimal 360-degree view which was approximately 20 meters at observer's eye level above the water's surface. Shifts lasted three hours followed by at three hours of break. Monitoring occurred daily beginning at approximately 09:45 UTC and continued throughout the end of the UTC day until the surrounding area could no longer be effectively observed due to darkness at approximately 22:00 UTC.

PSOs collected data at approximately 20-minute intervals while on watch and recorded in observation logs. Daily observation logs included information about environmental conditions, vessel and survey operations, marine debris observed, any vessel/gear and wildlife interactions, and any wildlife sightings.

Distances to protected species were determined visually by comparing an animal or an object's position relative to objects at known distances. Prior to the initiation of the source for ramp-ups or tests during daylight hours, dedicated watches of no less than 60 minutes were conducted to monitor for protected species within the exclusion zone. Communication between visual observers, and seismic operators was carried out using the vessel's internal communication system.

Identification of marine mammals and sea turtles were made or confirmed using Guide to Marine Mammals and Turtles of the U.S. Atlantic & Gulf of Mexico (Wynne, K. and Schwartz, M. 1999) and Whales, Dolphins and Porpoises (Mark Carwardine and Martin Camm).

4 SURVEY DATA

4.1 Operations Summary

The AUV sources was active 1612 hours 43 minutes. Full volume production occurred for a total of 1538 hours 29 mins. There was a total of 222 AUV source ramps ups and deployments, all occurring during daylight hours. AUV retrievals were done during daylight and occasionally at nighttime during the survey.

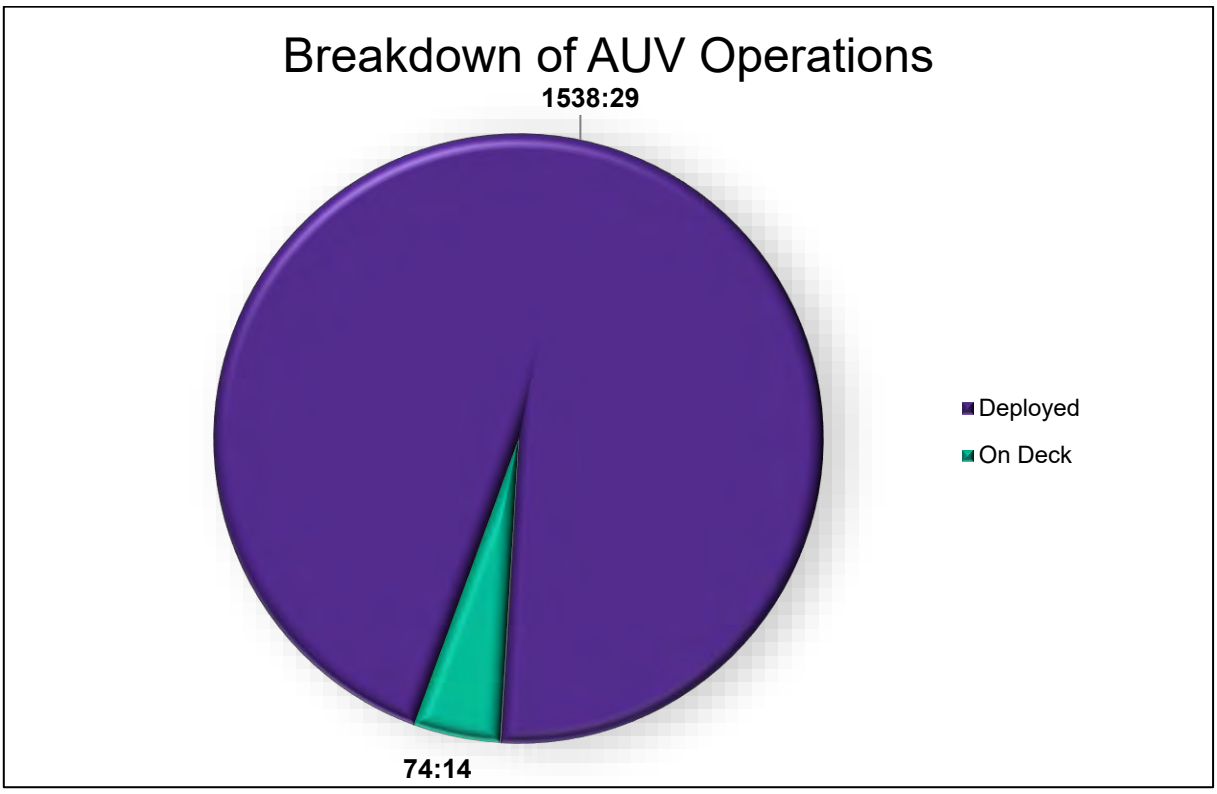

Figure 4: Breakdown of active AUV Operations

4.2 Visual Monitoring Effort Summary

Visual observations were conducted by the PSOs for a total of 1537 hours 12 minutes. A total of 1329 hours 30 minutes of visual watch was undertaken while the source was active. A total of 207 hours and 42 minutes of visual watch was conducted while the source was not active. There were 116 hours and 45 minutes were the AUVs were deployed without visual monitoring due to nighttime operations.

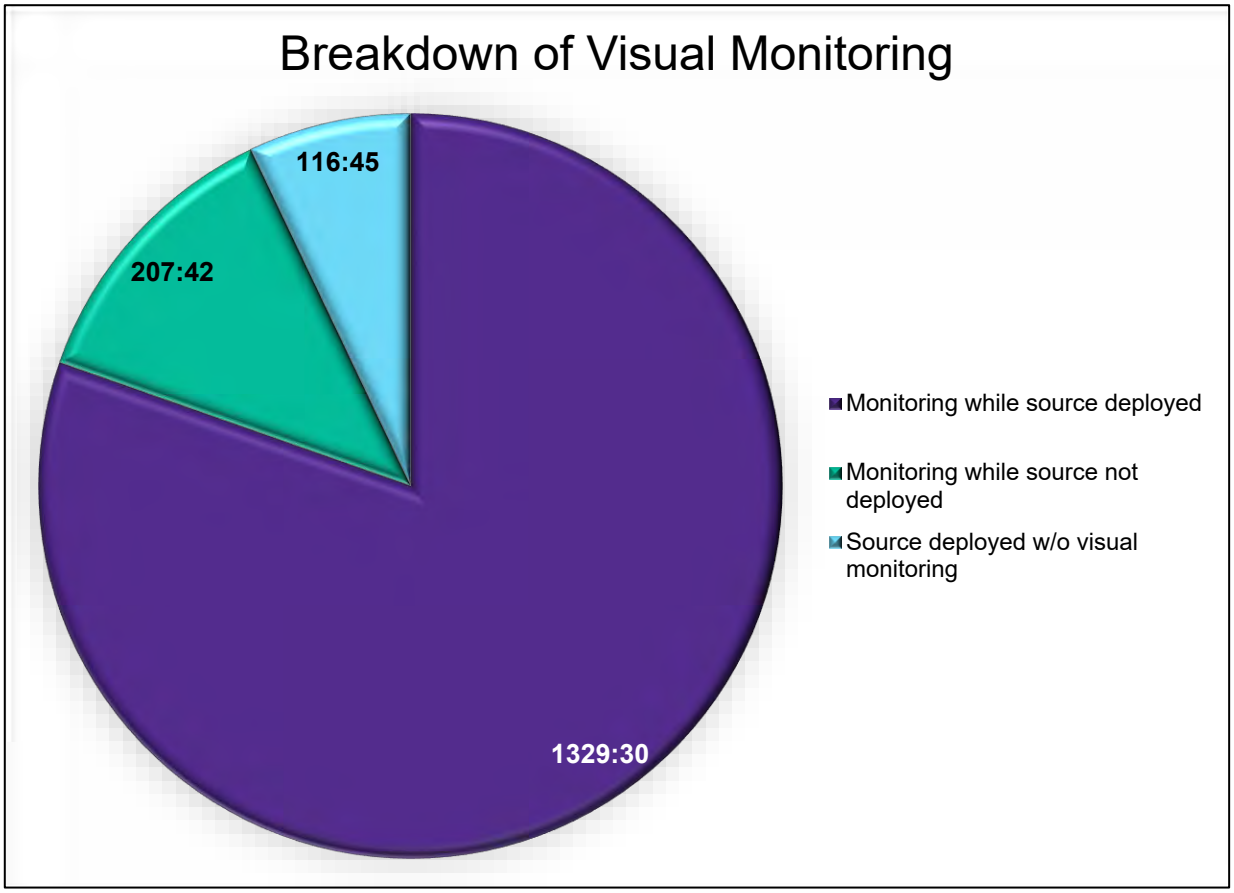

Figure 5: Breakdown of Visual Monitoring

Beaufort state was between two to six during the reporting period with visibility of more than five kilometers (km). with exception during times of rain when visibility was reduced to 2-5km for less than two hours. Swells were less than two and no more than four meters and glare from the sun was mostly moderate during the reporting period.

4.3 Mitigation Action Summary

There were no mitigation actions required during either part of this survey.

4.4 Wildlife Summary

There were 23 visual sightings; 13 detections of Common bottlenose dolphins, four detections of unidentified dolphins, two detections Short-finned pilot whale, one detection of Atlantic spotted dolphin, one detection of Pantropical spotted dolphin, one detection of green sea turtle, and one detection of loggerhead sea turtle. Figure 6 shows the distribution of the visual detections in the survey area.

The detection information is provided in Table 2 for each visual sighting.

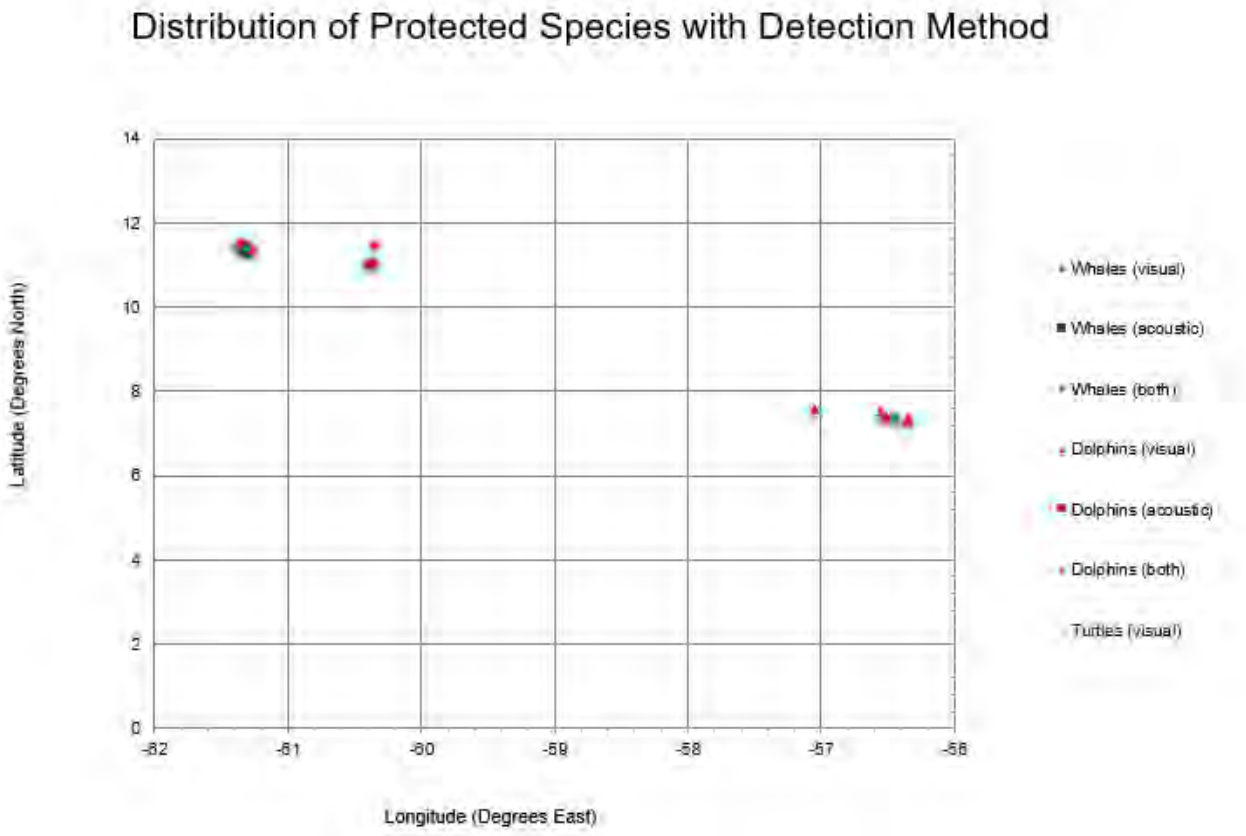

Figure 6: Distribution of protected species during the survey.

Table 2: Detection Summary

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range from vessel when First Detected
2019-12-17	1		11:50	11:59	Common bottlenose dolphin	Visually	11.08345°N	060.34513°W	557	4	200
2019-12-18	2		10:03	10:16	Common bottlenose dolphin	Visually	11.07022°N	060.39422°W	152	3	50
2019-12-18	3		10:40	11:03	Common bottlenose dolphin	Visually	11.07050°N	060.39658°W	147	6	100
2019-12-24	4		19:20	19:25	Common bottlenose dolphin	Visually	11.50398°N	060.35332°W	600	1	100
2019-12-27	5		10:12	10:13	Unidentified dolphin	Visually	11.51892°N	061.37008°W	565	9	50
2019-12-28	6		15:57	16:23	Common bottlenose dolphin	Visually	11.41418°N	061.31705°W	190	3	50
2019-12-28	7		19:20	19:30	Common bottlenose dolphin	Visually	11.41603°N	061.31500°W	186	2	200
2020-01-01	8		20:20	20:22	Common bottlenose dolphin	Visually	11.49502°N	061.35265°W	517	7	50
2020-01-03	9		15:30	15:31	Green sea turtle	Visually	11.45323°N	061.32313°W	225	1	50
2020-01-04	10		14:00	14:22	Common bottlenose dolphin	Visually	11.39555°N	061.29267°W	180	6	20
2020-01-05	11		11:37	11:46	Common bottlenose dolphin	Visually	11.41400°N	061.31713°W	190	20	300
2020-01-06	12		22:09	22:17	Common bottlenose dolphin	Visually	11.50183°N	061.33478°W	533	11	5
2020-01-06	13		10:39	10:42	Common bottlenose dolphin	Visually	11.41342°N	061.28198°W	193	5	50
2020-01-06	14		20:20	20:22	Short-finned pilot whale	Visually	11.51428°N	061.34118°W	348	3	100
2020-01-06	15		21:00	21:06	Common bottlenose dolphin	Visually	11.47502°N	061.31795°W	400	15	20
2020-01-08	16		15:45	15:50	Atlantic spotted dolphin	Visually	11.41940°N	061.28765°W	186	3	300
2020-02-21	17		20:27	20:32	Loggerhead sea turtle	Visually	07.42.040°N	056.44566°W	1450	1	300
2020-02-26	18		21:15	21:35	Unidentified dolphin	Visually	07.37598°N	056.34367°W	1300		400
2020-02-28	19		19:35	19:57	Short-finned pilot whale	Visually	07.34411°N	056.36110°W	625	2	400
2020-03-15	20		20:50	21:00	Pantropical spotted dolphin	Visually	07.36052°N	056.56315°W	900	9	300
2020-04-25	21		13:20	13:45	Pantropical spotted dolphin	Visually	07.41571°N	056.50175°W	1050	3	4
2020-04-27	22		15:55	16:00	Unidentified dolphin	Visually	07.43367°N	056.45418°W	700	5	200
2020-05-02	23		09:45	09:55	Unidentified dolphin	Visually	07.41406°N	056.44566°W	1000	17	400

5 DATA FORMS COVER PAGE

Regulatory Reference Number	Country	Project Number
20161202-CSPEP	Guyana	206923
Client	**AUV Contractor**	**Vessel Name**
ExxonMobil	Ocean Infinity	*M/V Seabed Constructor* *M/v Normand Frontier*
Reporting Period Start Date	**Reporting Period End Date**	**Survey Type**
2019-12-14	2020-05-21	other: AUV

Source Vessel(s)	Type of Source	
M/V Seabed Constructor *M/V Normand Frontier*	AUVs	

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.)	Magnification of optical equipment (e.g. binoculars)	Height of eye off water surface (metres)	How was distance of animals estimated?
Binoculars	9-27x50	15	[x] by eye [ ] with rangefinder stick / calipers [ ] with reticle binoculars [x] by relating to object at known distance [ ] other

Marine Mammal Observers	Training of MMOs
Matthew Robinson Delroy Thomas Romeo De Freitas, Sr Antonio Hackett	[ ] JNCC approved MMO induction course for UK waters [x] PSO training course for the Gulf of Mexico [ ] other [ ] none

Was PAM used?	PAM Operator(s)	
no	n/a	
Description of PAM equipment		
n/a		
Range of PAM hydrophones from airguns (metres)	**Bearing of PAM hydrophones from airguns relative to direction of travel** (degrees)	**Depth of PAM hydrophones** (metres)
n/a	n/a	n/a

Table 3: Bird species identified during the survey

Common Name	Class	Order	Family	Genus	Species	Number of Individuals Observed	Number of Days Observed
Masked Booby	Aves	Pelecaniformes	Sulidae	*Sula*	*dactylatra*	152	94
Laughing Gull	Aves	Charadriiformes	Laridae	*Larus*	*atricilla*	1	94
Great Shearwater	Aves	Procellariiformes	Procellariidae	*Ardenna*	*A.gravis*	265	94
Red Billed tropicbird	Aves	Phaethontiformes	Phaethontidae	*Plaethon*	*P.aethereus*	16	94
Brown Booby	Aves	Pelecaniformes	Sulidae	*Sula*	*leucogaster*	37	94
Magnificent Frigatebird	Aves	Suliformes	Fregatidae	*Fregata*	*magnificens*	6	94
Wilison Storm Petrel	Aves	Procellariiformes	Oceanitidae	*Oceanites*	*oceanicus*	40	94
Parasitic Jaeger	Aves	Charadriiformes	Stercorariidae	*Stercorarius*	*parasiticus*	8	94
Common Tern	Aves	Charadriformes	Sternidae	*Sterna*	*hirundo*	10	94
Brown Noody	Aves	Charadriiformes	Laridae	*Anous*	*stolidus*	1	94
Roseate Tern	Aves	Charadriiformes	Laridae	*Sterna*	*S.dougalii*	13	94
Sooty Tern	Aves	Charadriformes	Laridae	*Onychoprion*	*O.fuscatus*	1	94
Fuscous Flycatcher	Aves	Passeriformes	Tyrannidae	*Cnemotriccus*	*c.fuscatus*	1	94

Table 4: Fish species observed in this survey

Common Name	Class	Order	Family	Genus	Species	Number of Individuals Observed
Atlantic Flying Fish	Actinopterygii	Beloniformes	Exocoetidae	*Cheiloogon*	*C.melanurus*	100+
Dolphinfish	n/a	n/a	n/a	*n/a*	*n/a*	100+
Ocean Sunfish	Actinopterygii	Tetraodontiformes	Molidae	*Mola*	*M.mola*	6
Mahi Mahi	Actinopterygii	Perciformes	Coryphaenidae	*Coryphaena*	*hippurus*	2

Appendix A: Wildlife Photos

Figure 7: Detection #17, Loggerhead sea turtle

Figure 8: Detection #18, Unidentified dolphins

Figure 9: Detection #20, Pantropical spotted dolphin

Figure 10: Detection #5, Unidentified dolphins

Figure 11: Common Tern, Magnificent Frigate Bird, Laughing Gull, Red Billed Tropic Bird, Masked Booby and Fuscous flycatcher

APPENDIX O

Coastal Sensitivity Maps

Resubmitted without changes

March 2022

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Guyana

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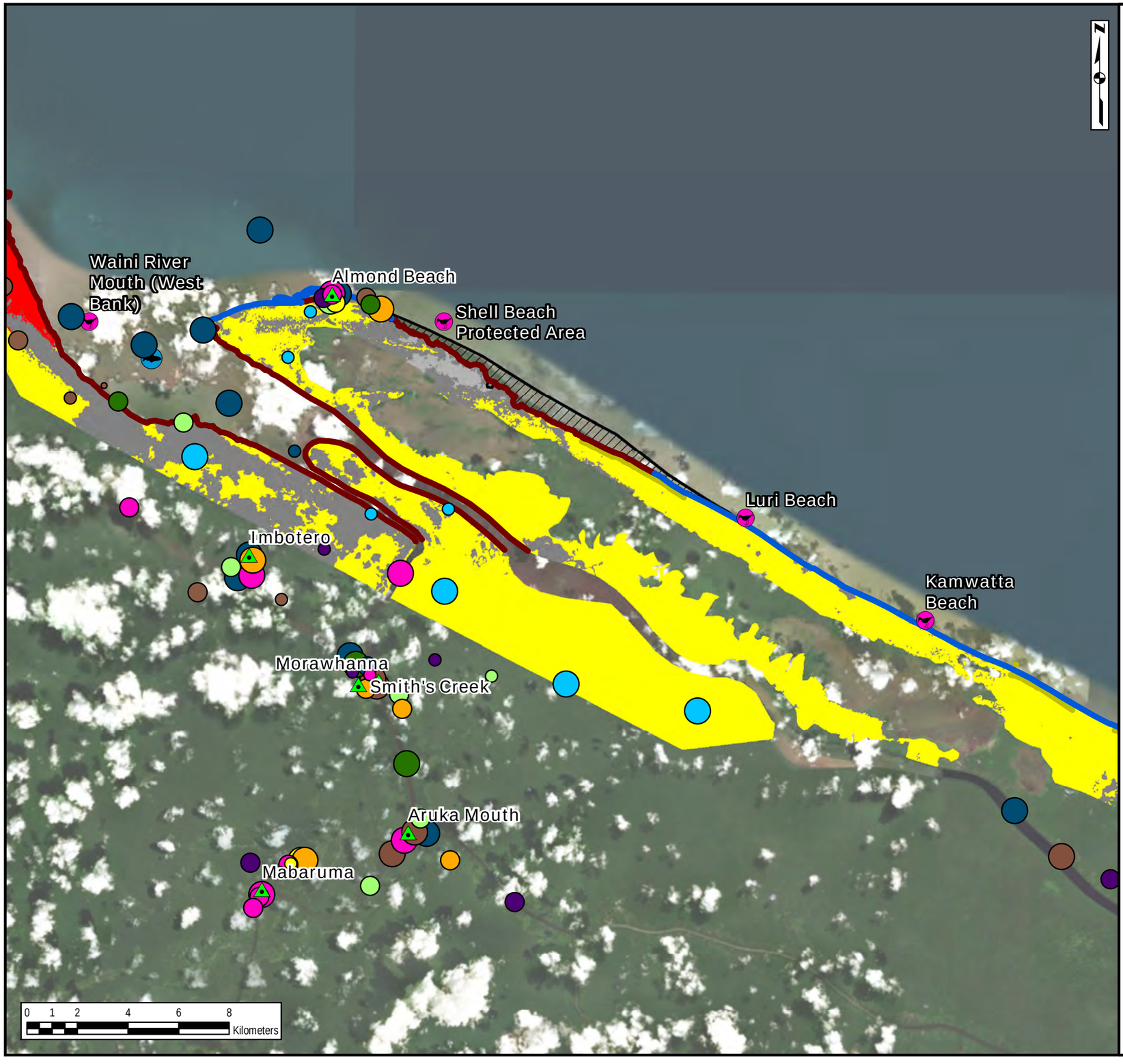

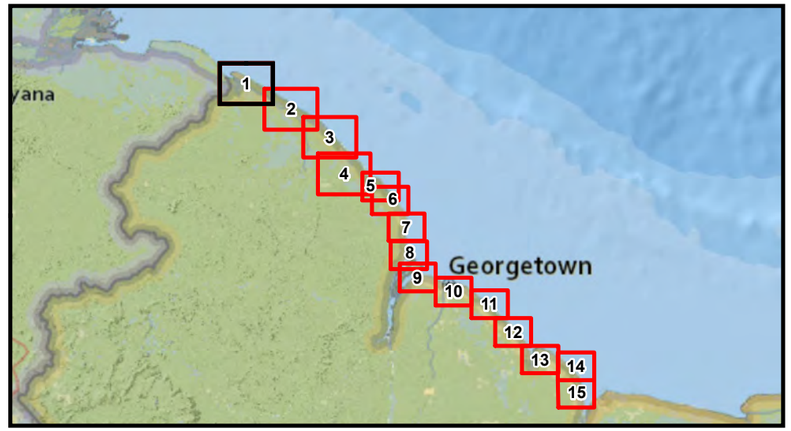

Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

Fishing
Agriculture
Biodiversity
Carbon Sequestration
Ecotourism
Crabbing
Mangroves
Traditional Resources
Ritual / Religious
Social / Cultural
Trapping / Hunting
Other

Priority

Low
Medium
High
Critical

Environmental Sensitivity Index (ESI)

Shorelines

1B: Exposed, Solid Man-Made Structures
3A: Fine to Medium Grained Sand Beaches
6B: Riprap
7: Exposed Tidal Flats
9B: Vegetated Low Banks
10A: Salt and Brackish Water Marshes
10D: Mangroves
Important Fish Habitats Areas

Mangrove Sensitivity

Critical Sensitivity(Mature and Growing)
Very High Sensitivity(Young and Growing)
High Sensitivity(Mature and Degrading)
Medium Sensitivity
Low Sensitivity
Fully Eroded

Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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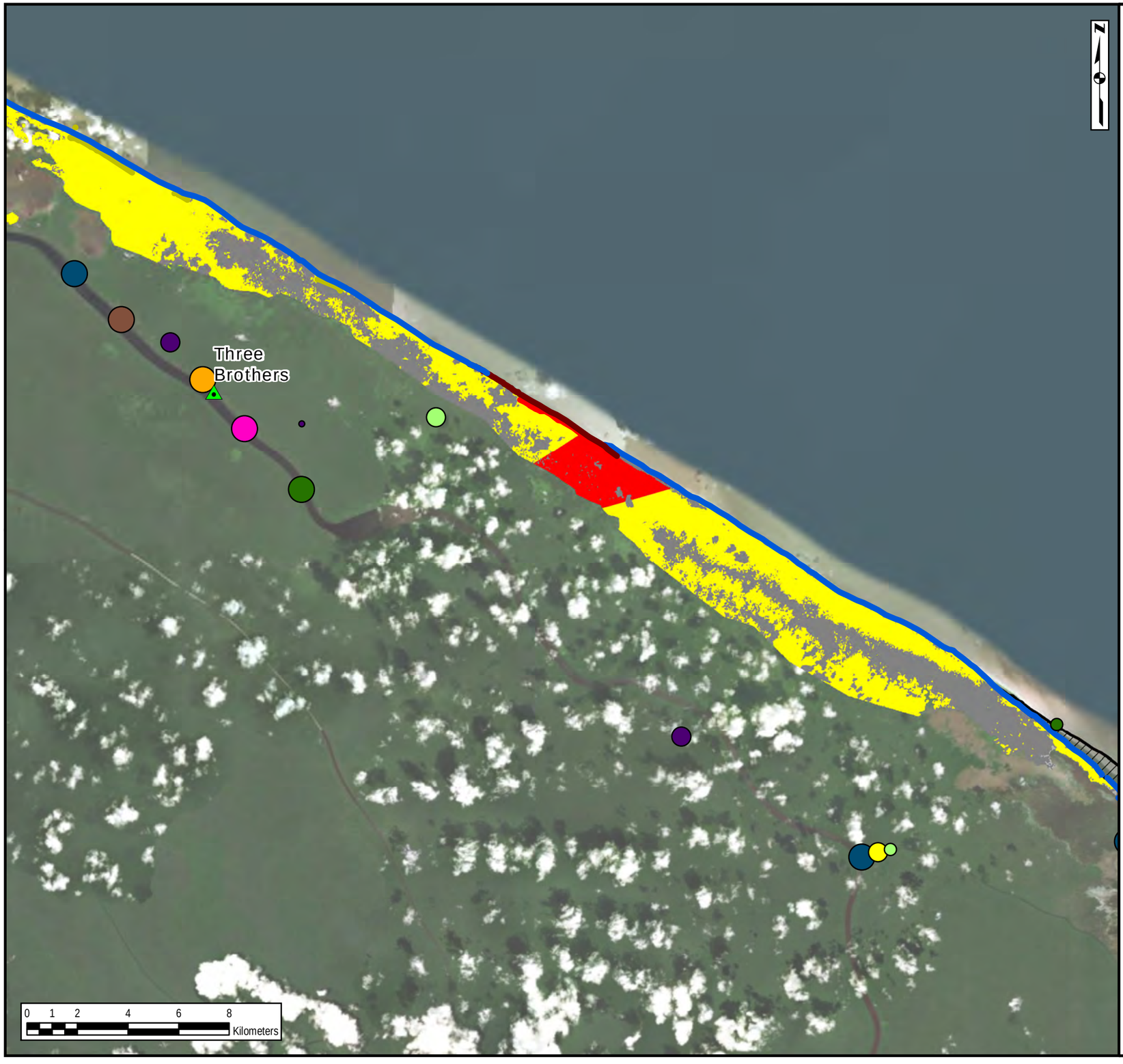

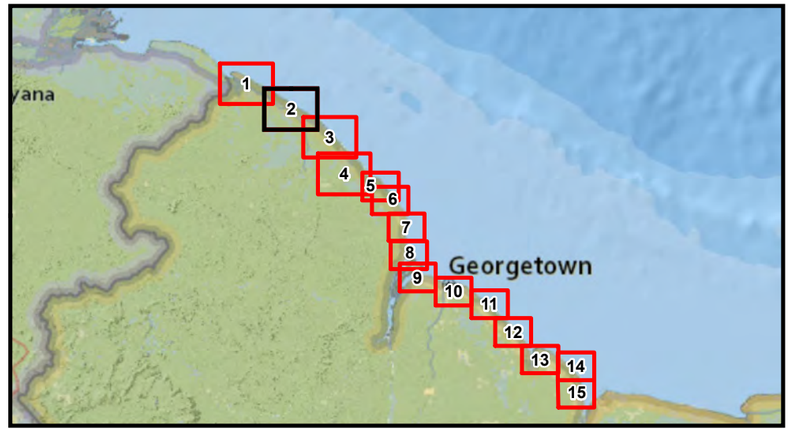

Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

Fishing
Agriculture
Biodiversity
Carbon Sequestration
Ecotourism
Crabbing
Mangroves
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Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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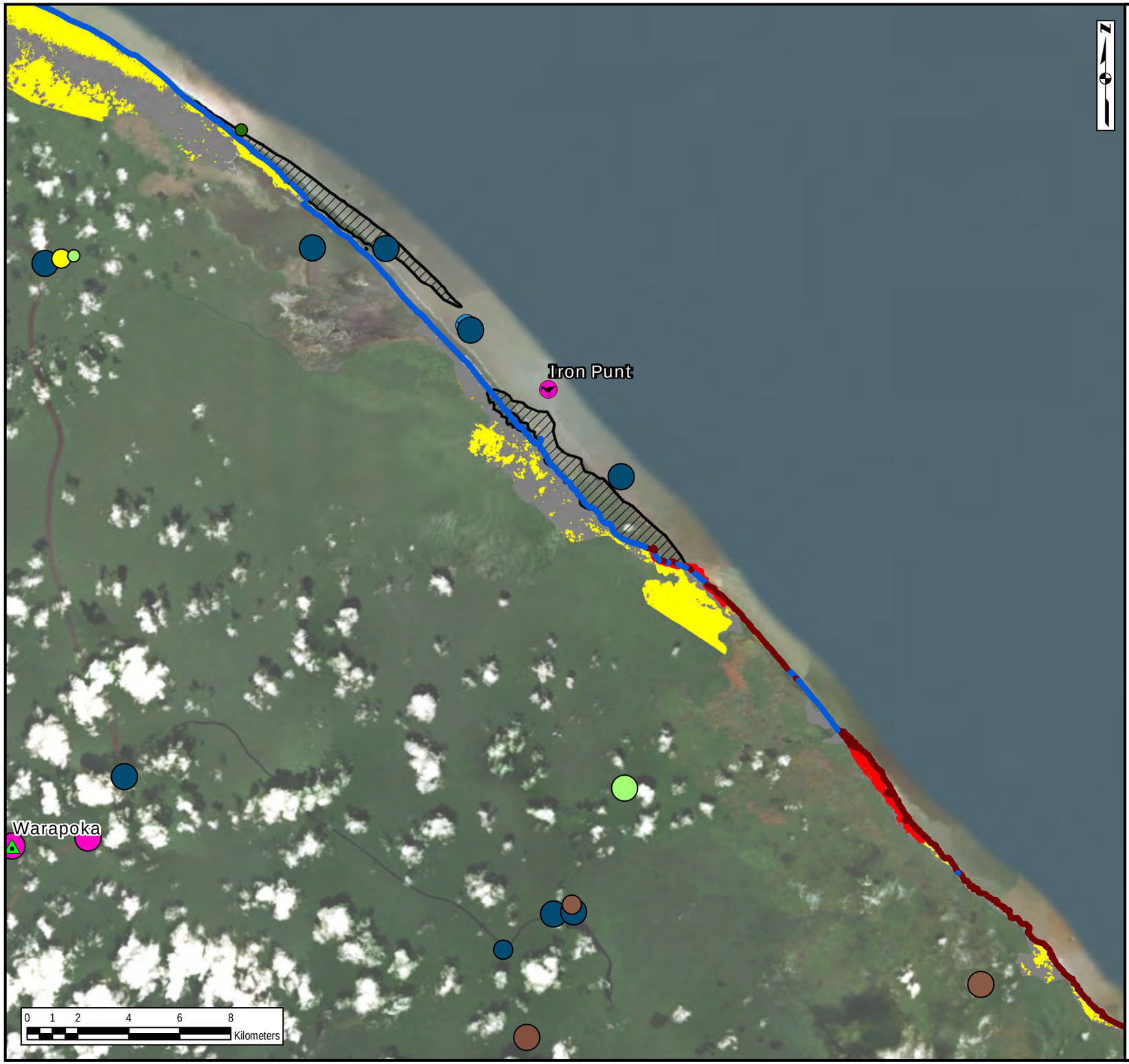

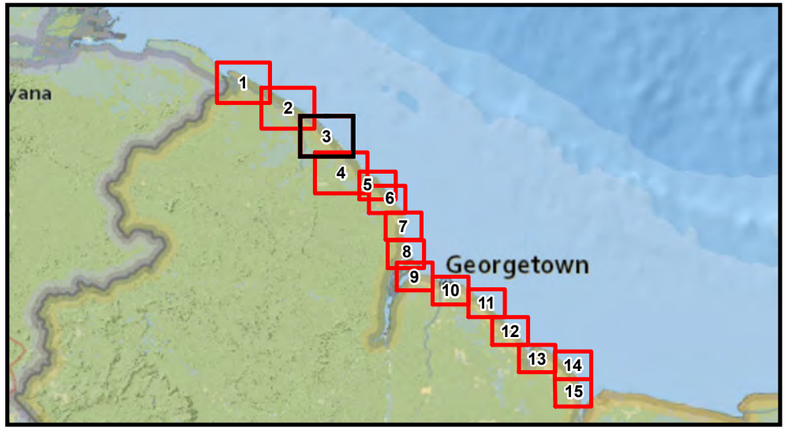

Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
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Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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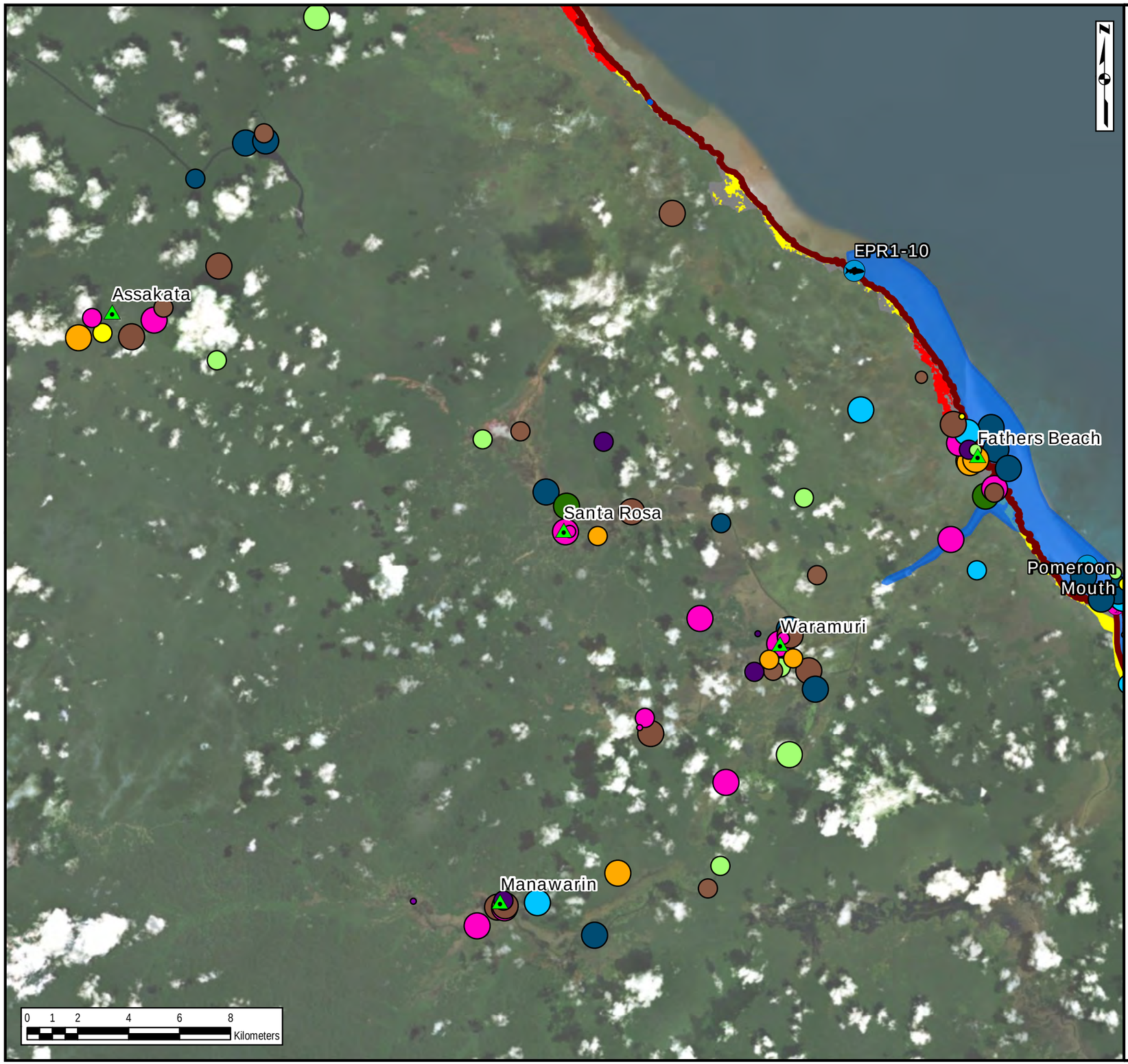

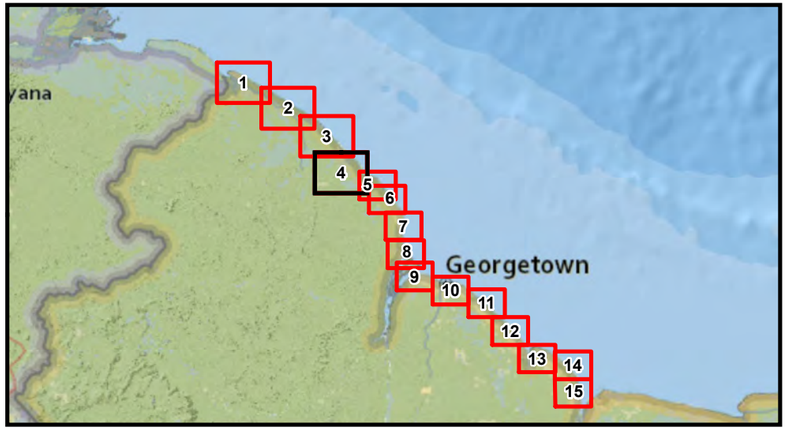

Legend

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- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
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Social and Biodiversity Sensitivities
EEPGL
Regions 1-6 Guyana
Febuary 2020

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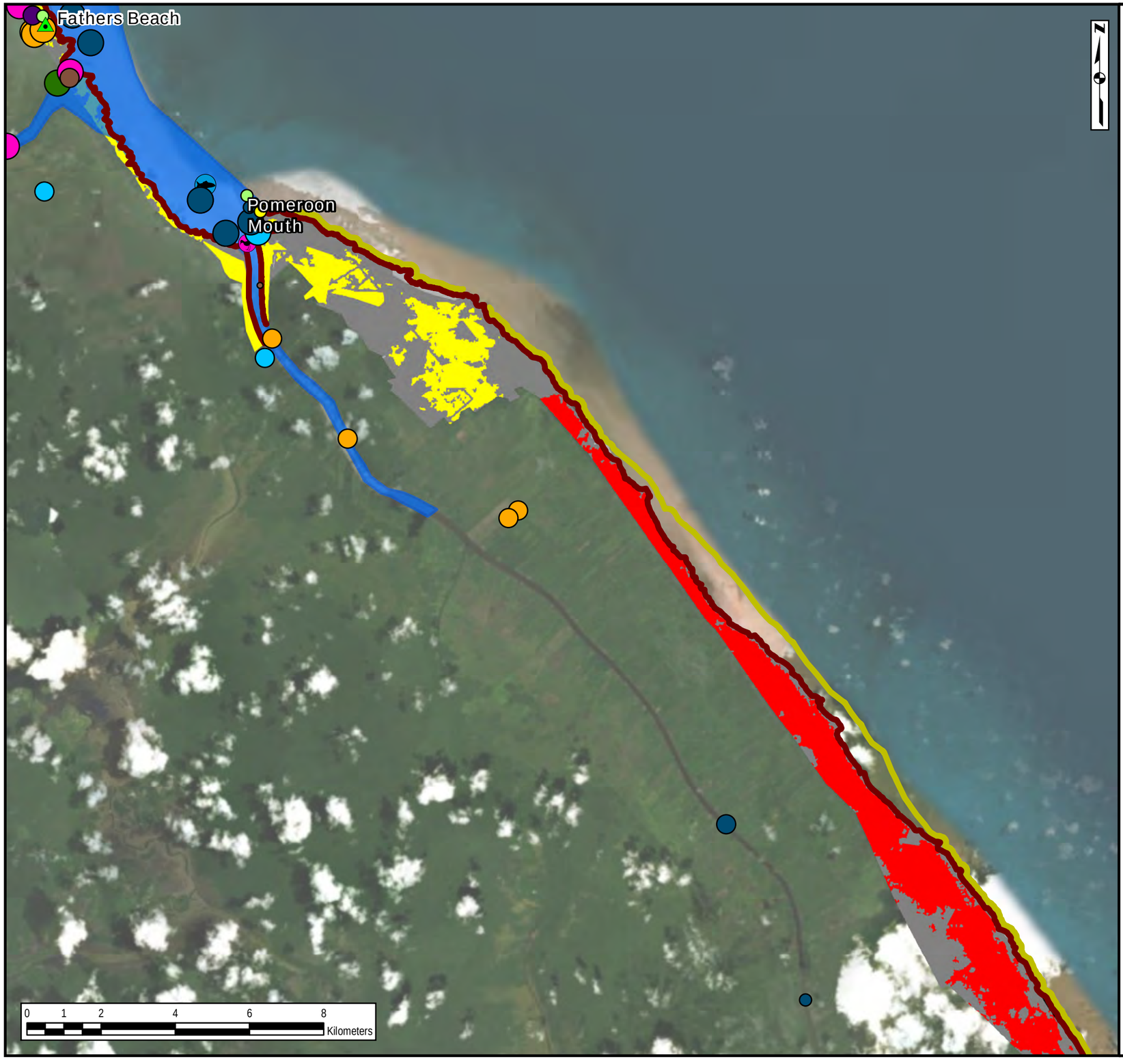

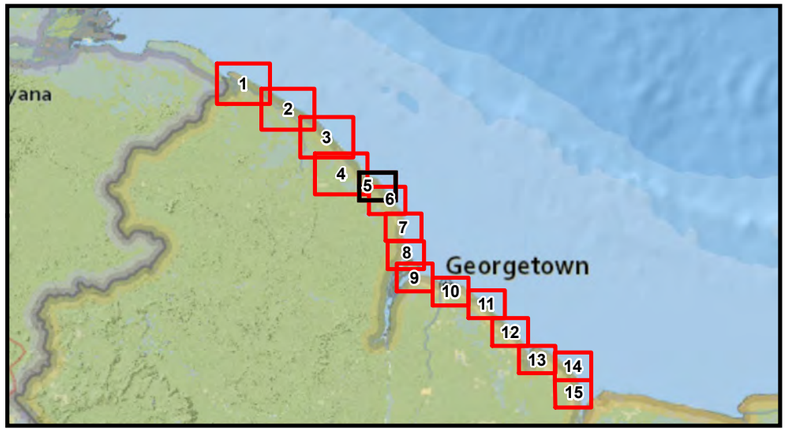

Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
- Ritual / Religious
- Social / Cultural
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Social and Biodiversity Sensitivities
EEPGL
Regions 1-6 Guyana
Febuary 2020

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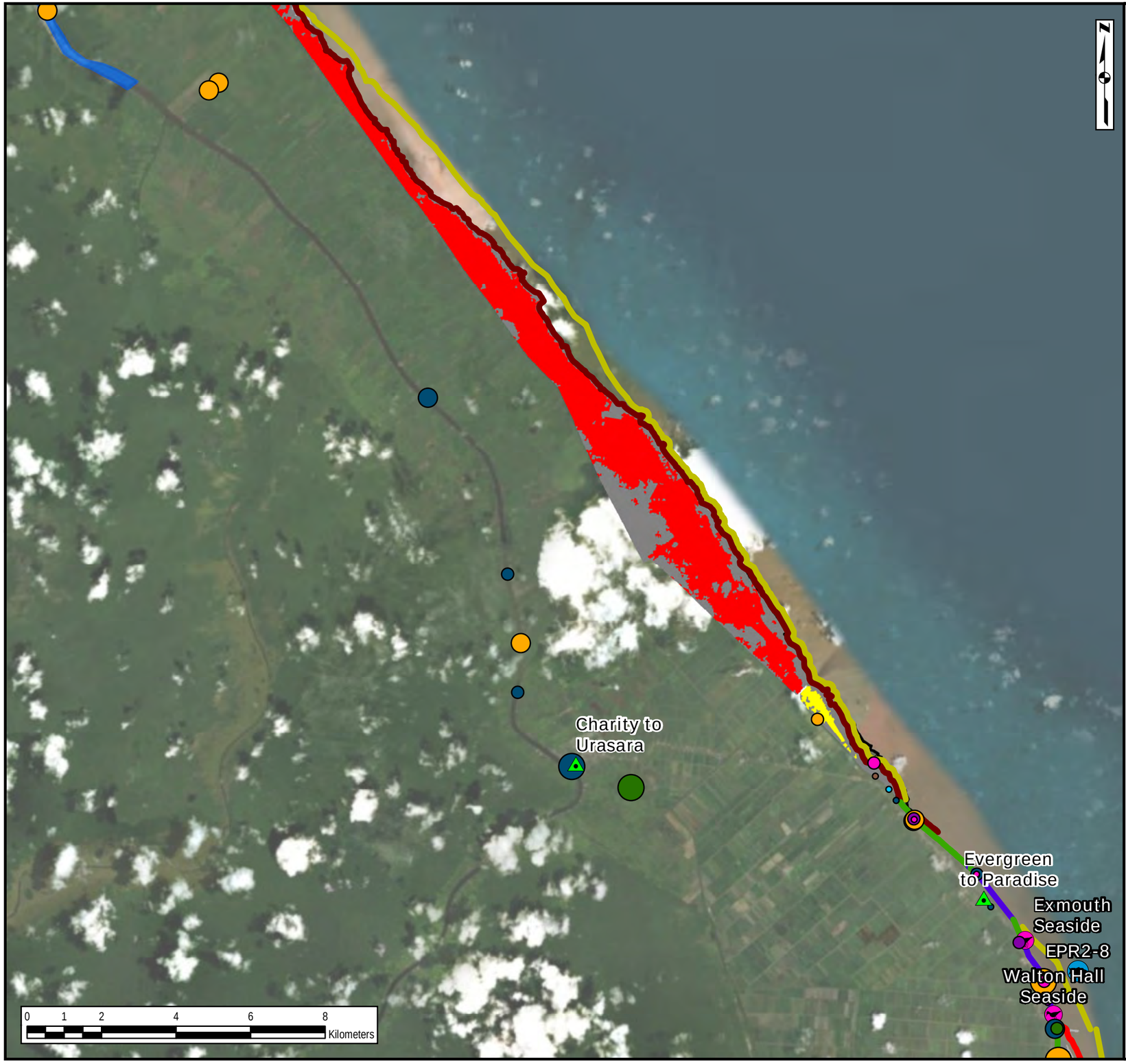

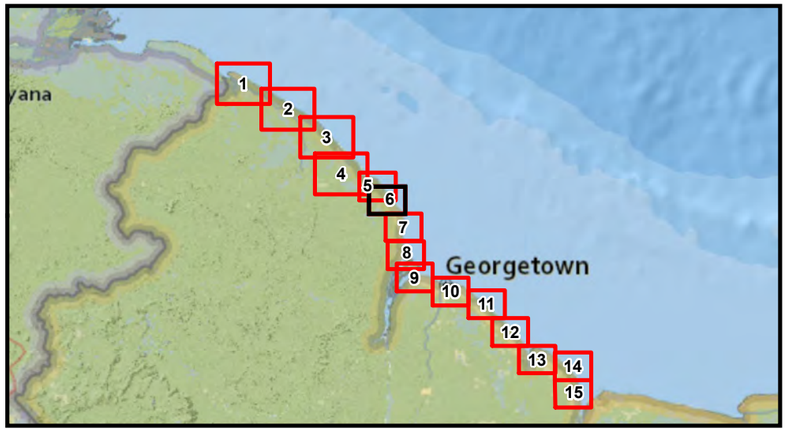

Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

Fishing
Agriculture
Biodiversity
Carbon Sequestration
Ecotourism
Crabbing
Mangroves
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Social and Biodiversity Sensitivities

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Regions 1-6 Guyana
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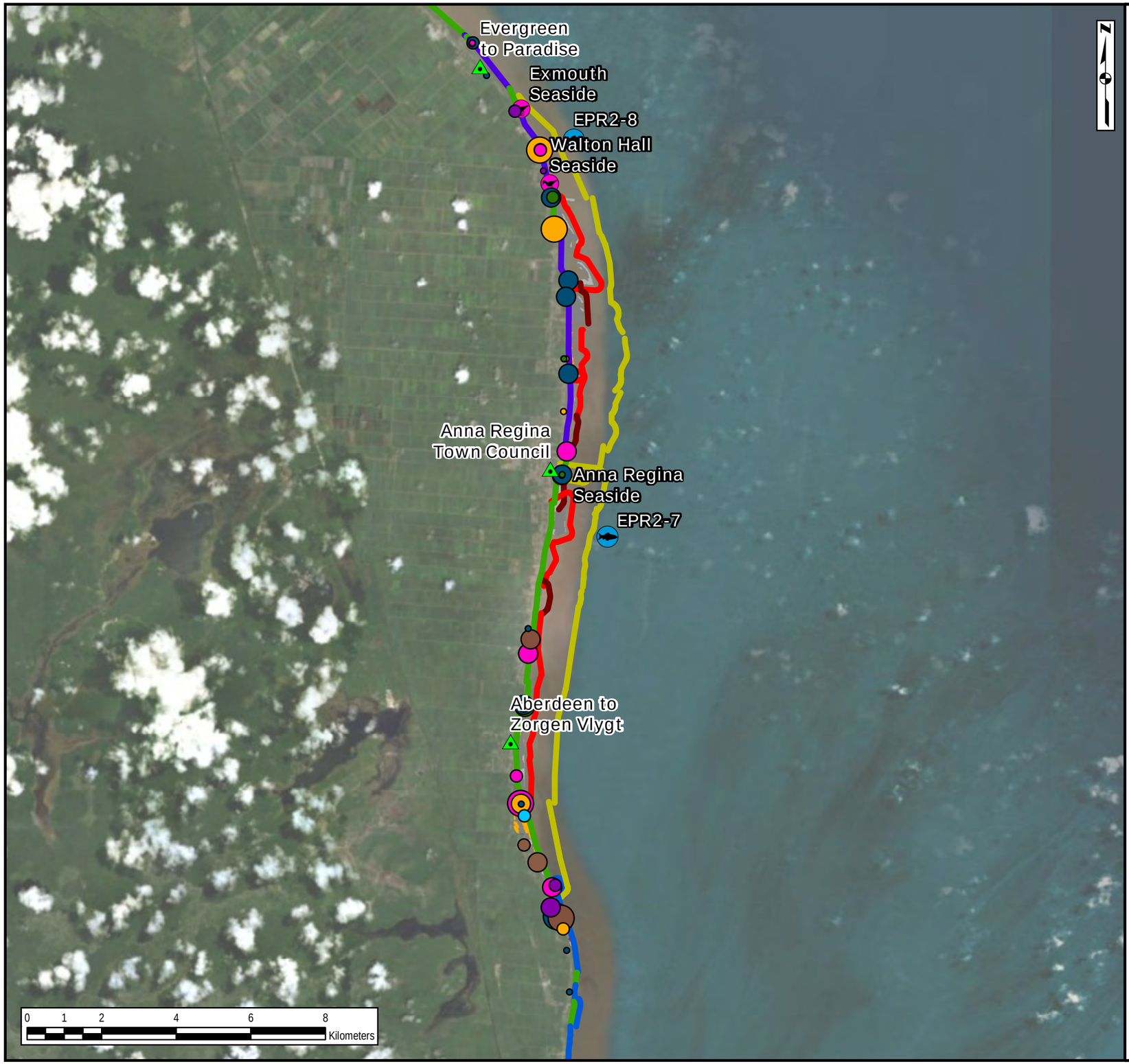

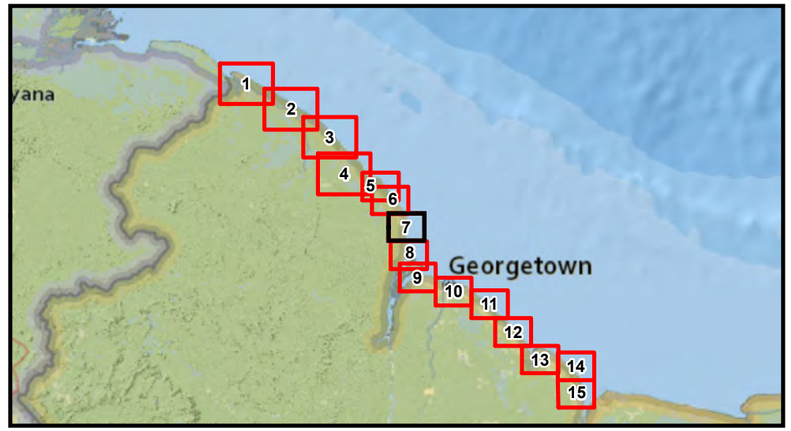

Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
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Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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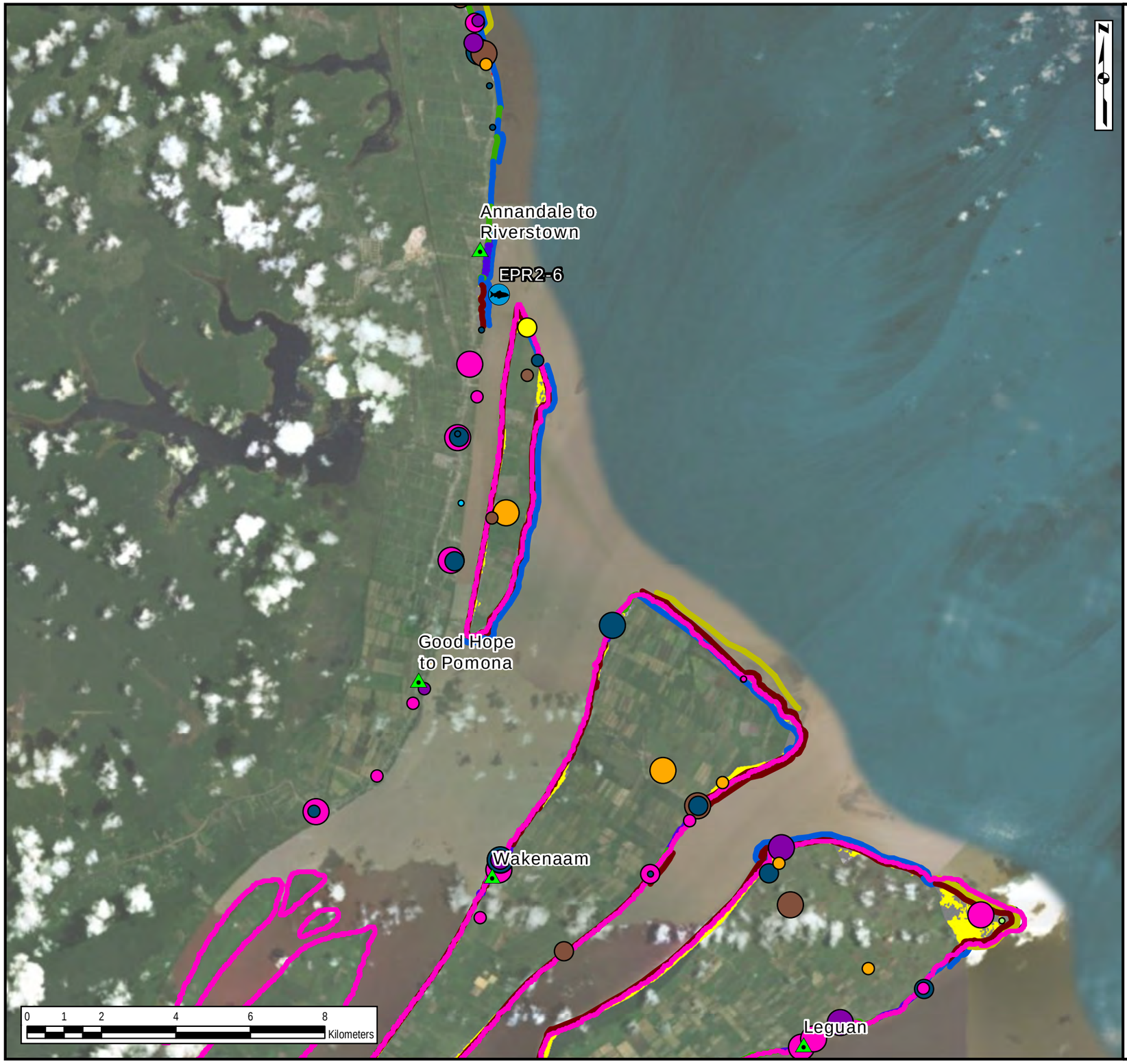

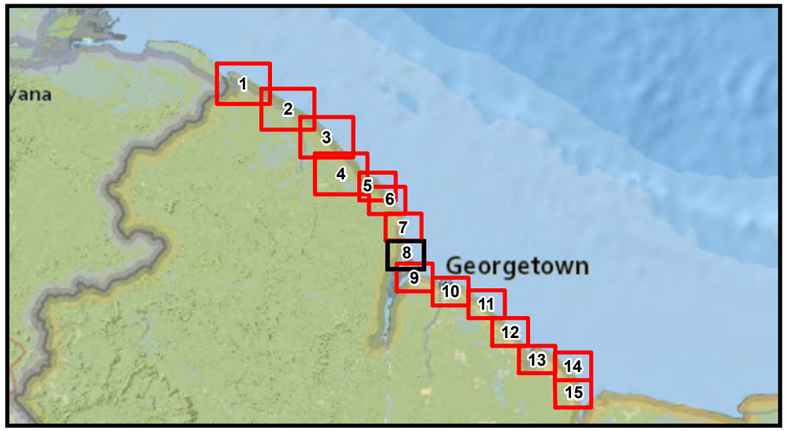

Legend

- NDC/CDC/VC/Town Council
- Essequibo Islands Important Bird Habitat
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
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- Social / Cultural
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Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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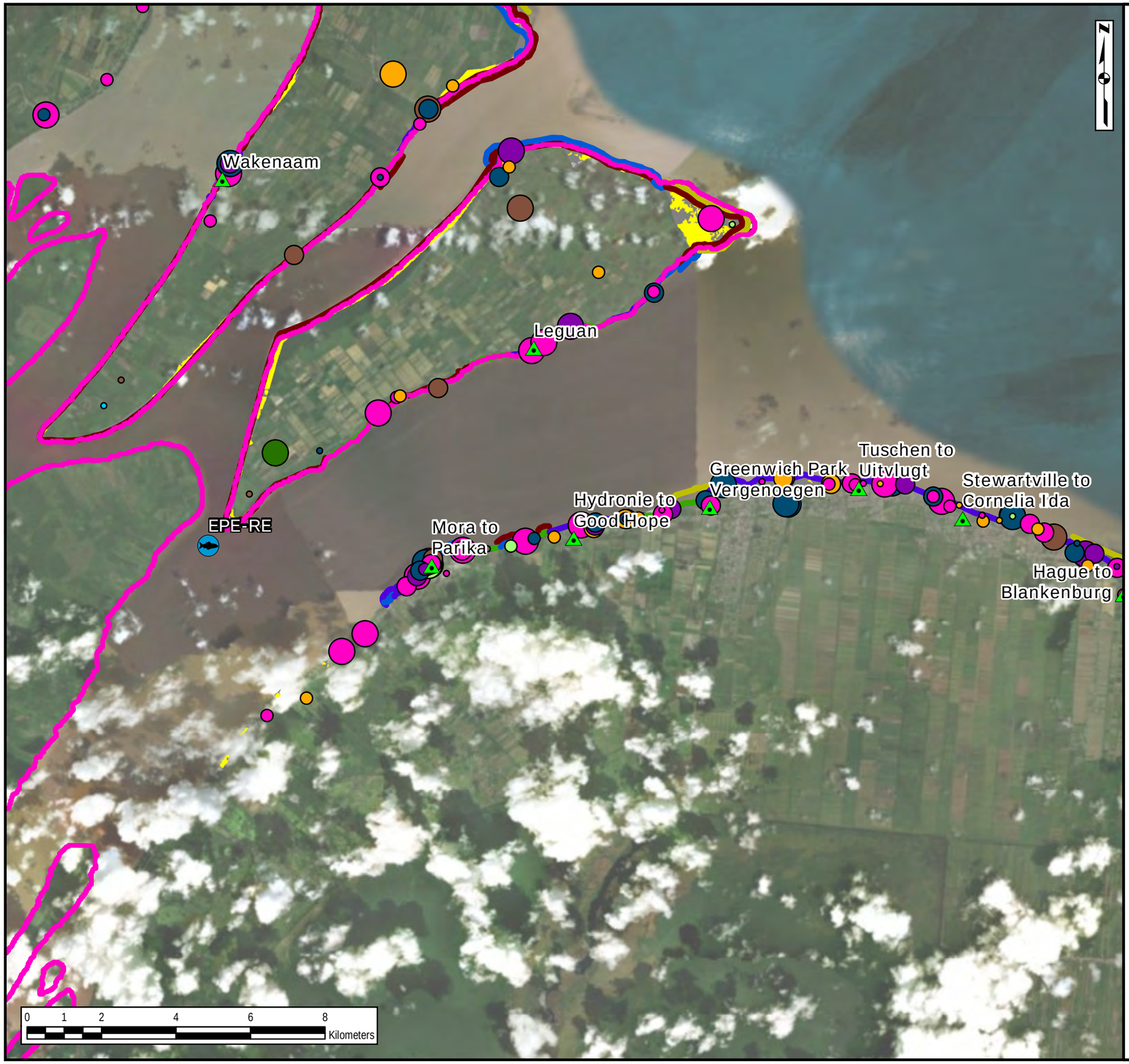

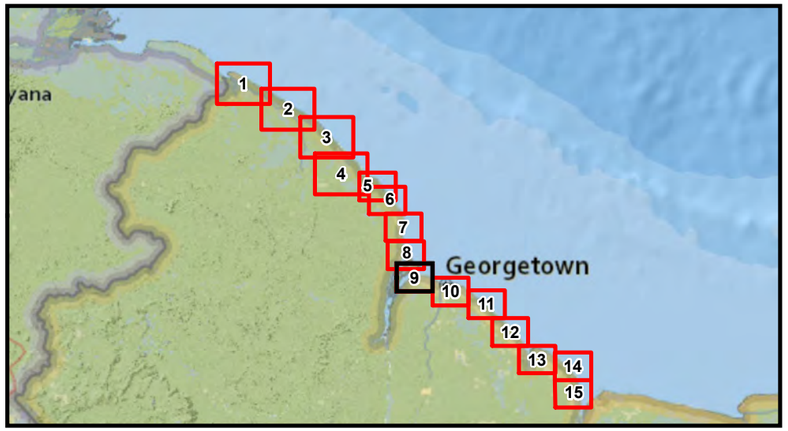

Legend

- NDC/CDC/VC/Town Council
- Essequibo Islands Important Bird Habitat
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
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Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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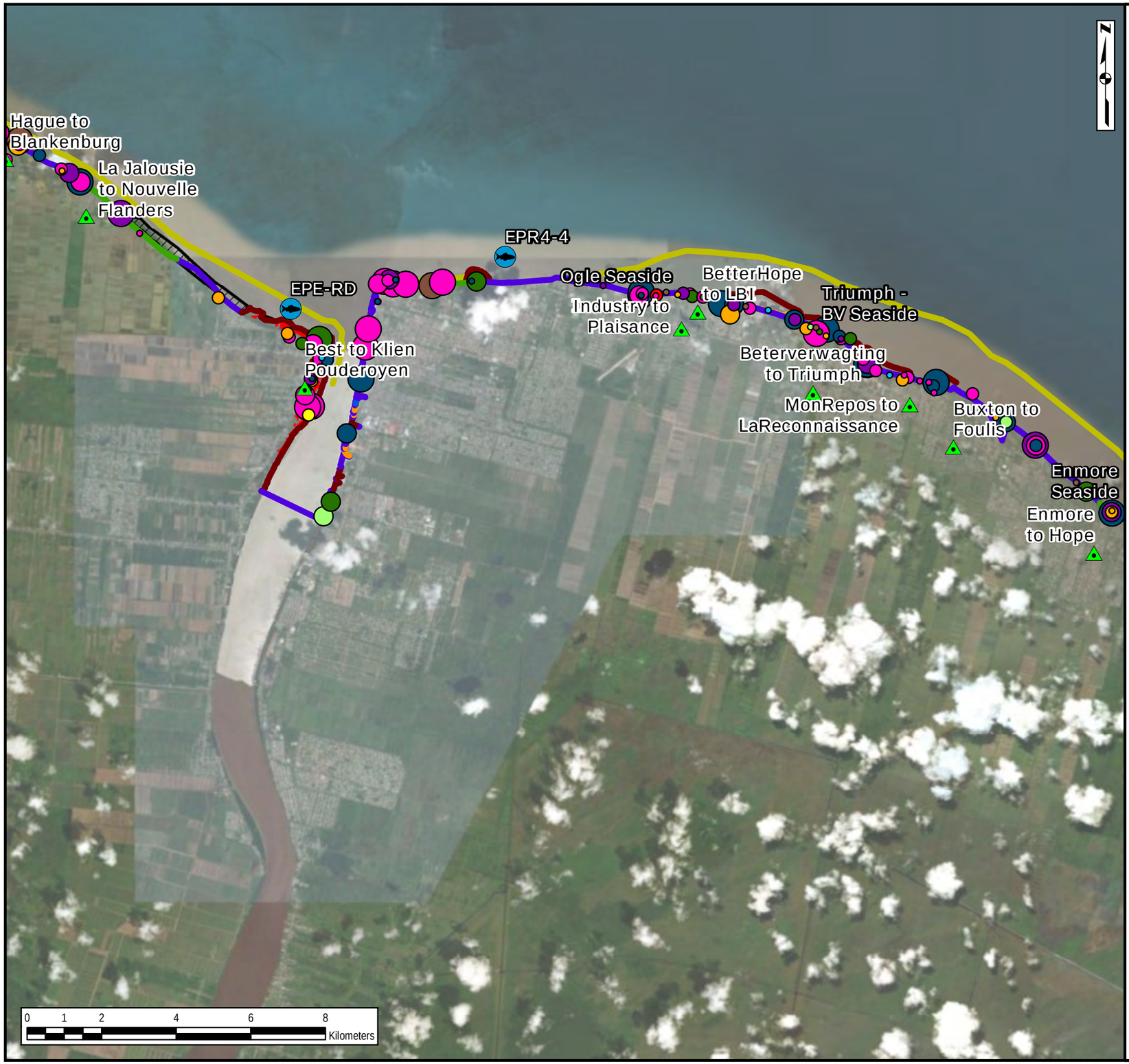

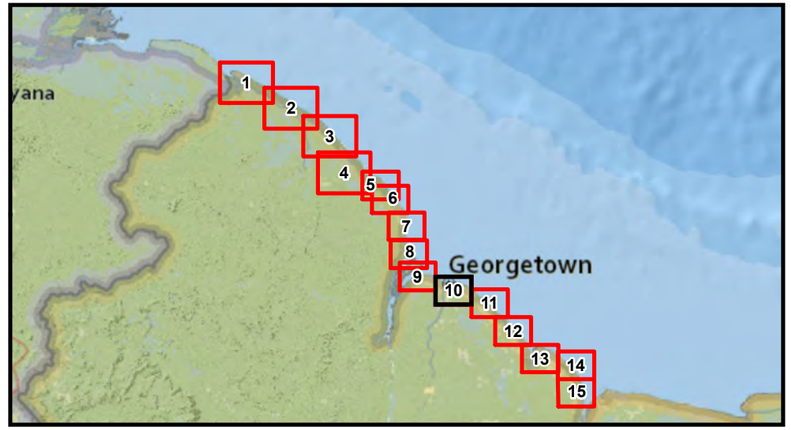

Legend

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- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

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Social and Biodiversity Sensitivities
EEPGL
Regions 1-6 Guyana
Febuary 2020

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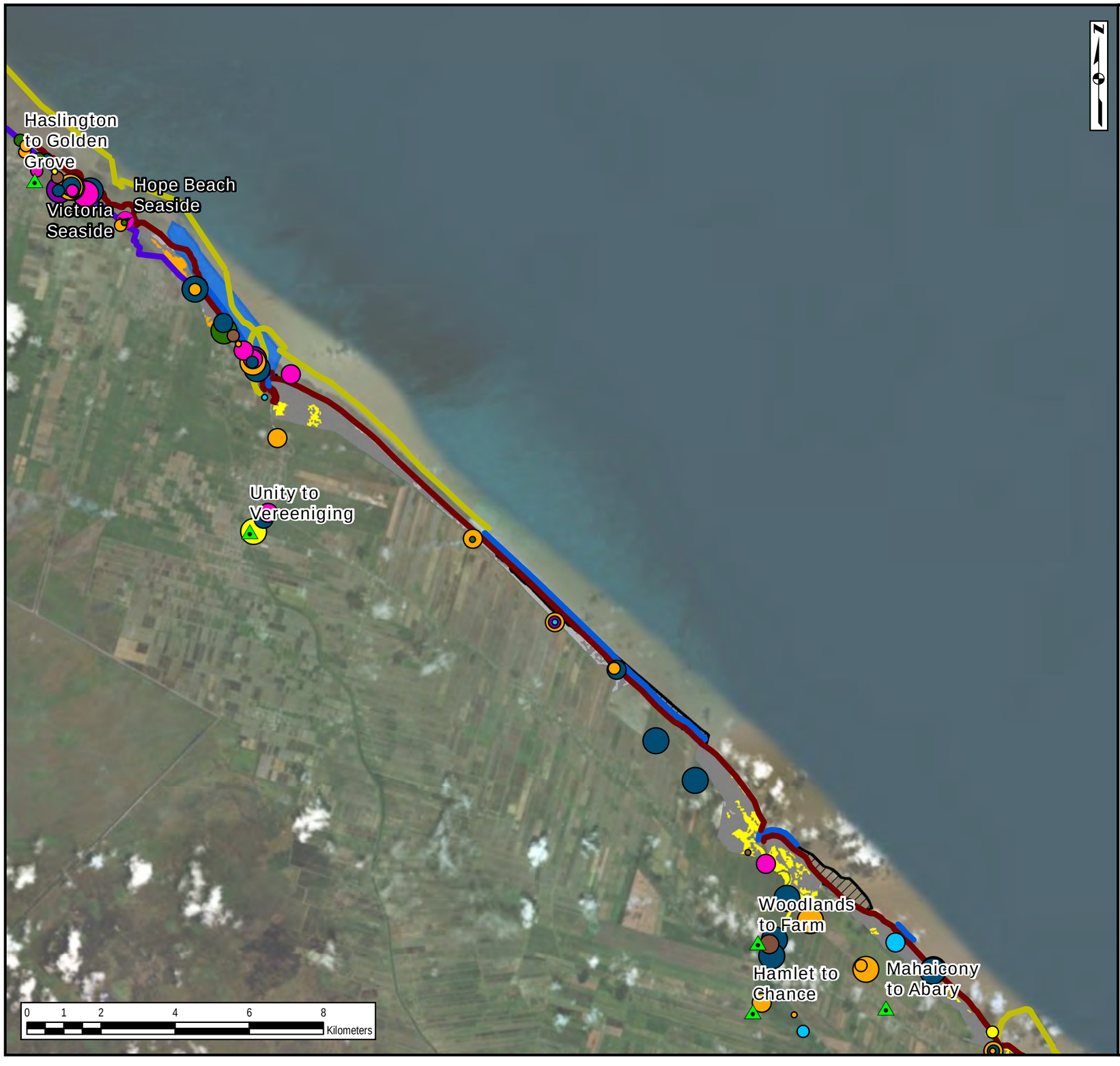

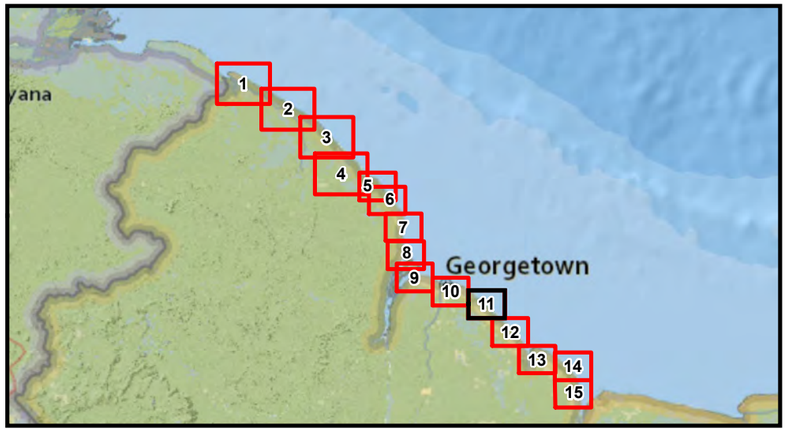

Legend

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- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

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Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

ERM

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Woodlands to Farm

Hamlet to Chance

Mahaicony to Abary

Profit to RisingSun

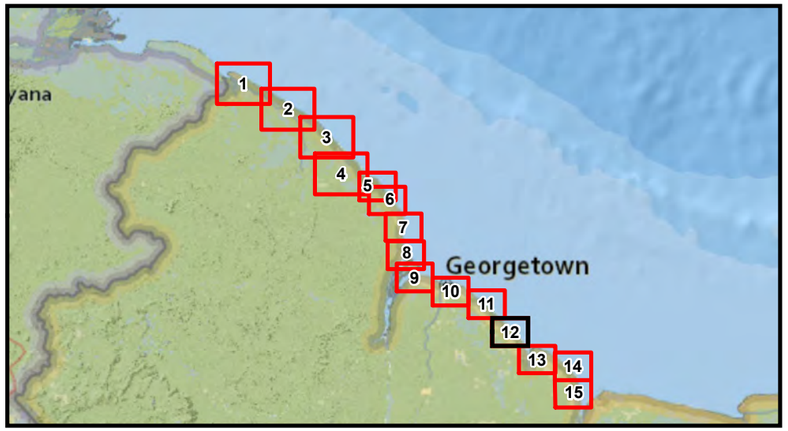
Seafield to Tempie

Bush Lot Seaside

Union to Naarstigheid

Bath to Woodley Park

0 1 2 4 6 8 Kilometers



Legend

NDC/CDC/VC/Town Council

Important Bird Habitats

Important Fish Habitats

Ecosystem Services

Types

Fishing

Agriculture

Biodiversity

Carbon Sequestration

Ecotourism

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Traditional Resources

Ritual / Religious

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Trapping / Hunting

Other

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Social and Biodiversity Sensitivities
EEPGL
Regions 1-6 Guyana
Febuary 2020

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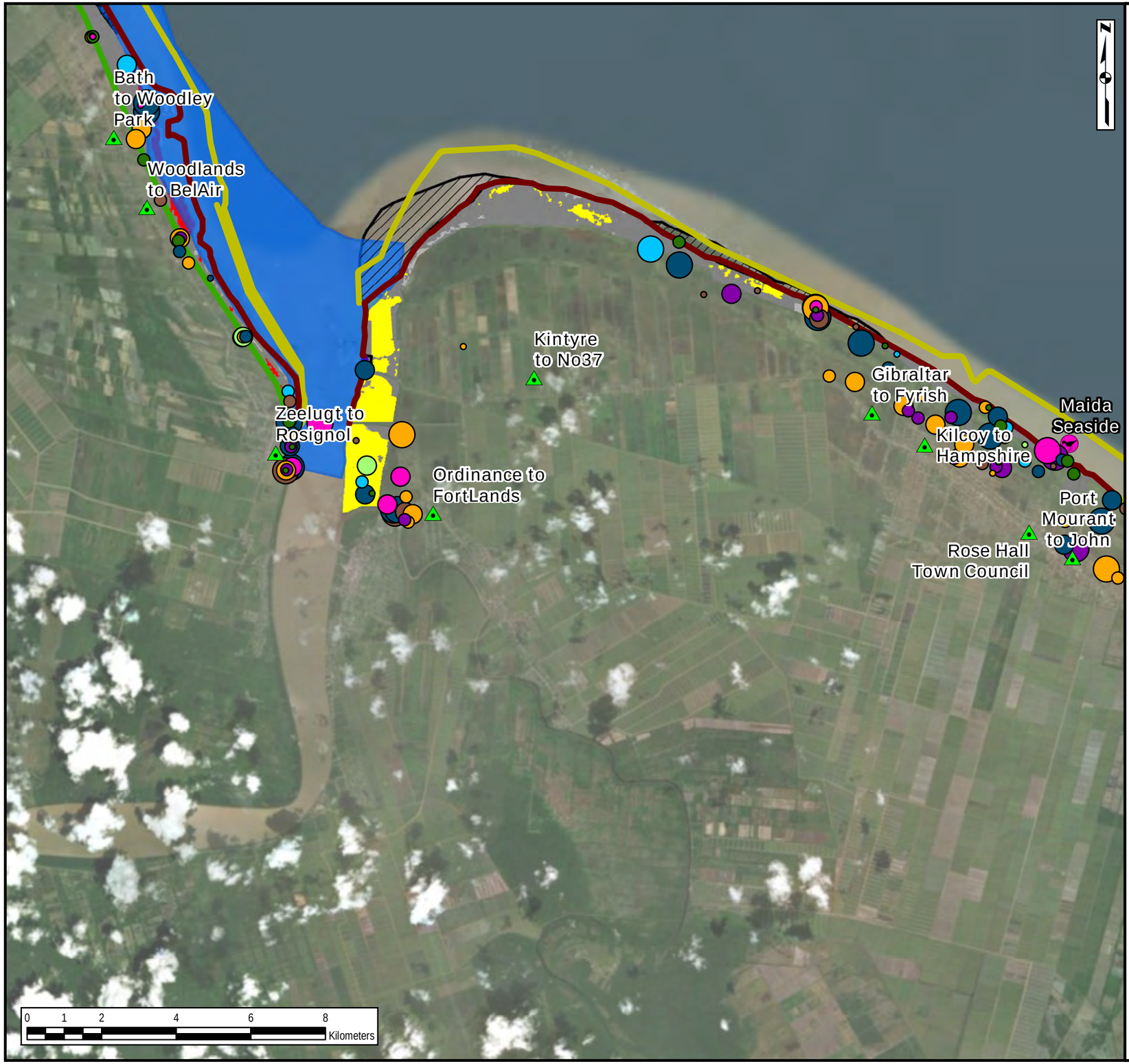

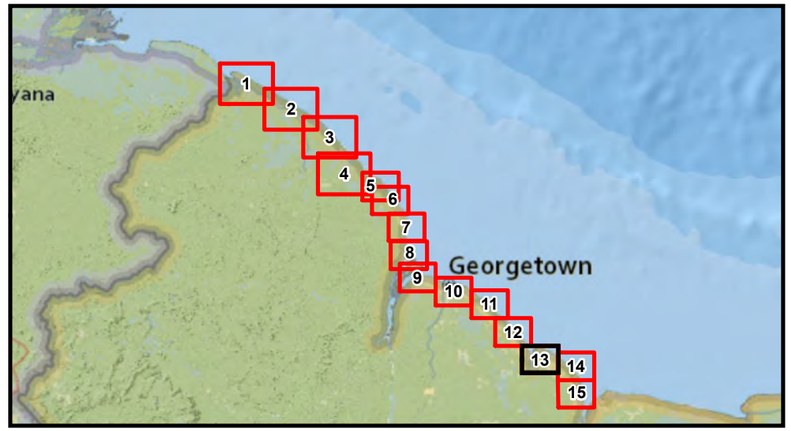

Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
- Ritual / Religious
- Social / Cultural
- Trapping / Hunting
- Other

Priority

- Low
- Medium
- High
- Critical

Environmental Sensitivity Index (ESI)

Shorelines

- 1B: Exposed, Solid Man-Made Structures
- 3A: Fine to Medium Grained Sand Beaches
- 6B: Riprap
- 7: Exposed Tidal Flats
- 9B: Vegetated Low Banks
- 10A: Salt and Brackish Water Marshes
- 10D: Mangroves
- Important Fish Habitats Areas

Mangrove Sensitivity

- Critical Sensitivity(Mature and Growing)
- Very High Sensitivity(Young and Growing)
- High Sensitivity(Mature and Degrading)
- Medium Sensitivity
- Low Sensitivity
- Fully Eroded

Social and Biodiversity Sensitivities
EEPGL
Regions 1-6 Guyana
Febuary 2020

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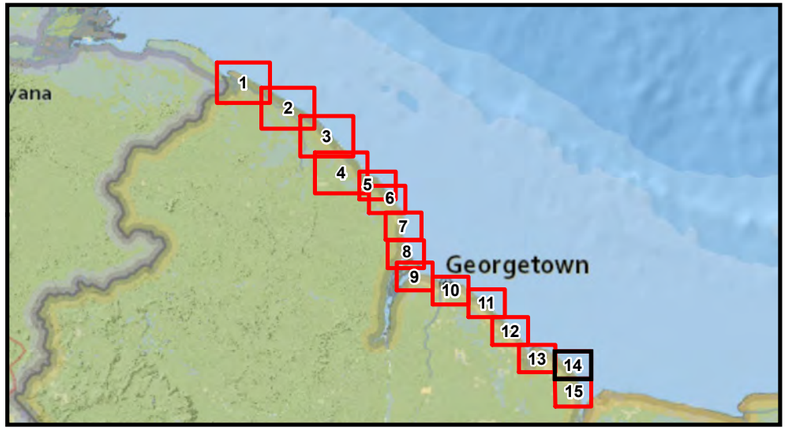

Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
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- Mangroves
- Traditional Resources
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- Very High Sensitivity(Young and Growing)
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- Medium Sensitivity
- Low Sensitivity
- Fully Eroded

Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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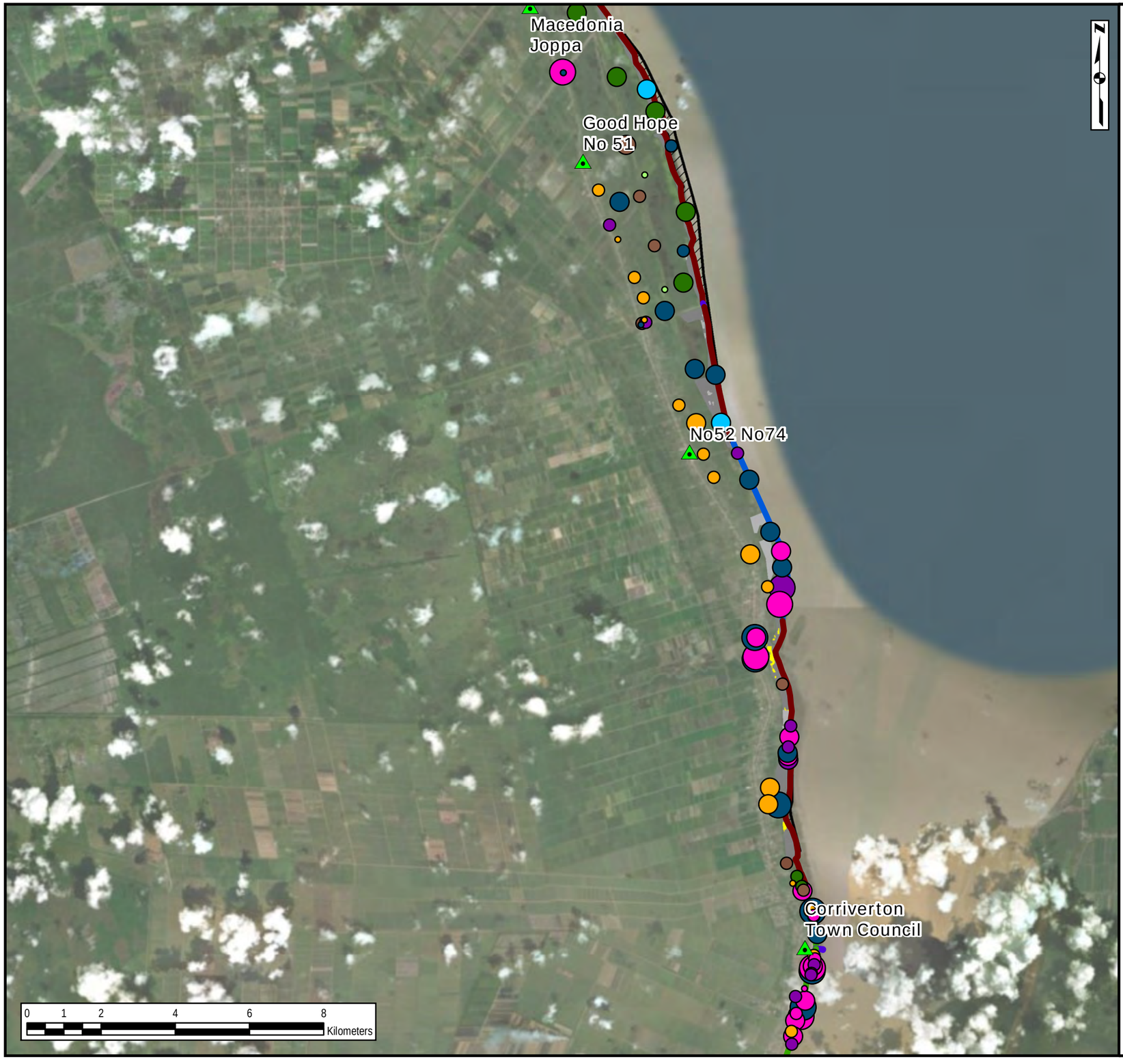

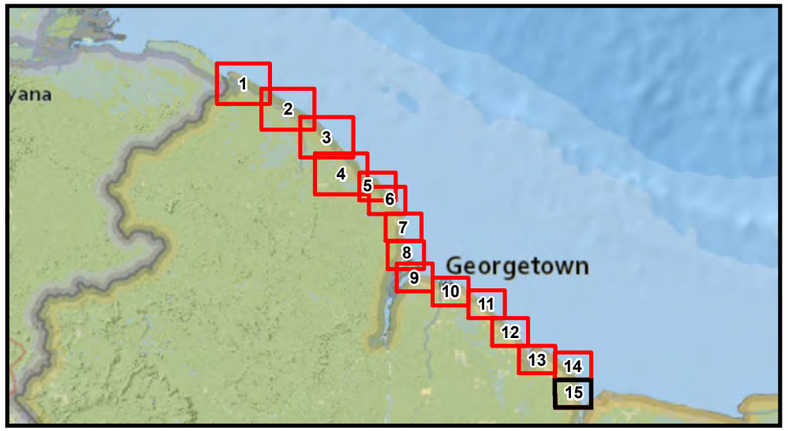

Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
- Ritual / Religious
- Social / Cultural
- Trapping / Hunting
- Other

Priority

- Low
- Medium
- High
- Critical

Environmental Sensitivity Index (ESI)

Shorelines

- 1B: Exposed, Solid Man-Made Structures
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- 10D: Mangroves
- Important Fish Habitats Areas

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- Medium Sensitivity
- Low Sensitivity
- Fully Eroded

Social and Biodiversity Sensitivities

EEPGL
Regions 1-6 Guyana
Febuary 2020

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Trinidad and Tobago

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Little Tobago

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- Mangrove Areas (ESI
- Coral Reefs
- Turtle Nesting
- Seagrass
- IUCN Category III, IV
- Police Stations
- School
- Port or Marina
- Rock

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 1 of 16
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02 July 2019

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Buccoo Reef

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Turtle Nesting
- Seagrass
- IUCN Category III, IV
- Police Stations
- School
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 2 of 16
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St. David Reserve

Eastern Extension Matura

Matura Swamp Reserve

Matura Reserve Western Ext.

Manzanilla Ext.

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Manatees
- Coral Reefs
- Turtle Nesting
- Seagrass
- IUCN Category I, II
- IUCN Category III, IV
- Police Stations
- School
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 3 of 16
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Matura Swamp Reserve

Manzanilla Ext.

Melajo Reserve

Manzanilla Windbelt Reserve

Long Stretch Reserve

Brigand Hill Reserve

Central Range Reserve

Port of Spain

El Cerra del Aripo

TRINIDAD

Gulf of Paria

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Mangrove Areas (ESI
- Manatees
- Turtle Nesting
- IUCN Category I, II
- IUCN Category III, IV
- Kindergarten
- School
- Rock

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Eccles ville Windbelt Reserve

Nariva Windbelt Reserve

Victoria Mayo Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Mangrove Areas (ESI
- Manatees

Marine International Protected

- Marine - RAMSAR
- IUCN Category III, IV
- Police Stations
- School
- Underwater Danger /Underwater Hazard

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Victoria Mayo Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 9B - Vegetated low banks
- Mangrove Areas (ESI
- Manatees
- Turtle Nesting
- Seagrass
- IUCN Category III, IV
- Port or Marina
- Rock
- Shipping Route
- Seabed Pipelines

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 6 of 16
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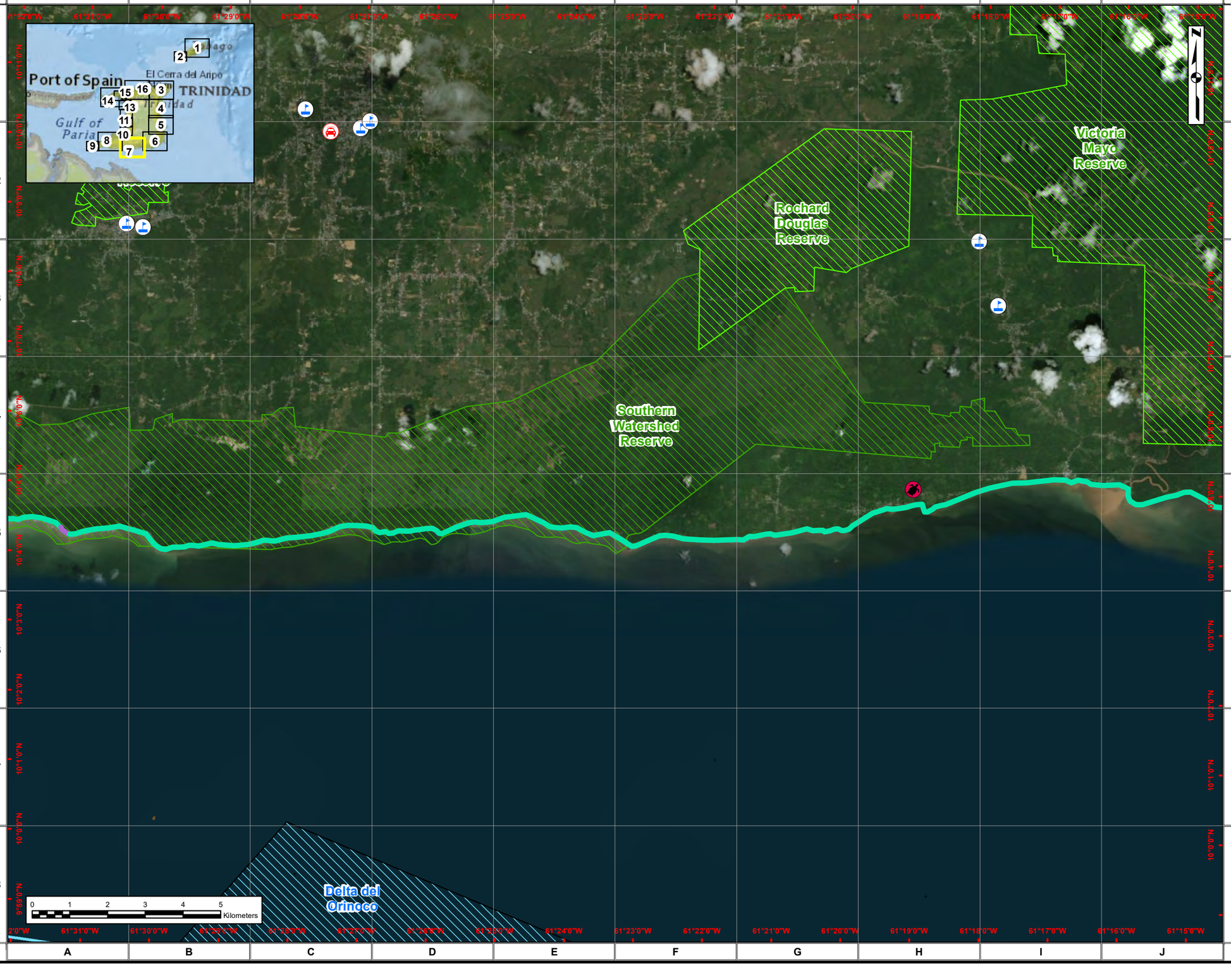

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 7 of 16
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Godineau Swamp Reserve

Morne L'Enfer Reserve

Siparia Reserve

Cap de Ville Reserve

Erin Reserve

Cedros Reserve

Southern Watershed Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category Not Reported
- Police Stations
- School
- Port or Marina
- Shipping Route
- Seabed Pipelines

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 8 of 16
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02 July 2019

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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or
- 4/5 - Sand or gravel beach
- Mangrove Areas (ESI
- Turtle Nesting
- Police Stations
- School

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 9 of 16
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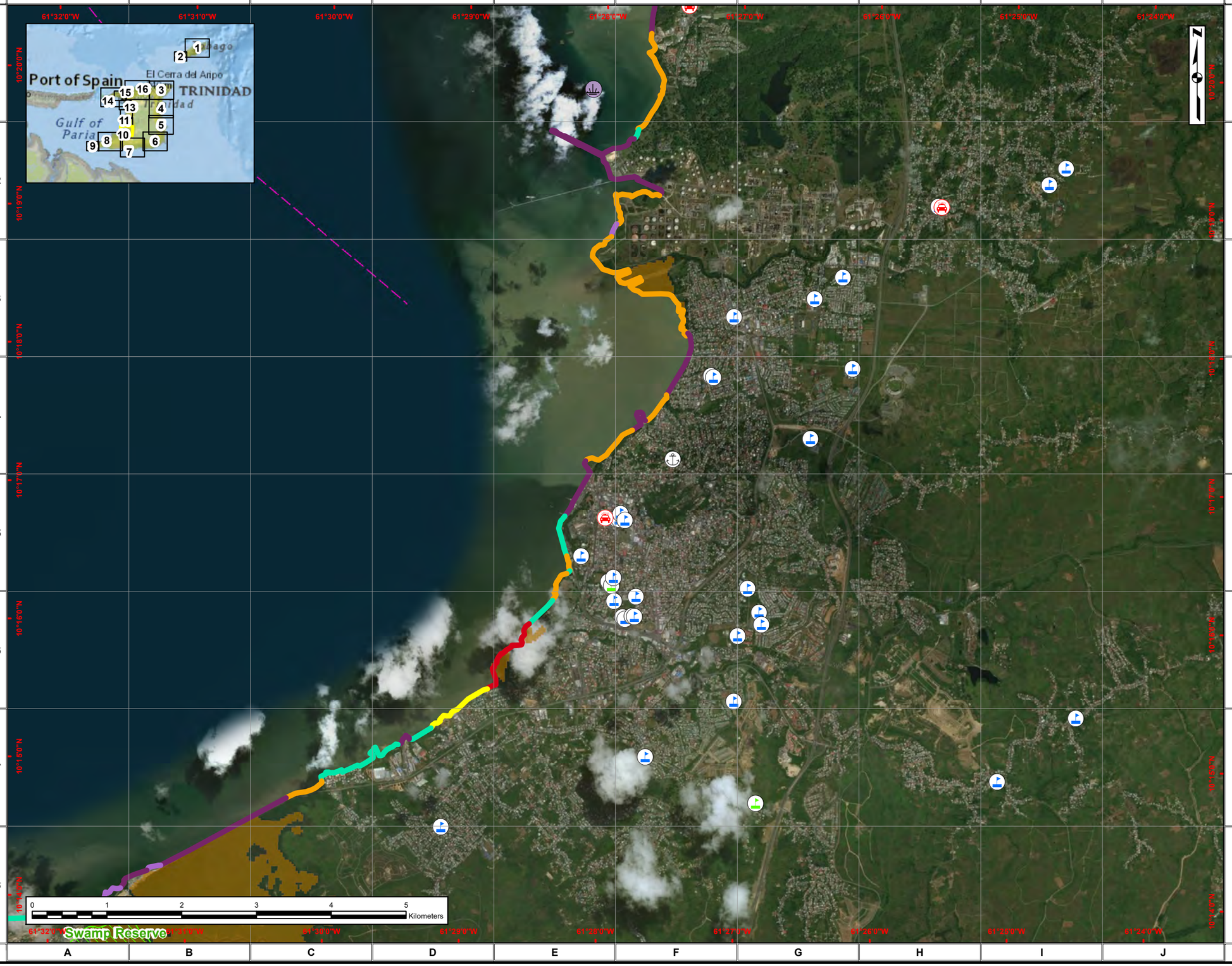

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made
- 1/2 - Exposed cliffs, scarp slopes or
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI
- Seagrass
- IUCN Category III, IV
- Police Stations
- Kindergarten
- School
- Port or Marina
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 10 of 16
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- Seagrass
- Police Stations
- School
- Shipping Route

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Caroni Swamp Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- IUCN Category I, II
- Kindergarten
- School
- Port or Marina
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Legend

Shoreline Sensitivity (ESI)

- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II
- Police Stations
- Kindergarten
- School
- Wreck
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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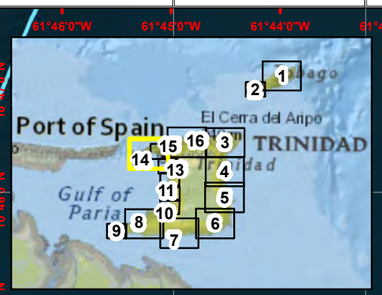

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Seagrass
- IUCN Category I, II
- Police Stations
- School
- College
- Port or Marina
- Wreck
- Shipping Route
- Seabed Cables
- Territorial Waters Boundary

Caroni Swamp Reserve

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 14 of 16
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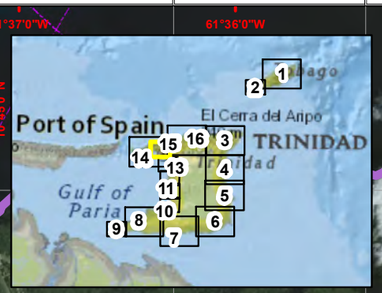

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- Mangrove Areas (ESI 10D)
- Seagrass
- Police Stations
- School
- College
- Port or Marina
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Las Cuevas Reserve

Yarra Reserve

Blanchisseuse Reserve

Paria Reserve

Nrrb.

Nrrc.

Nrra.

Tacarigua Reserve

Arima Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Turtle Nesting
- IUCN Category I, II
- IUCN Category III, IV
- Police Stations
- School

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 16 of 16
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Venezuela

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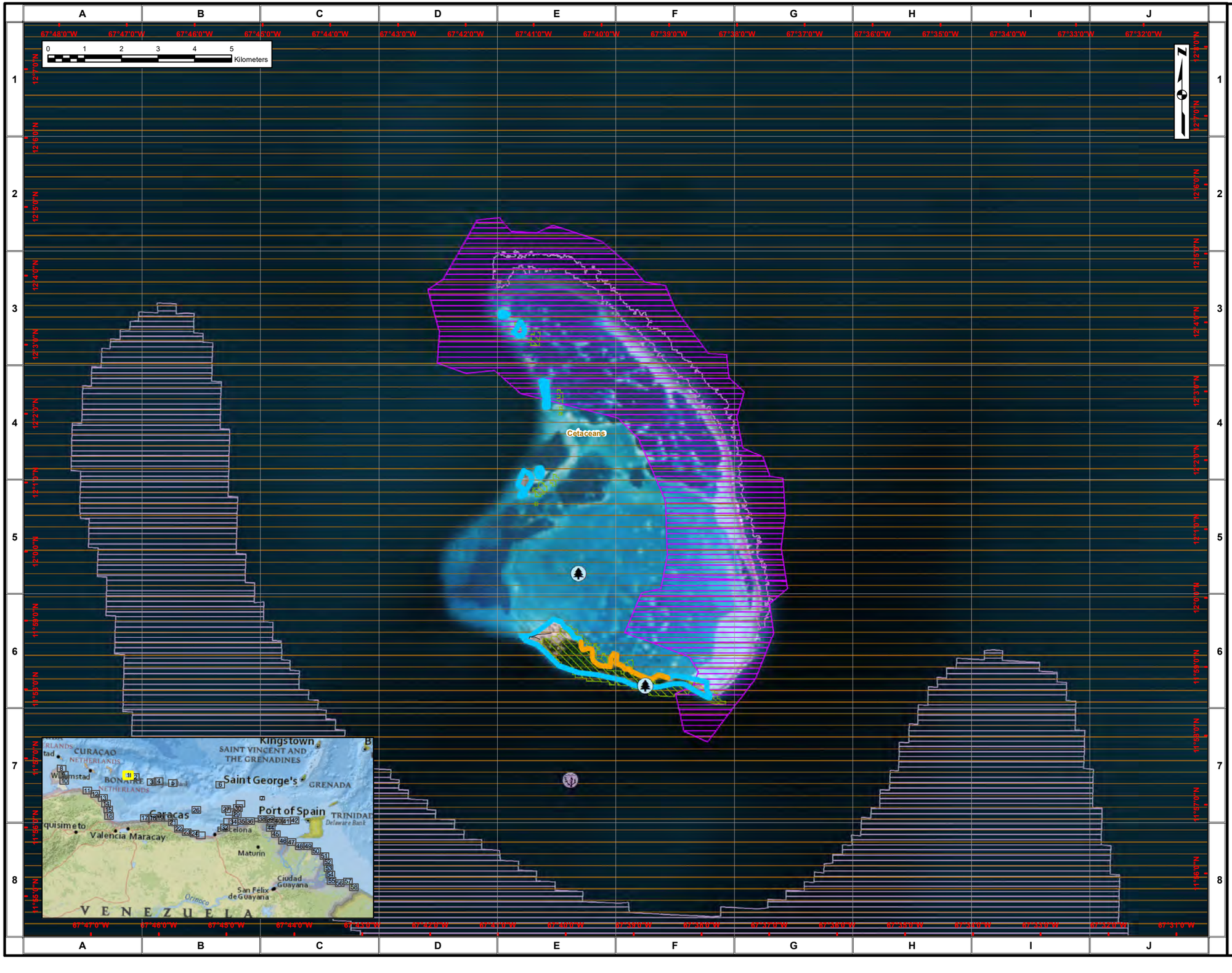

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef

Marine National Protected

- IUCN Category Not Reported
- Access Roads and Tracks
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Aves (West)
Map 1 of 58
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02 July 2019

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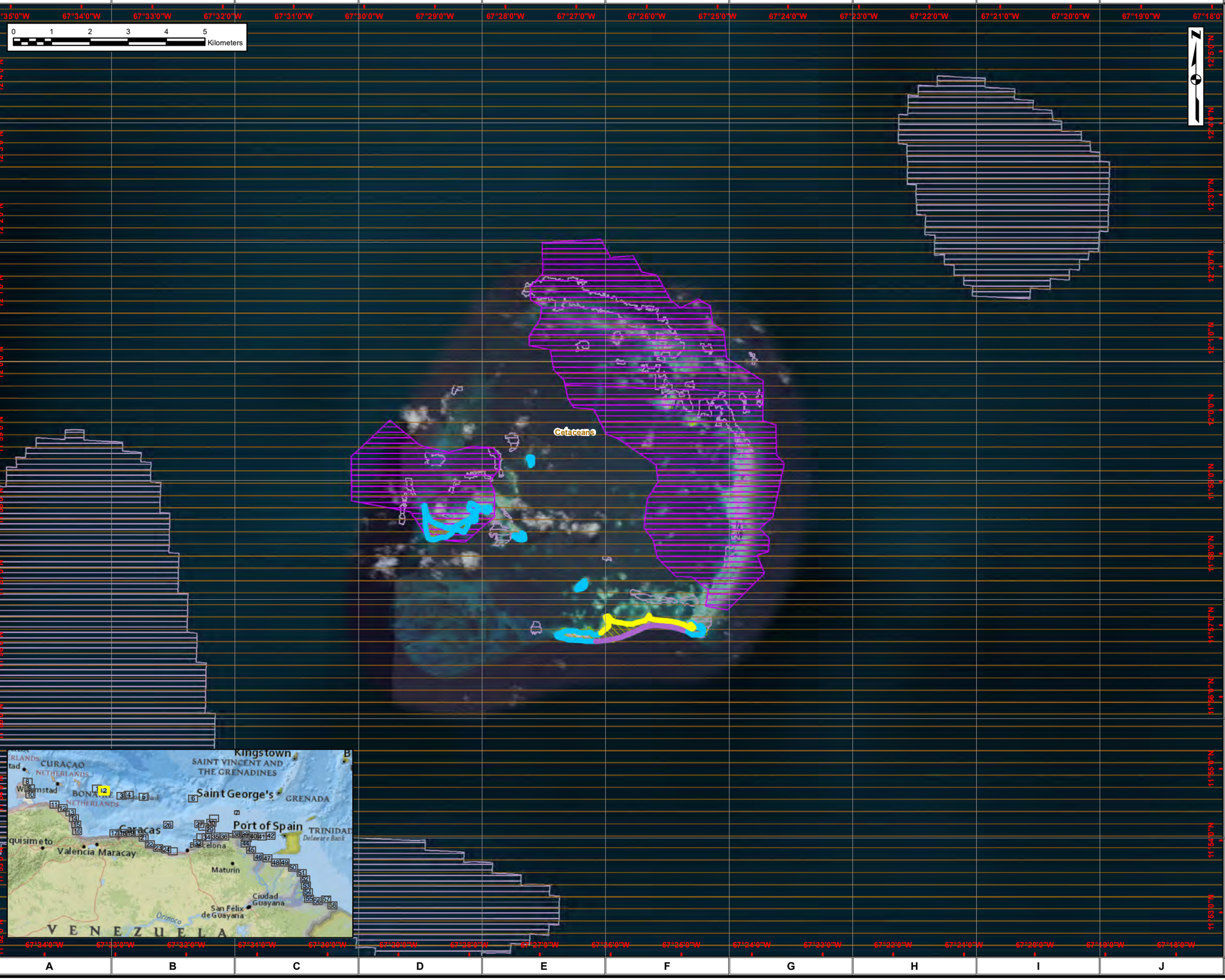

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8 - Sheltered bedrock or man-made structures
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Aves (East)
Map 2 of 58
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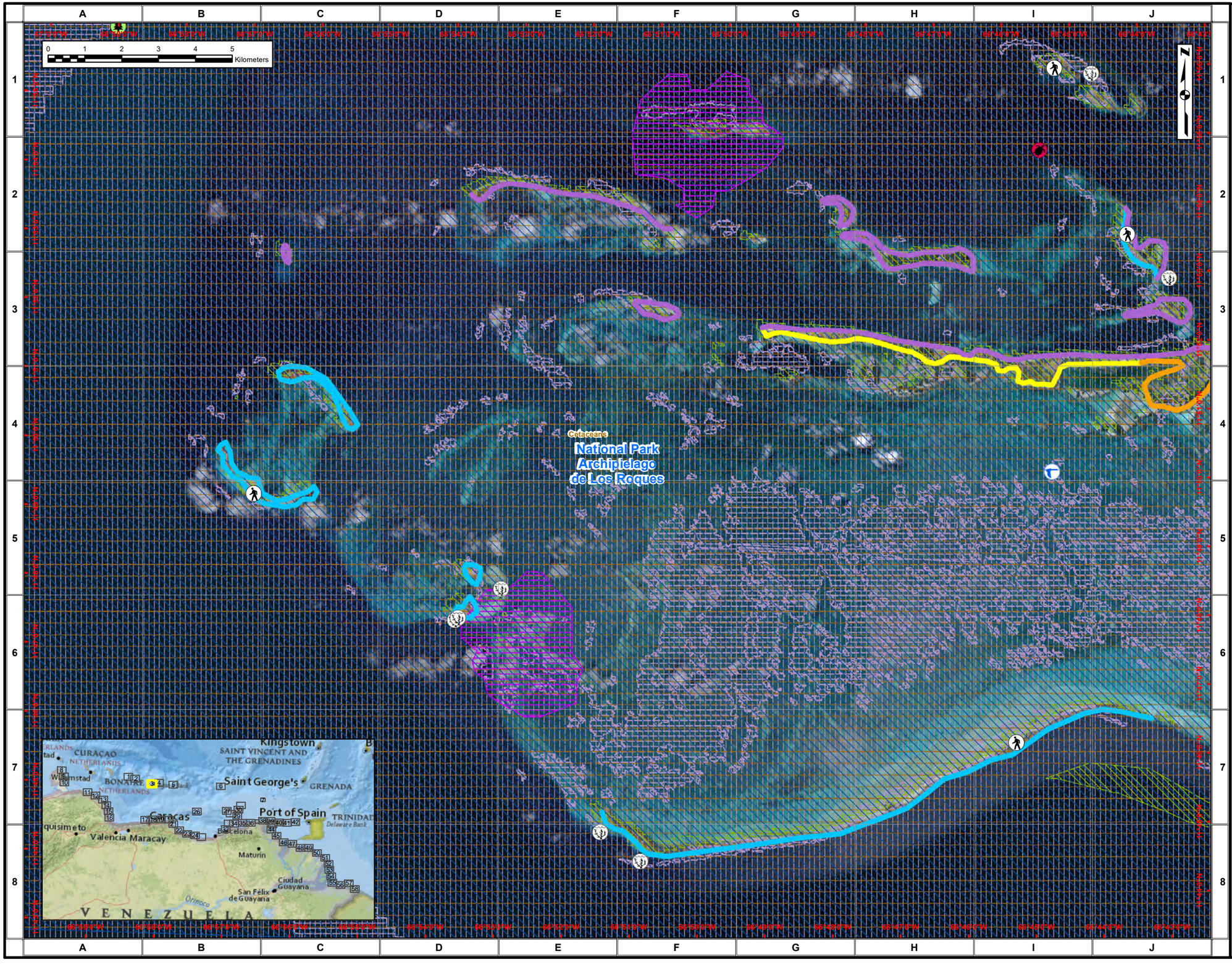

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef

REEF_SYSTEM

- Bleached Coral
- Seagrass

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category V & VI

AccessType

- Access by Foot (Beach)
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla los Roques (West)
Map 3 of 58
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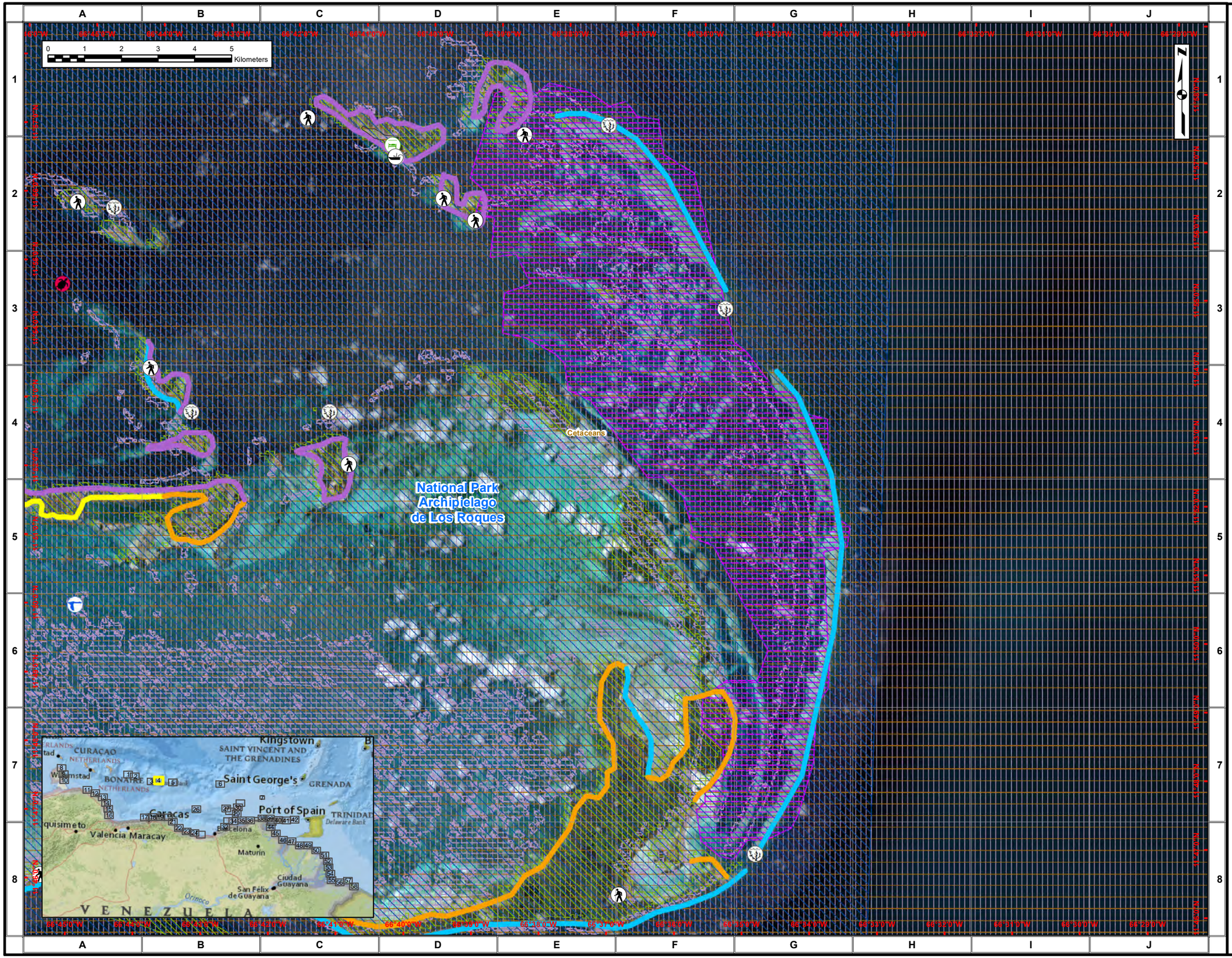

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8 - Sheltered bedrock or man-made structures
- 9A - Sheltered tidal flats
- 9B - Vegetated low banks
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef

REEF_SYSTEM

- Bleached Coral
- Seagrass

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II
- Fishing Dock or Landing
- Hotels
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla los Roques (East)
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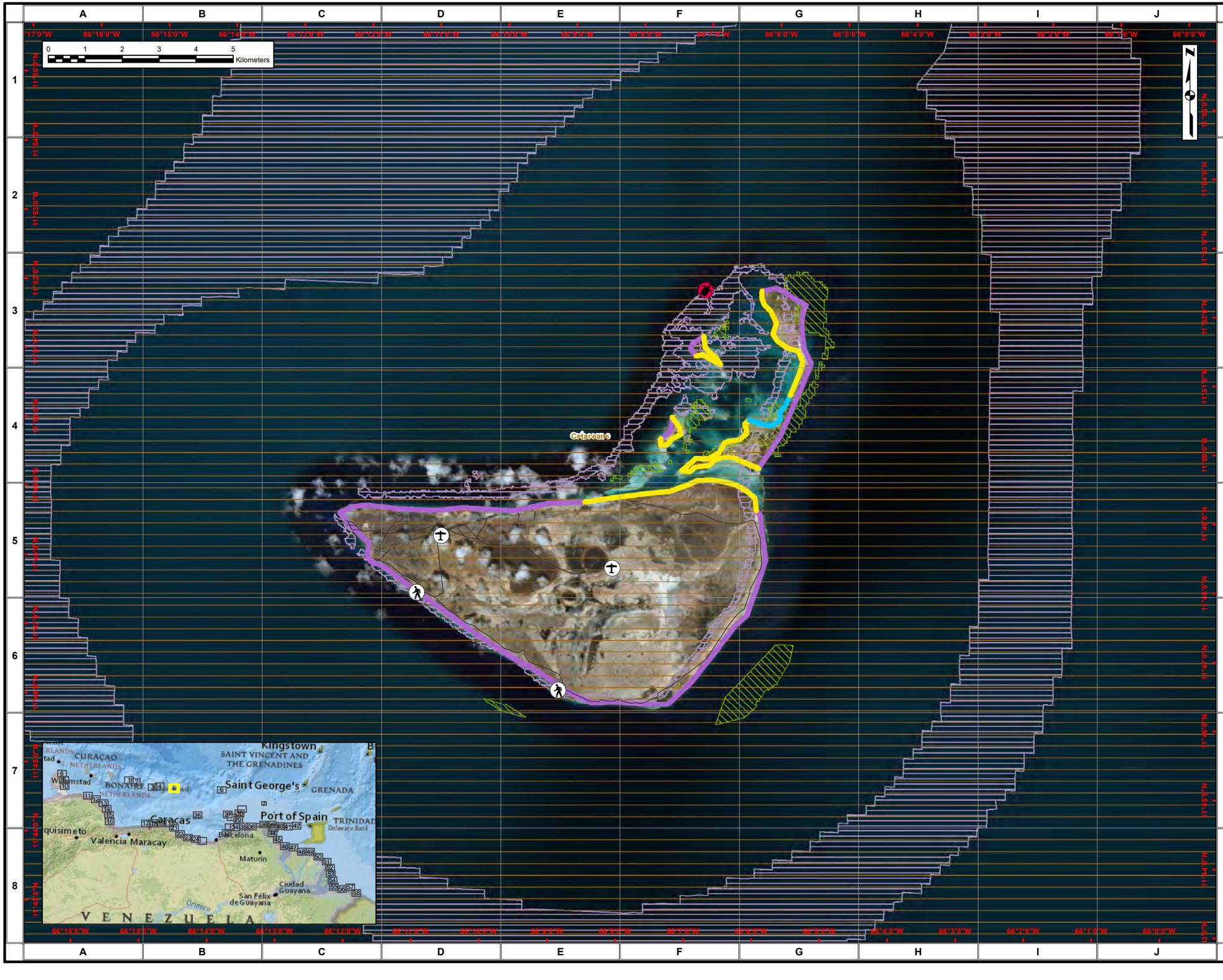

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8A - Sheltered scarps in bedrock, mud or clay
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla la Orchila
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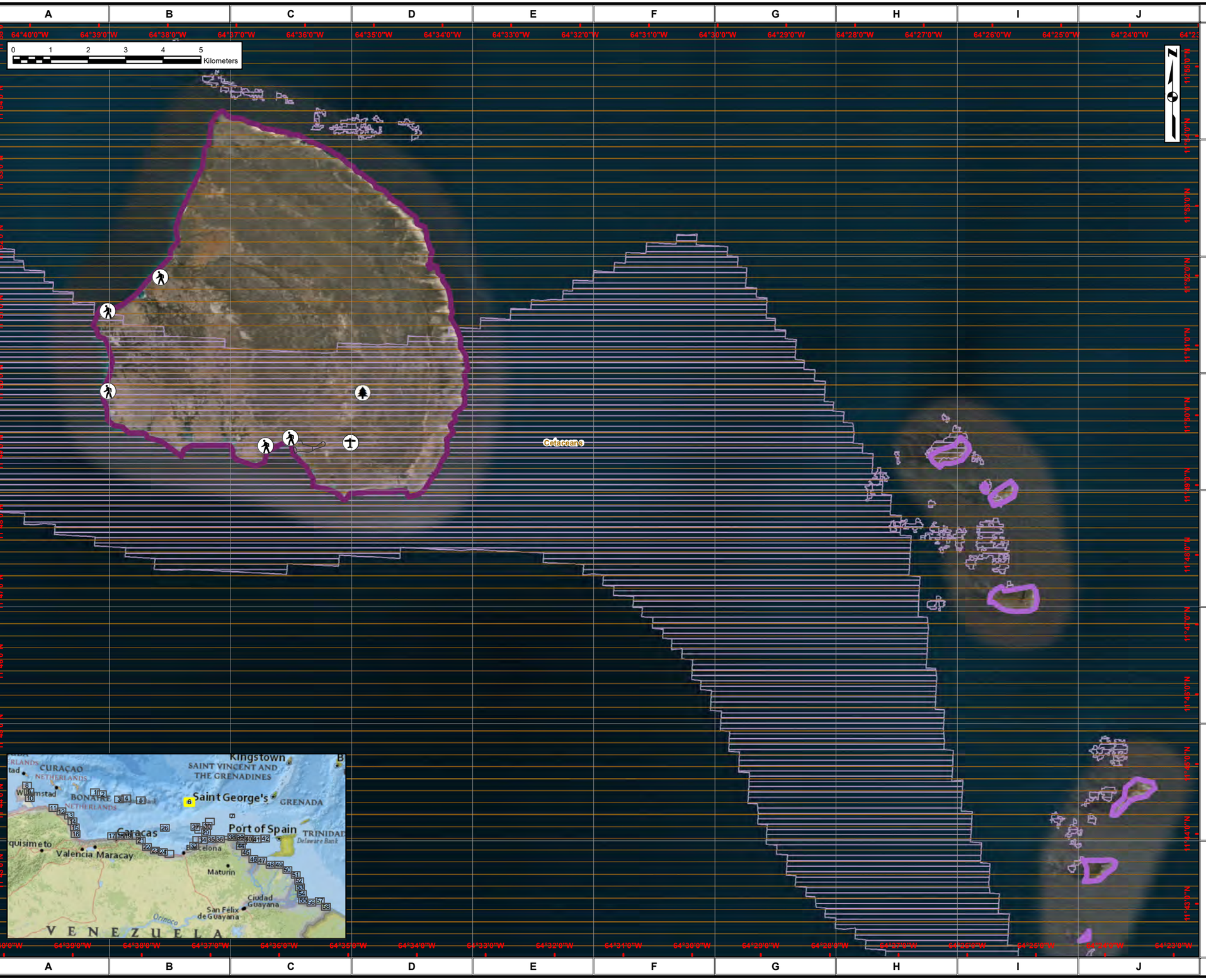

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- Marine Mammals
- Coral Reefs

Onshore National Protected Areas

- IUCN Category Not Reported
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla la Blanquilla
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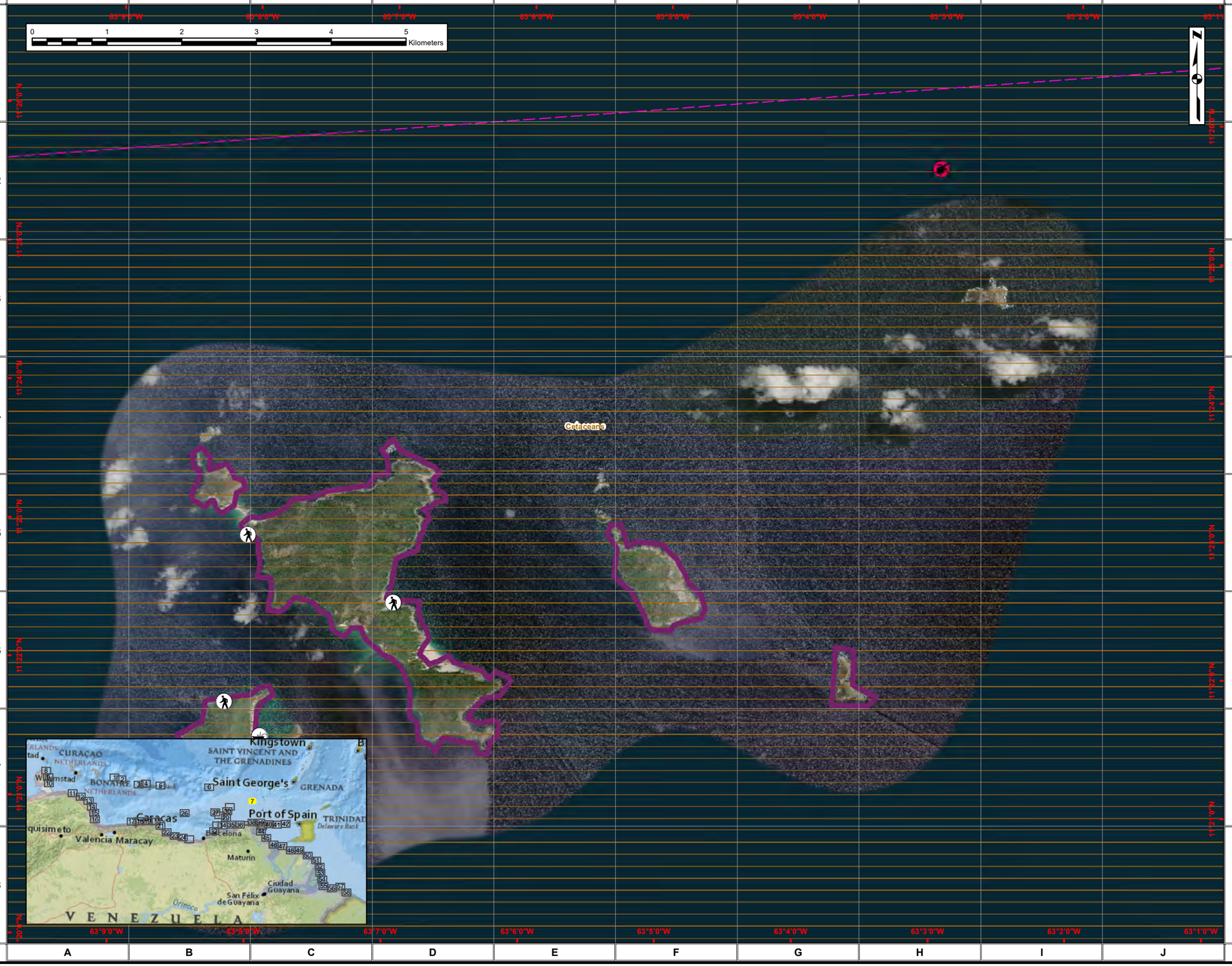

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- Turtle Nesting
- Marine Mammals
- Fishing Dock or Landing

AccessType

- Access by Foot (Beach)
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla los Testigos
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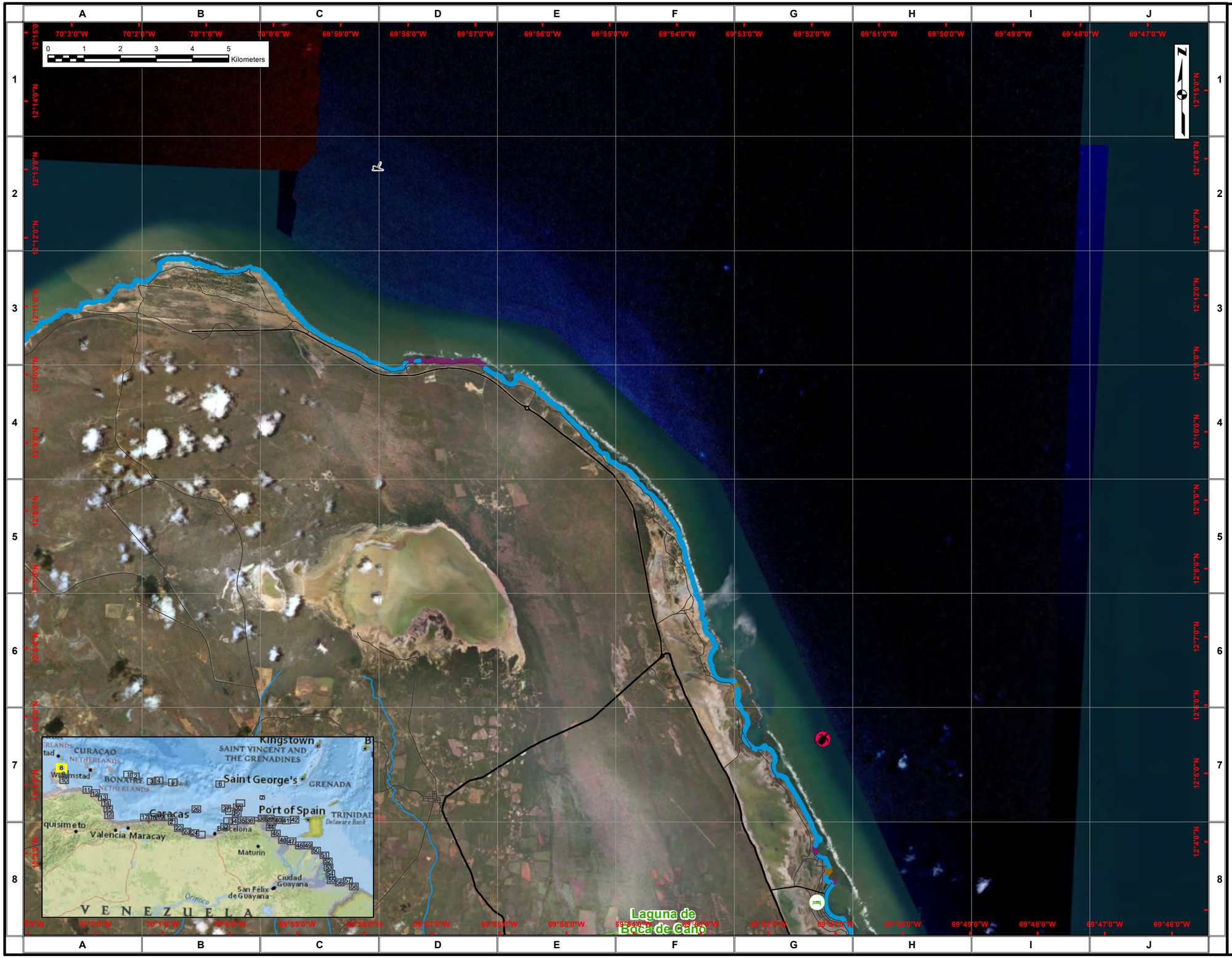

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Turtle Nesting

Onshore National Protected

- IUCN Category III, IV
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Wreck

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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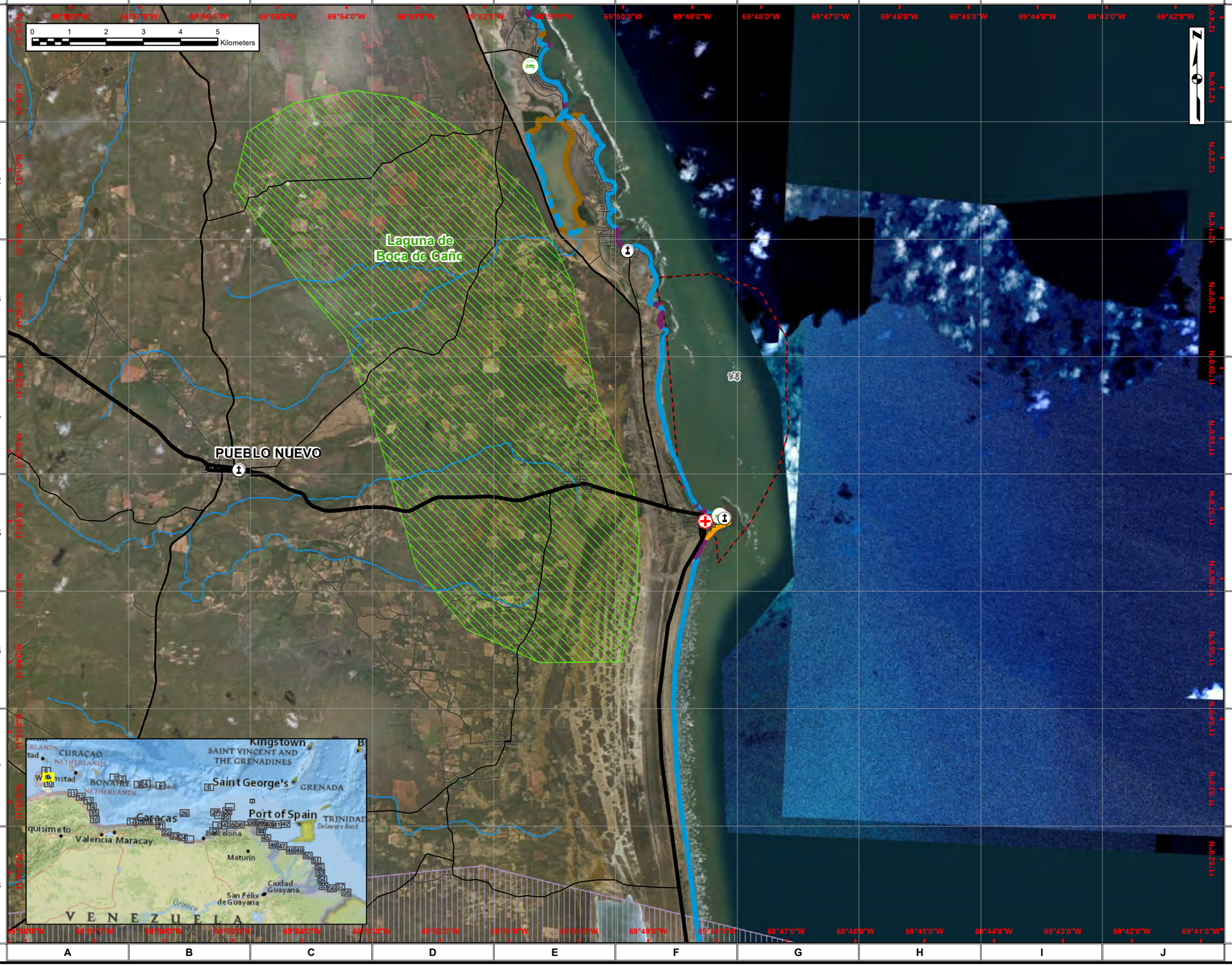

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves
- Seagrass

Onshore National Protected

- IUCN Category III, IV
- Hospitals
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Rock
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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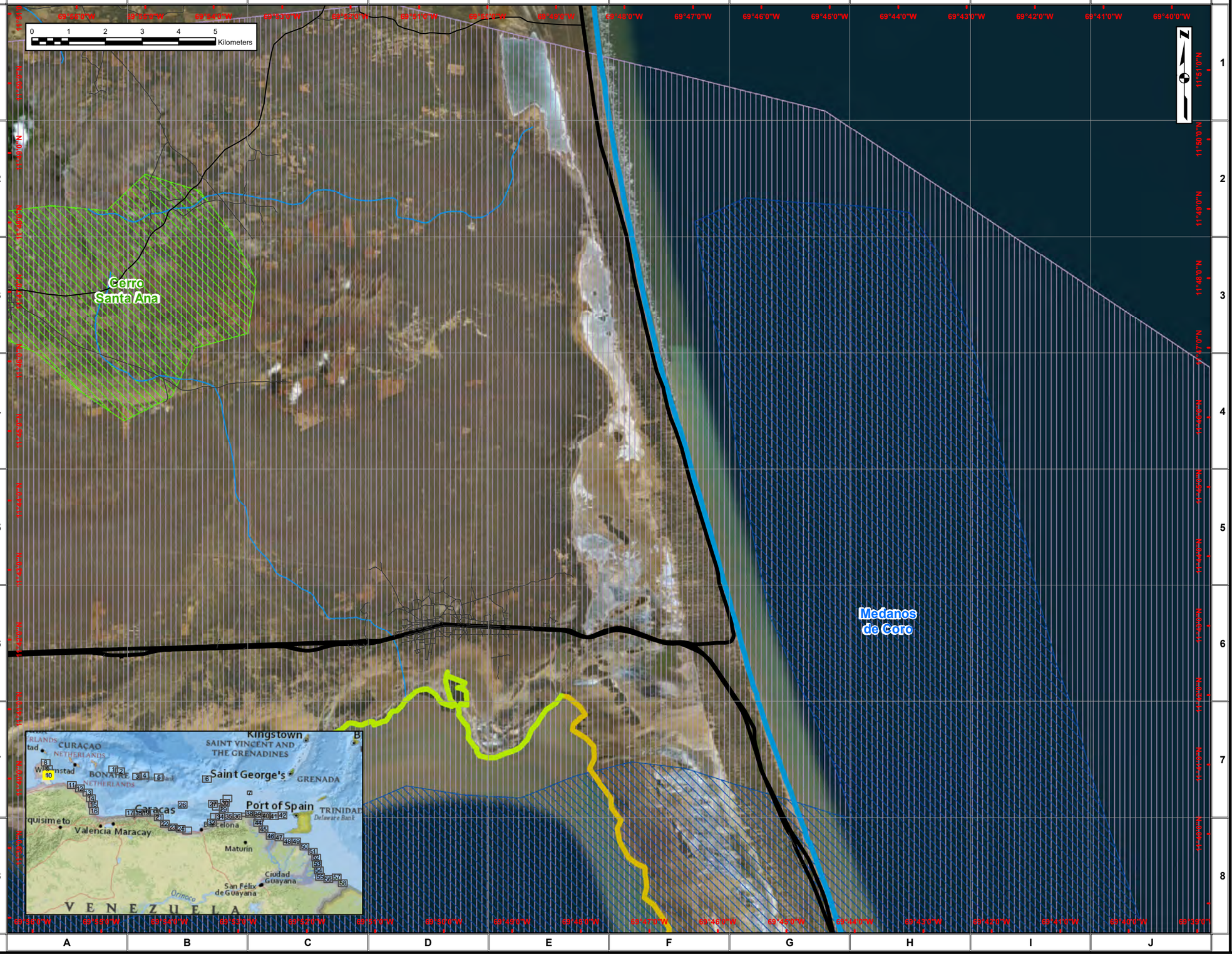

Legend

Shoreline Sensitivity (ESI)

- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- Seagrass
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category III, IV
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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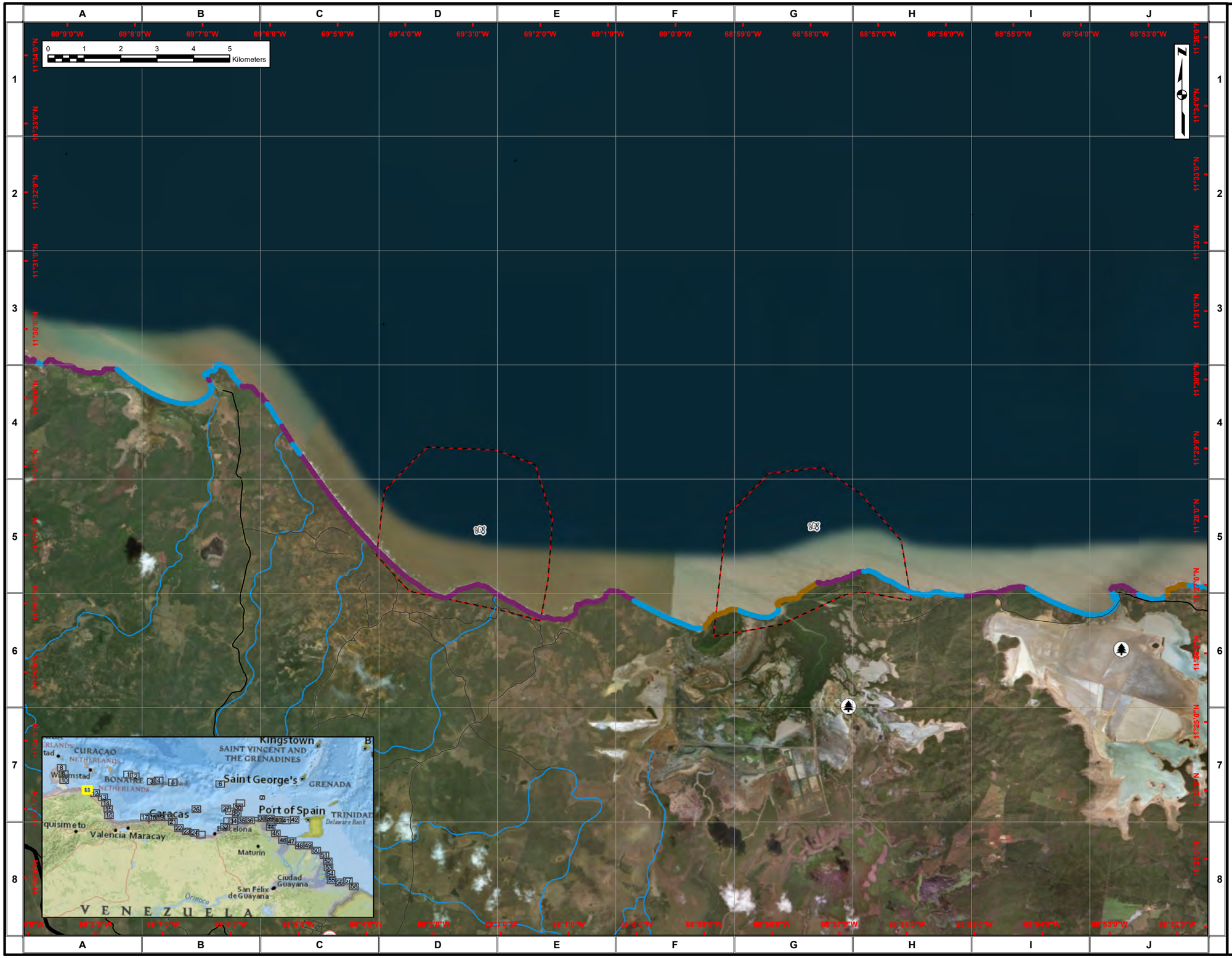

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves

Onshore National Protected

- IUCN Category Not Reported
- Police Stations
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Rock
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves

Onshore National Protected Areas

- IUCN Category Not Reported
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 10D - Mangroves
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Rock
- Hazardous Areas
- Hazardous Reefs
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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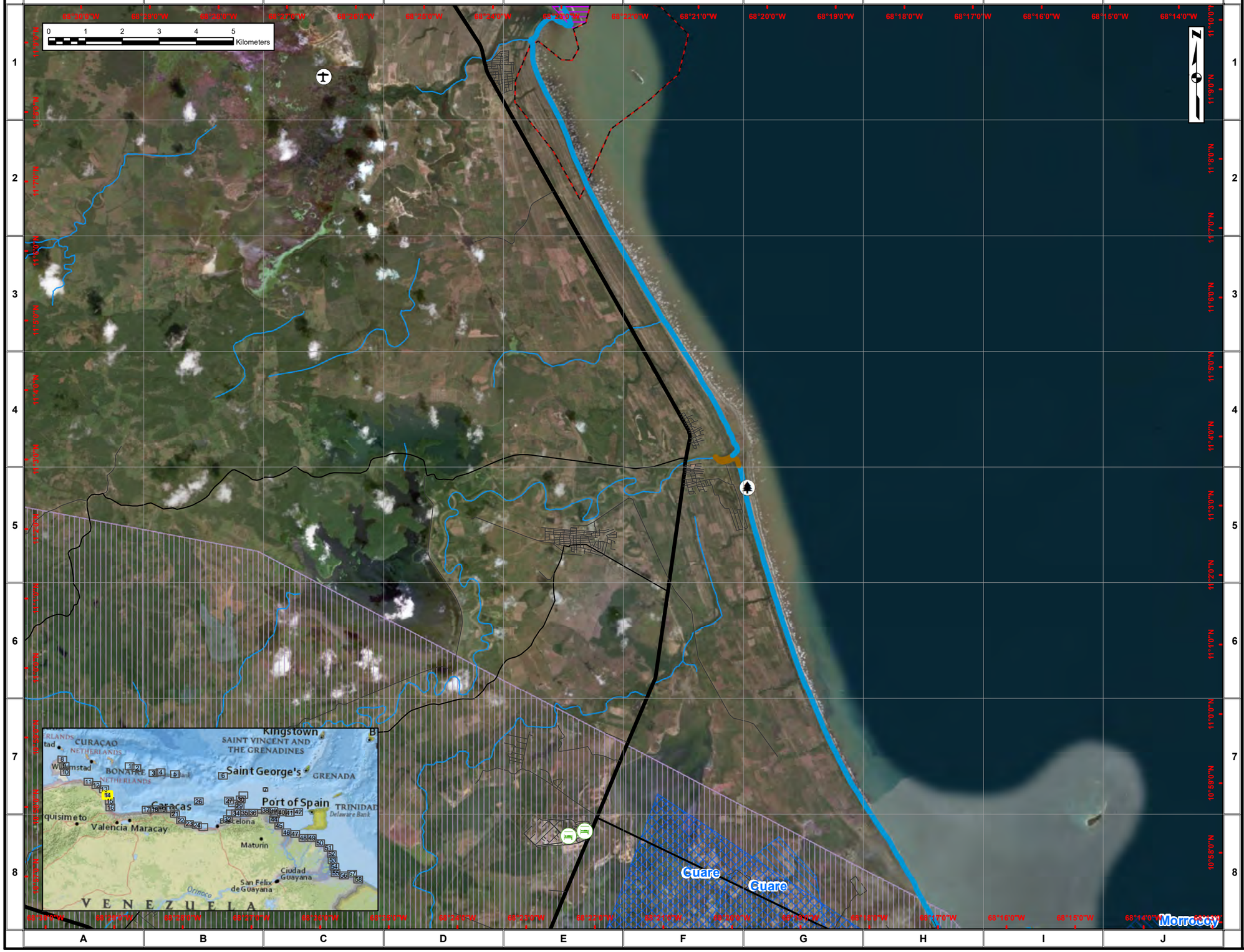

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Seagrass

Marine International Protected Areas

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV

Onshore National Protected Areas

- IUCN Category Not Reported
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Hazardous Areas
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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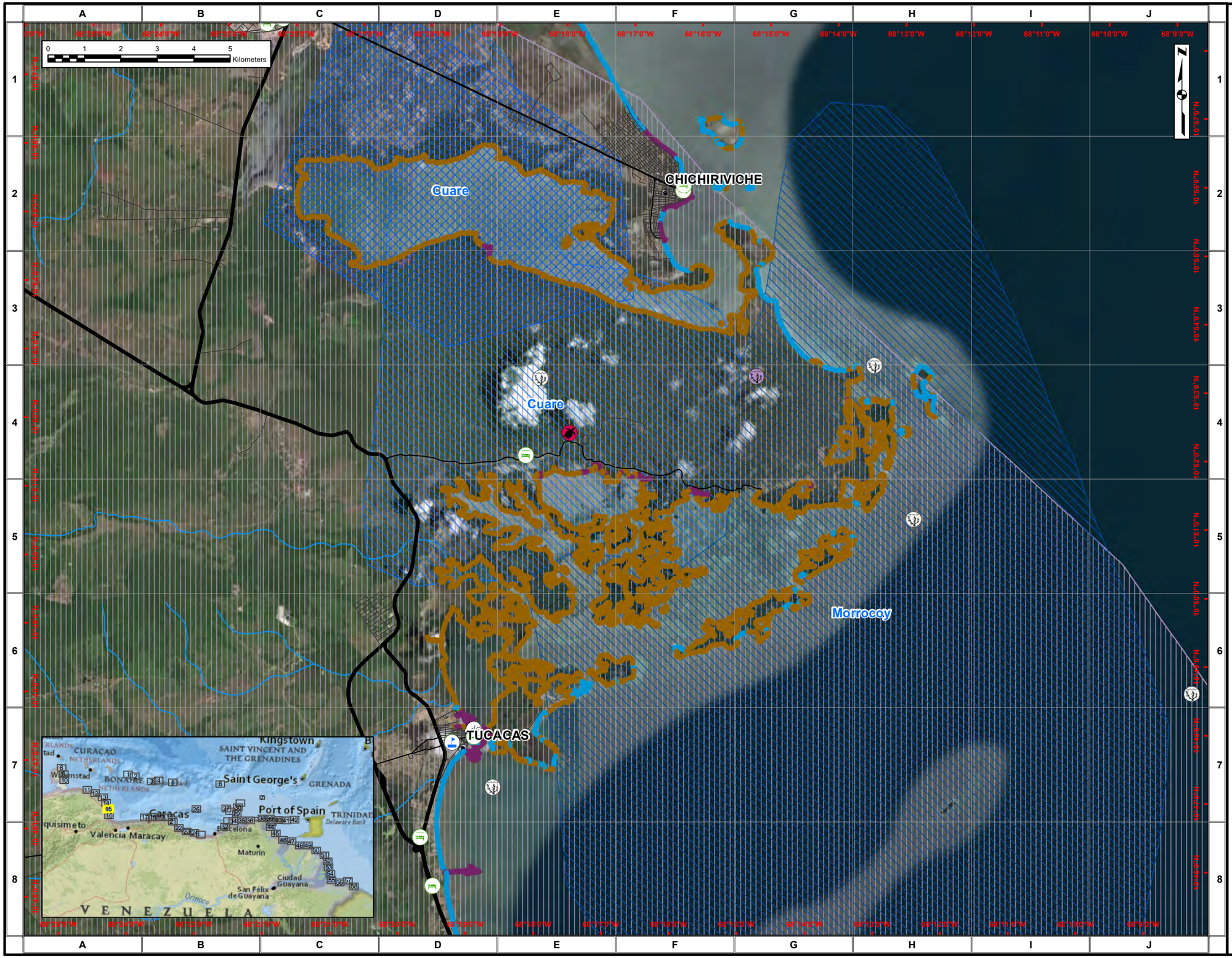

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Turtle Nesting
- Coral Reef

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- Bleached Coral
- Seagrass

Marine International Protected Areas

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- School
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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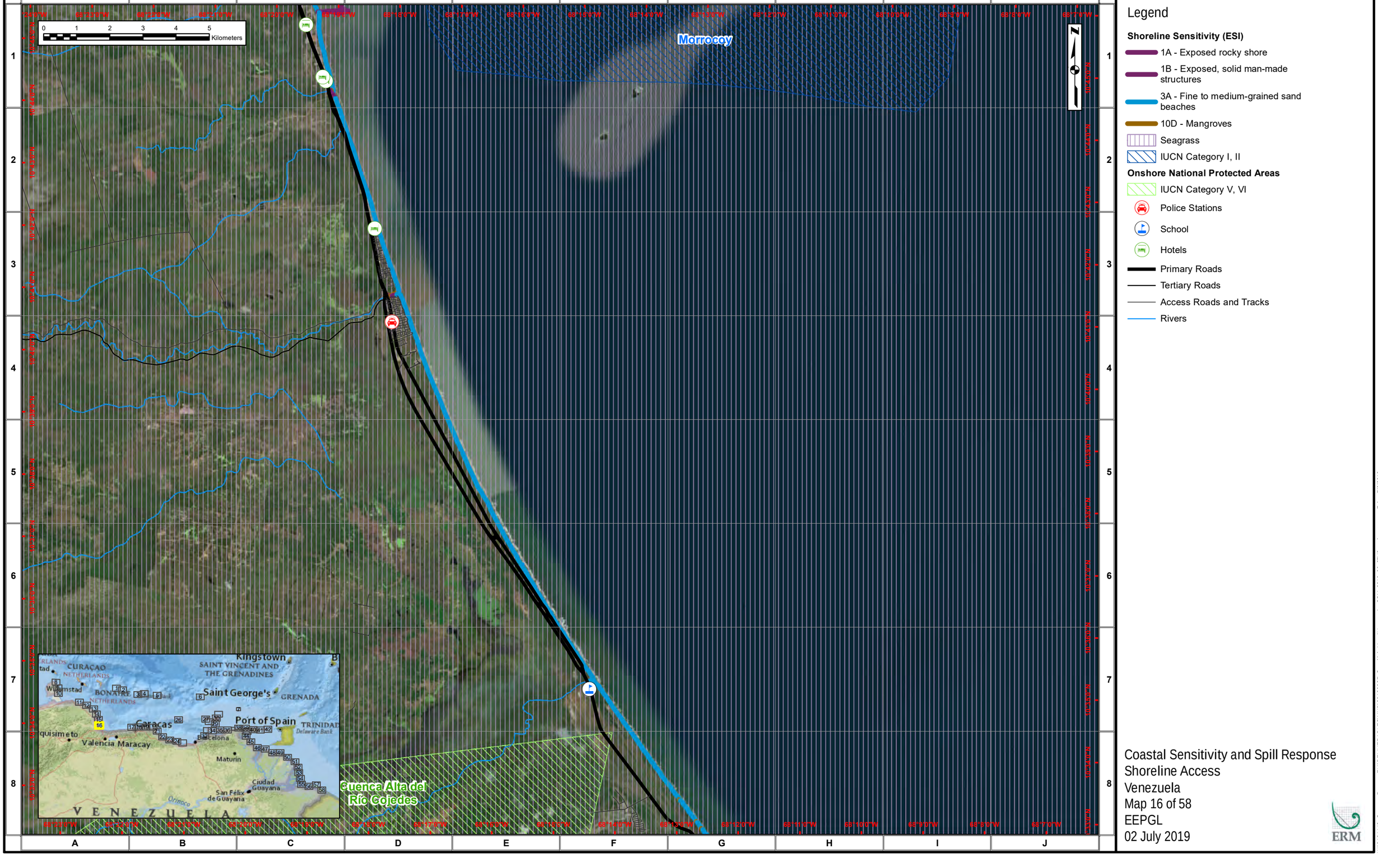

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Seagrass
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category V, VI
- Police Stations
- School
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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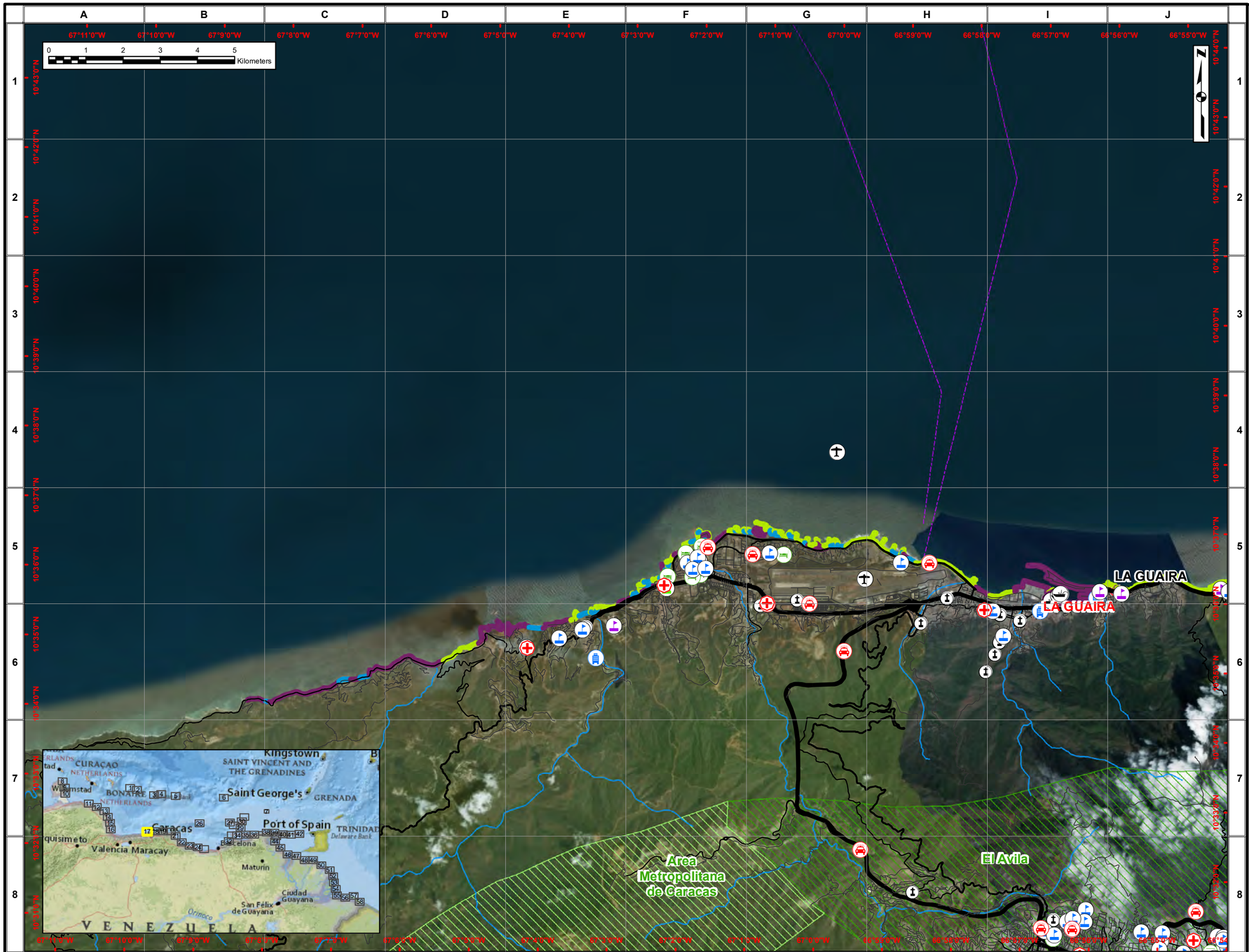

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category V, VI
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Seabed Cables
- State Capital
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)

Onshore National Protected

- IUCN Category I, II
- Hospitals
- Police Stations
- School
- College
- Places of Worship
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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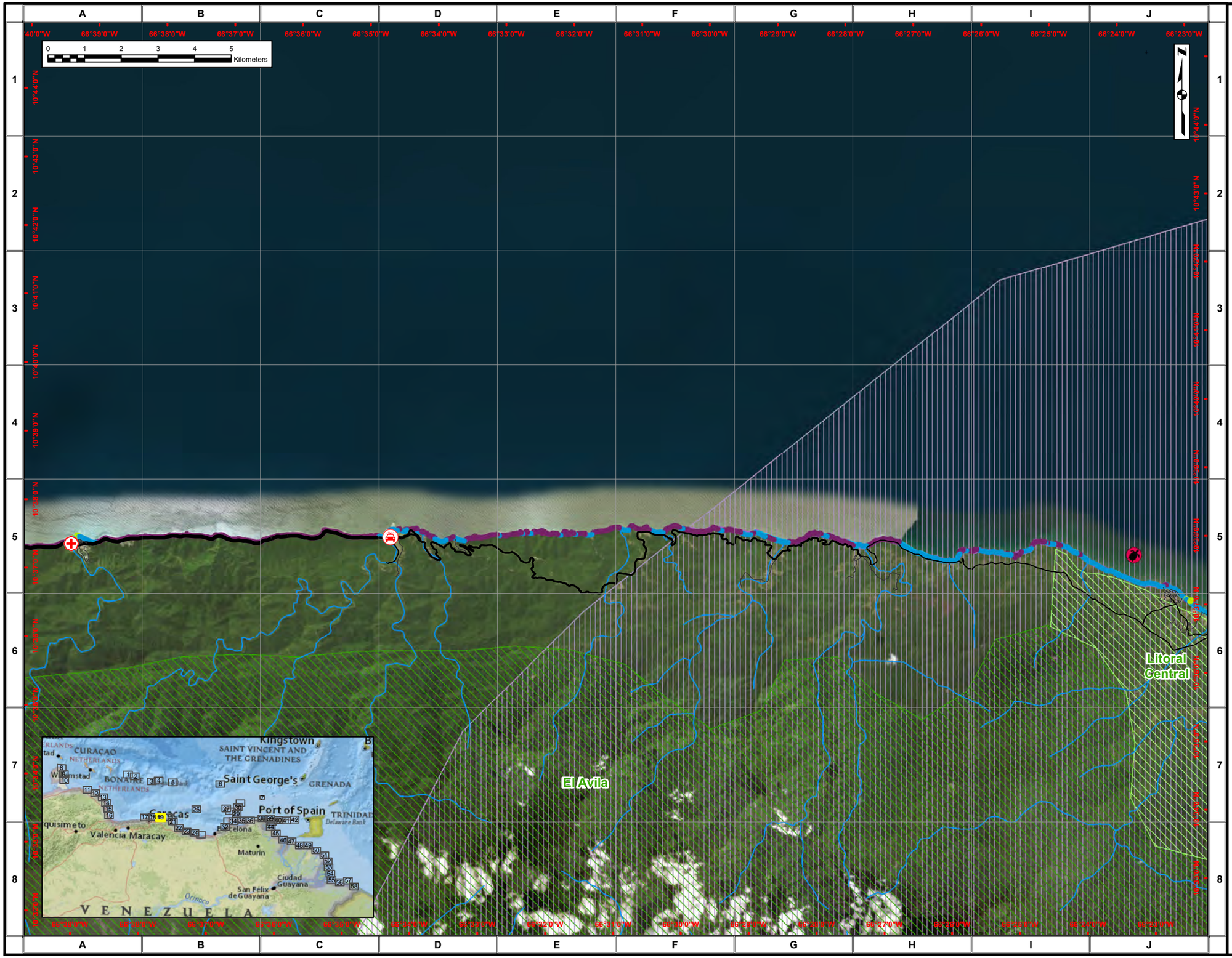

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3A - Fine to medium-grained sand beaches
- 3/4 - Sandy beaches or slopes
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Turtle Nesting
- Seagrass

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category V, VI
- Hospitals
- Police Stations
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3A - Fine to medium-grained sand beaches
- 3/4 - Sandy beaches or slopes
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Turtle Nesting
- Marine Mammals
- Seagrass

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category V, VI
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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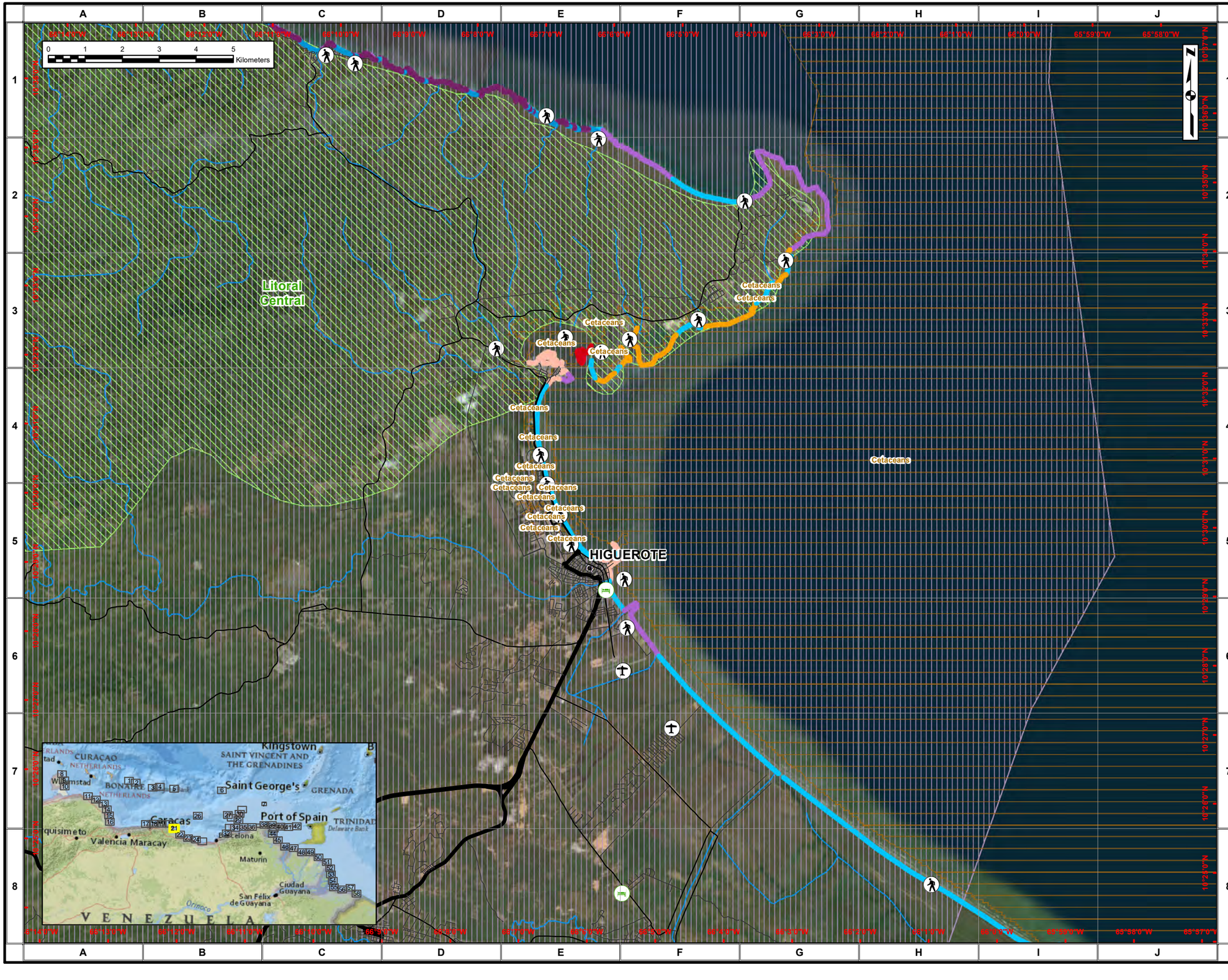

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3A - Fine to medium-grained sand beaches
- 3/4 - Sandy beaches or slopes
- 8B - Sheltered, solid man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Marine Mammals
- Seagrass

Onshore National Protected

- IUCN Category V, VI
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Brion
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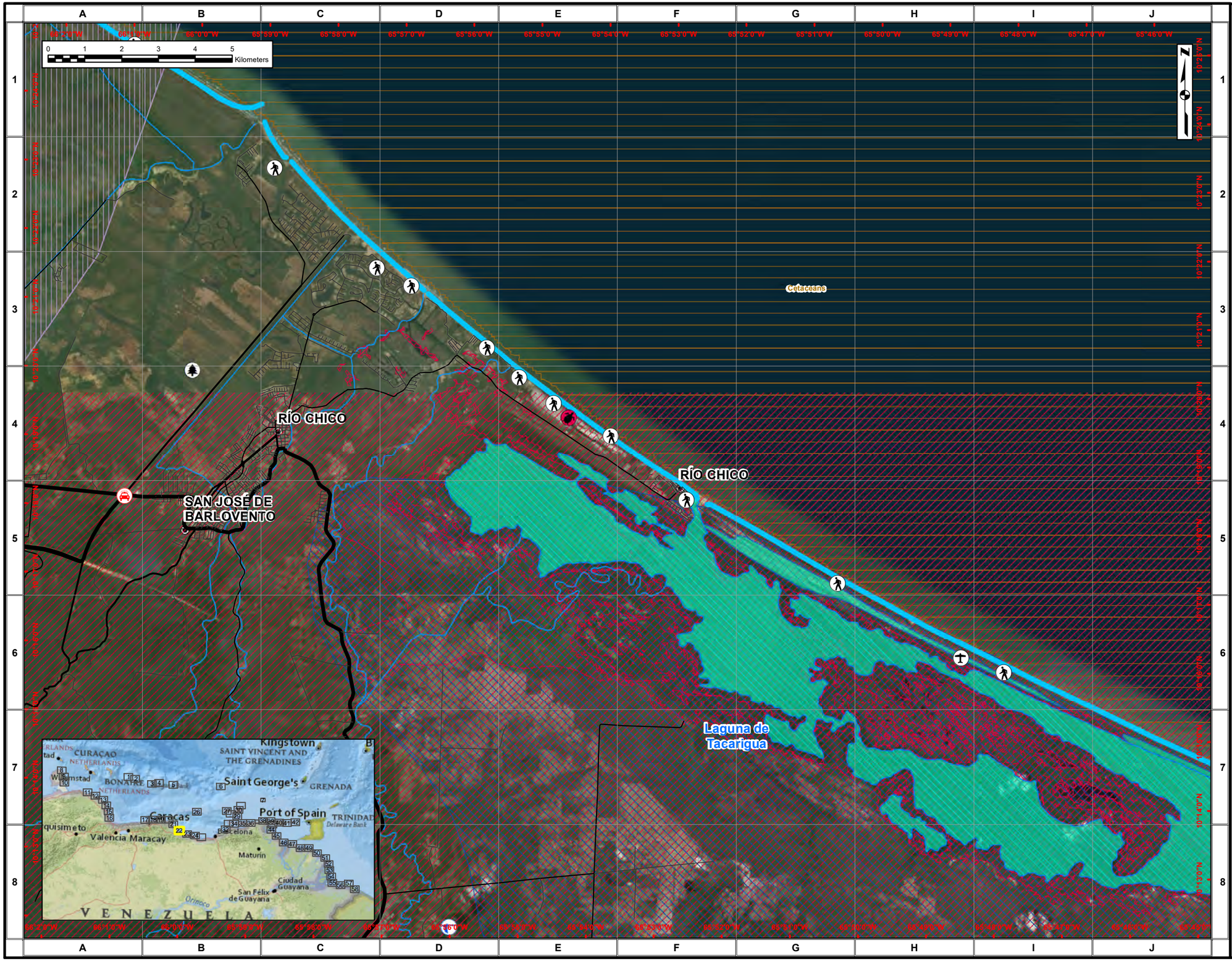

Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- Turtle Nesting
- Reptiles
- Marine Mammals
- Seagrass
- Lagoon

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category Not Reported
- Police Stations
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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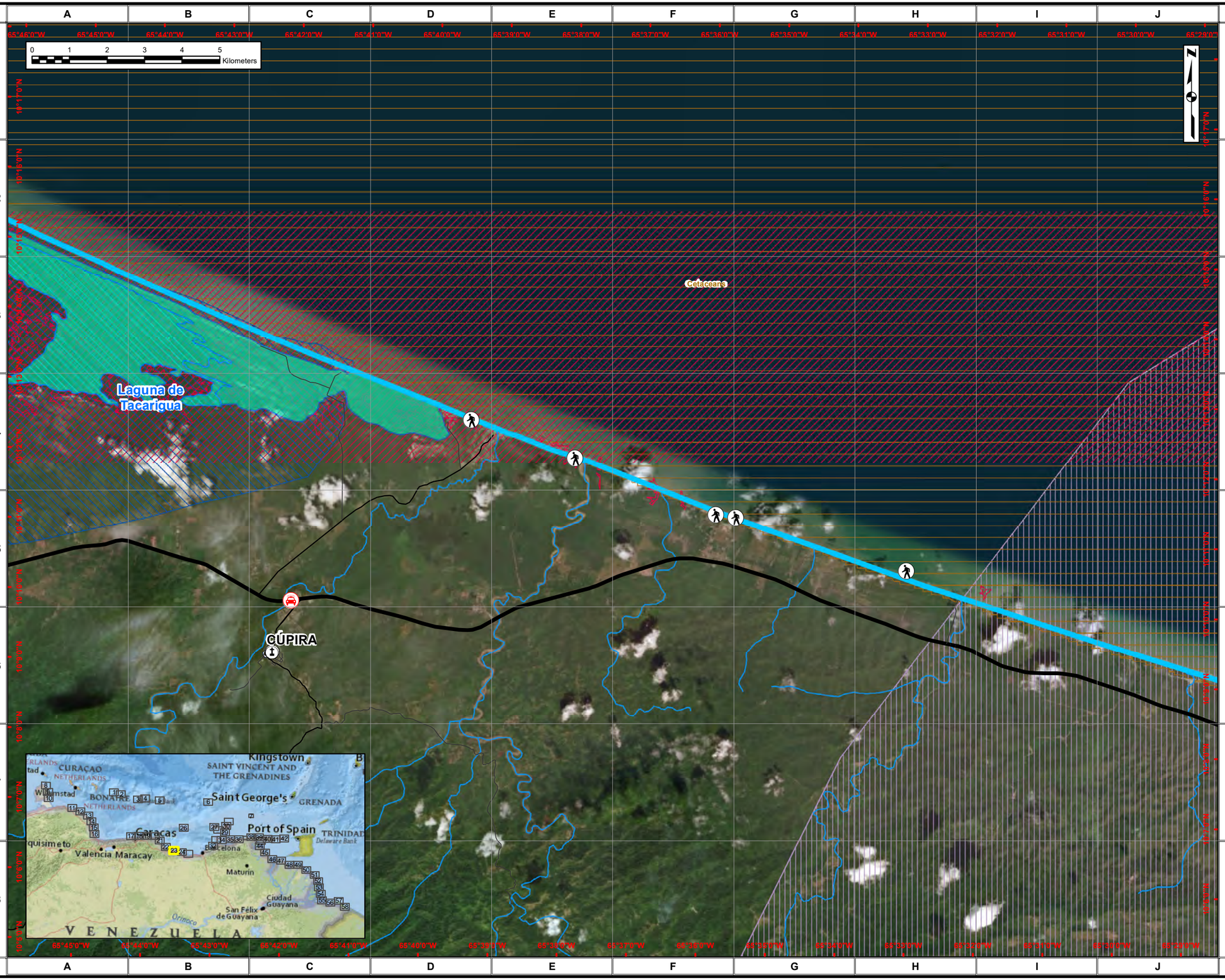

Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- Reptiles
- Marine Mammals
- Seagrass
- Lagoon
- IUCN Category I, II
- Police Stations
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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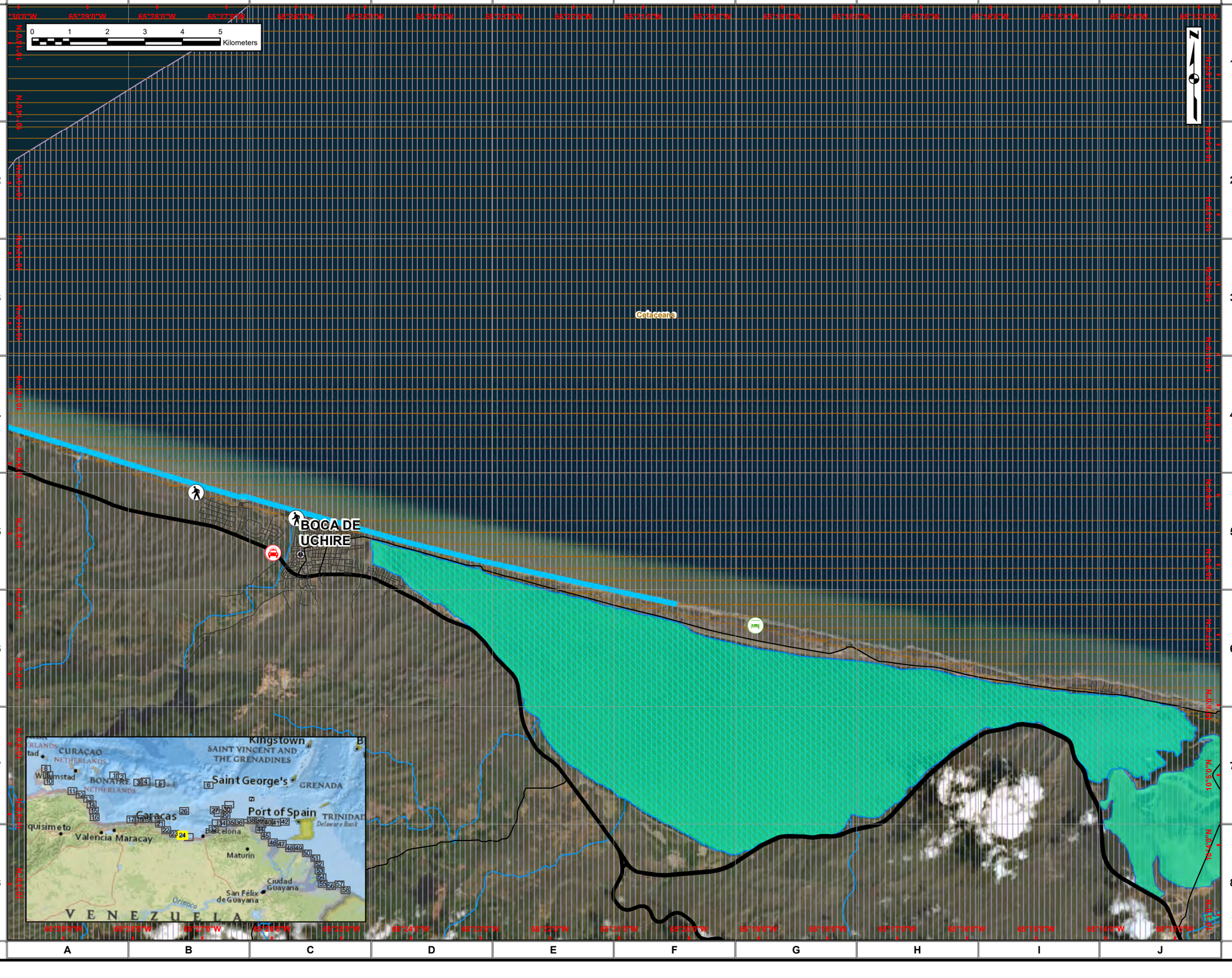

Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- Marine Mammals
- Seagrass
- Lagoon
- Police Stations
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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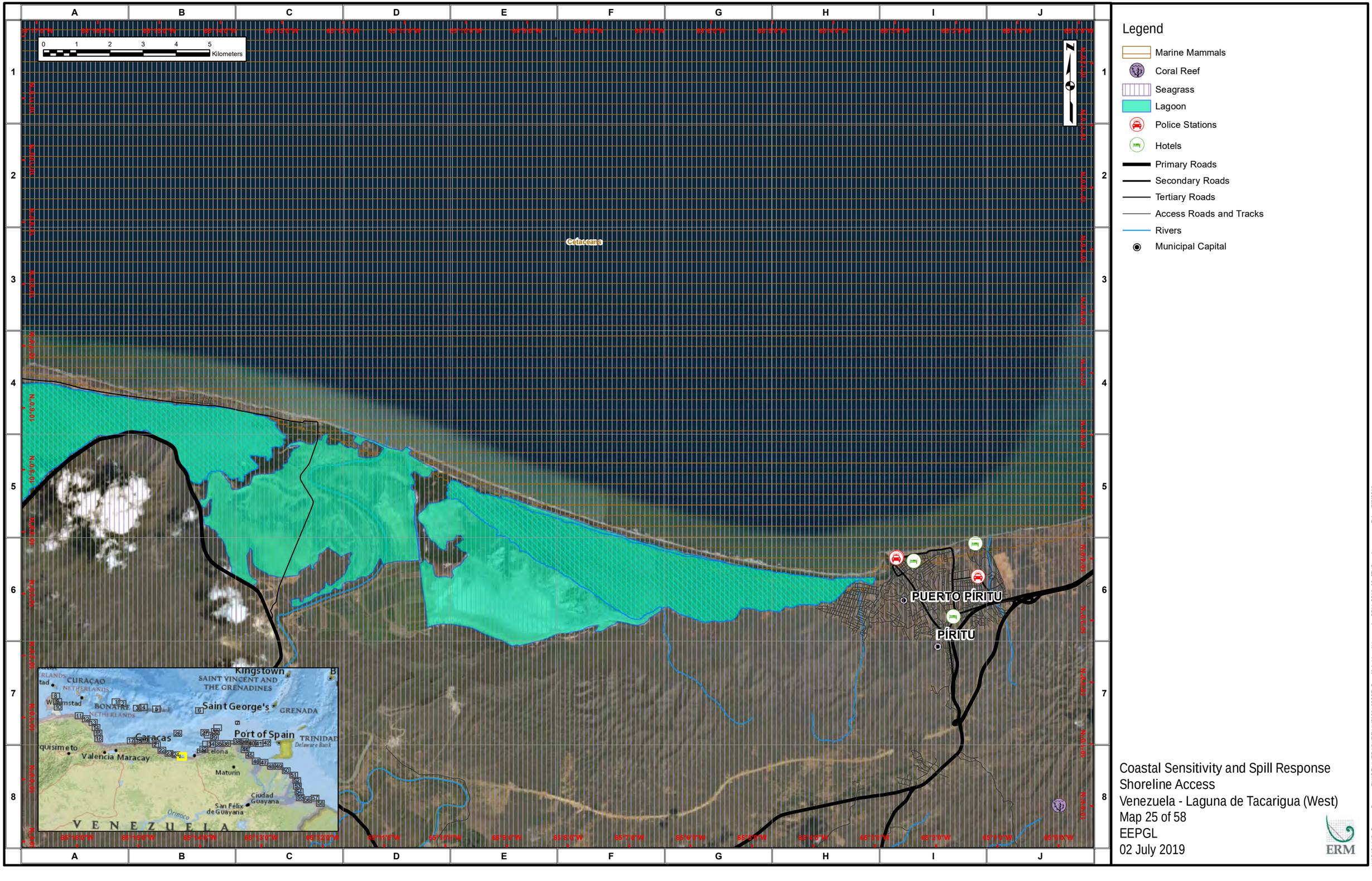

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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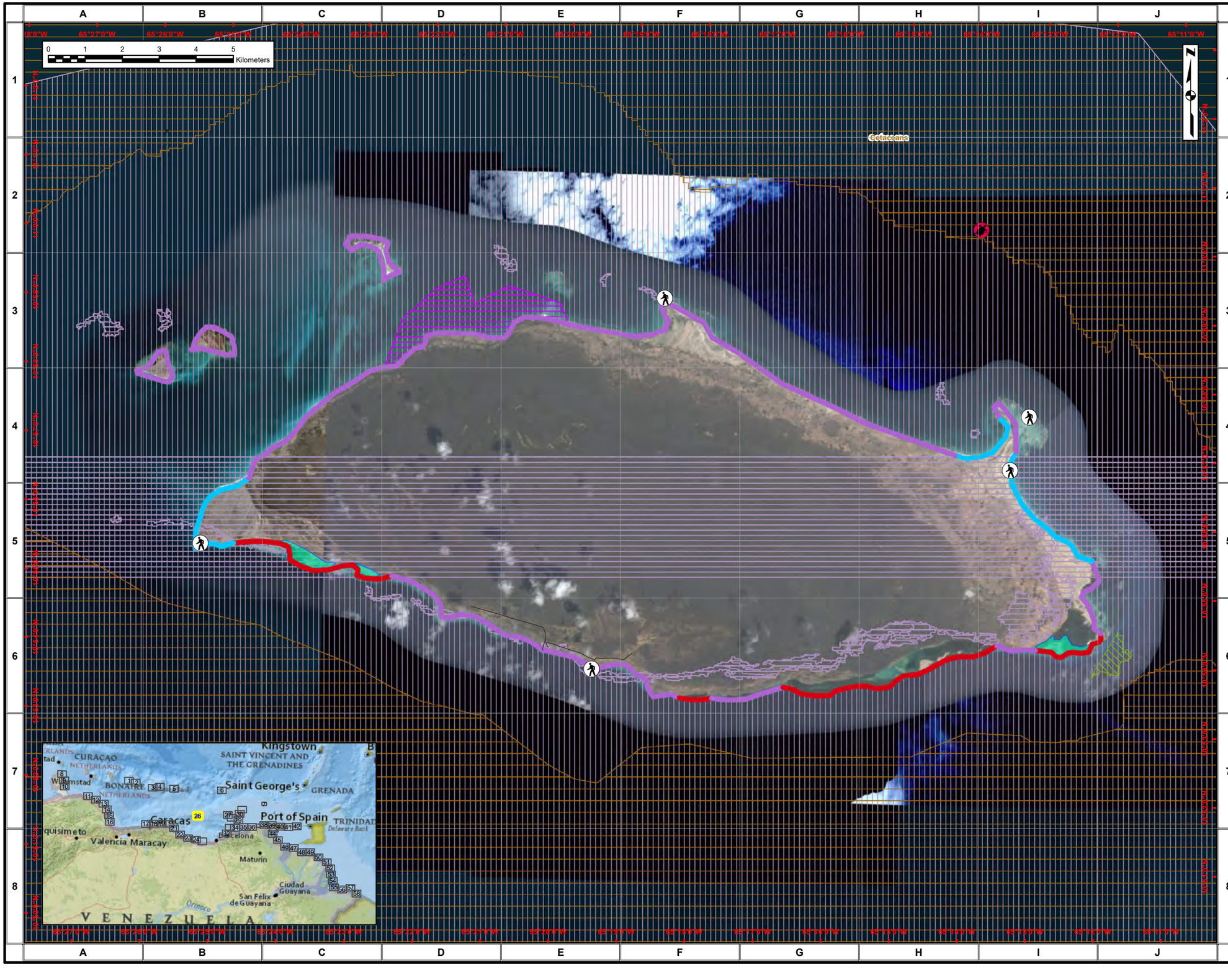

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 10A - Salt and brackish water marshes
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Seagrass
- Lagoon
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla la Tortuga
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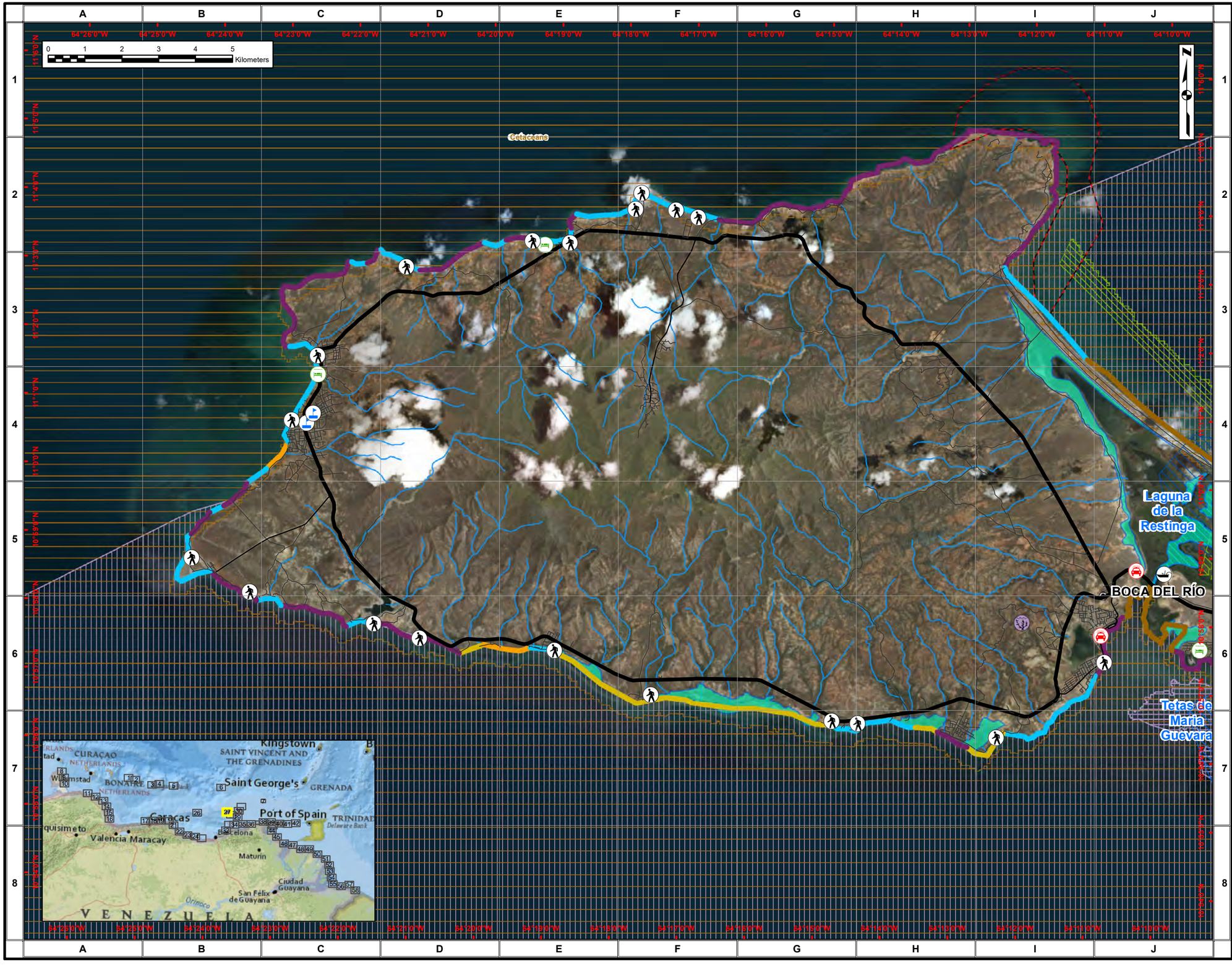

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef
- Seagrass
- Lagoon
- IUCN Category I, II
- IUCN Category III, IV
- Police Stations
- School
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Macano
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef
- Seagrass
- Lagoon
- IUCN Category I, II
- IUCN Category III, IV

Onshore National Protected

- IUCN Category V & VI
- Hospitals
- Police Stations
- College
- Port or Marina
- Fishing Dock or Landing
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de la Restinga
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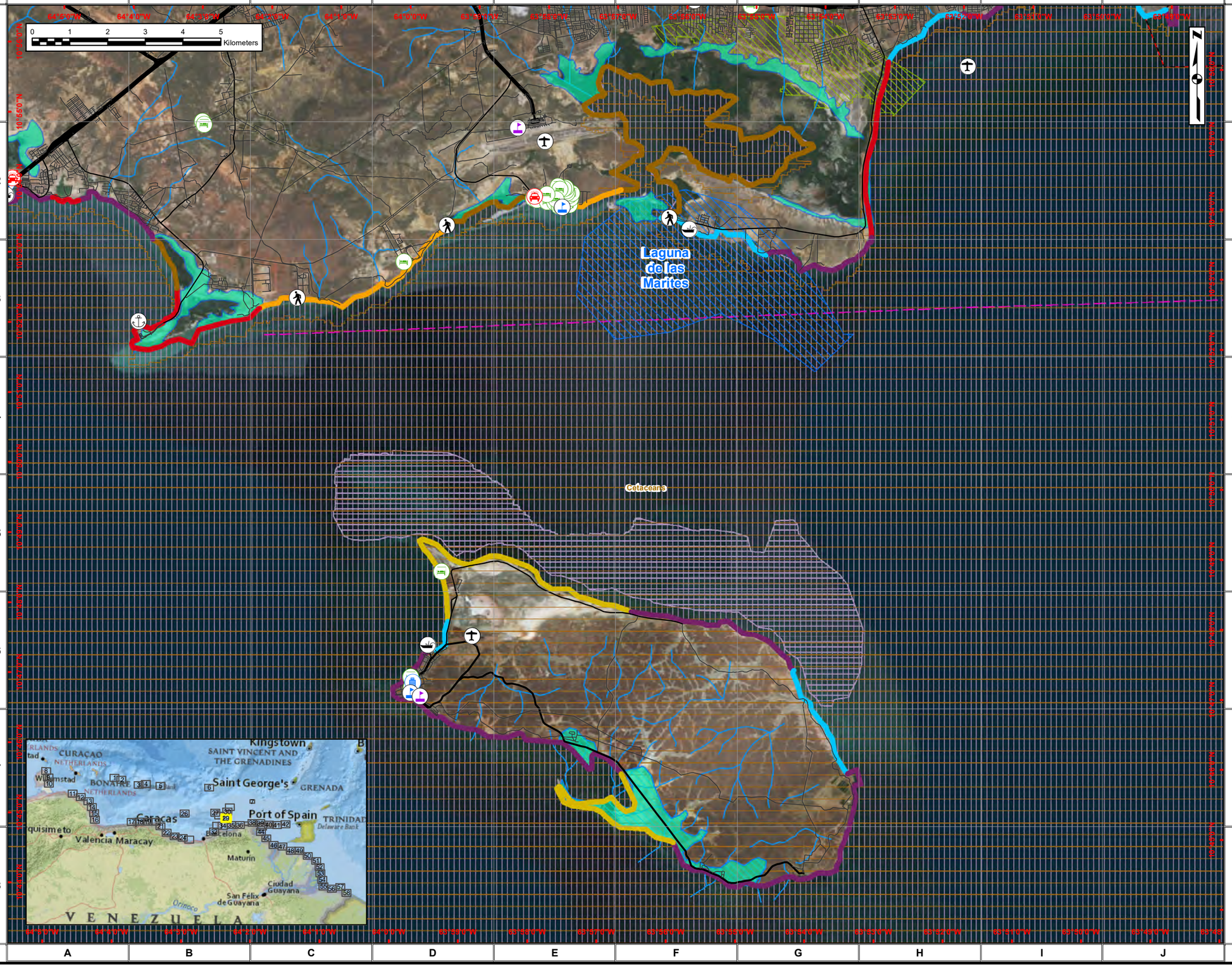

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Seagrass
- Lagoon
- IUCN Category III, IV
- Hospitals
- Police Stations
- School
- College
- Port or Marina
- Fishing Dock or Landing
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response Shoreline Access

Venezuela - Laguna de las Marites / Isla Coche

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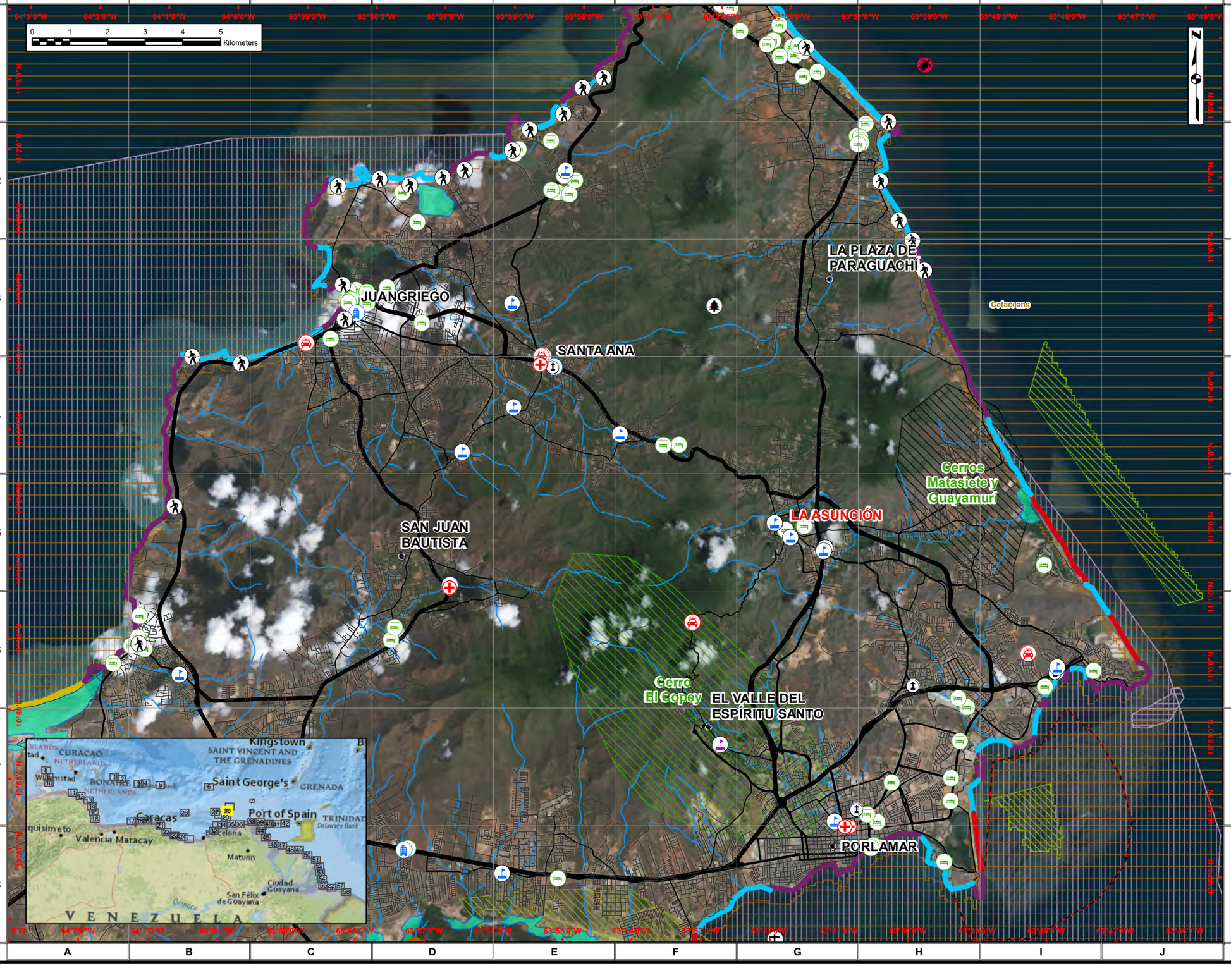

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Seagrass
- Lagoon

Onshore National Protected Areas

- IUCN Category V & VI
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- College
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- State Capital
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Margarita
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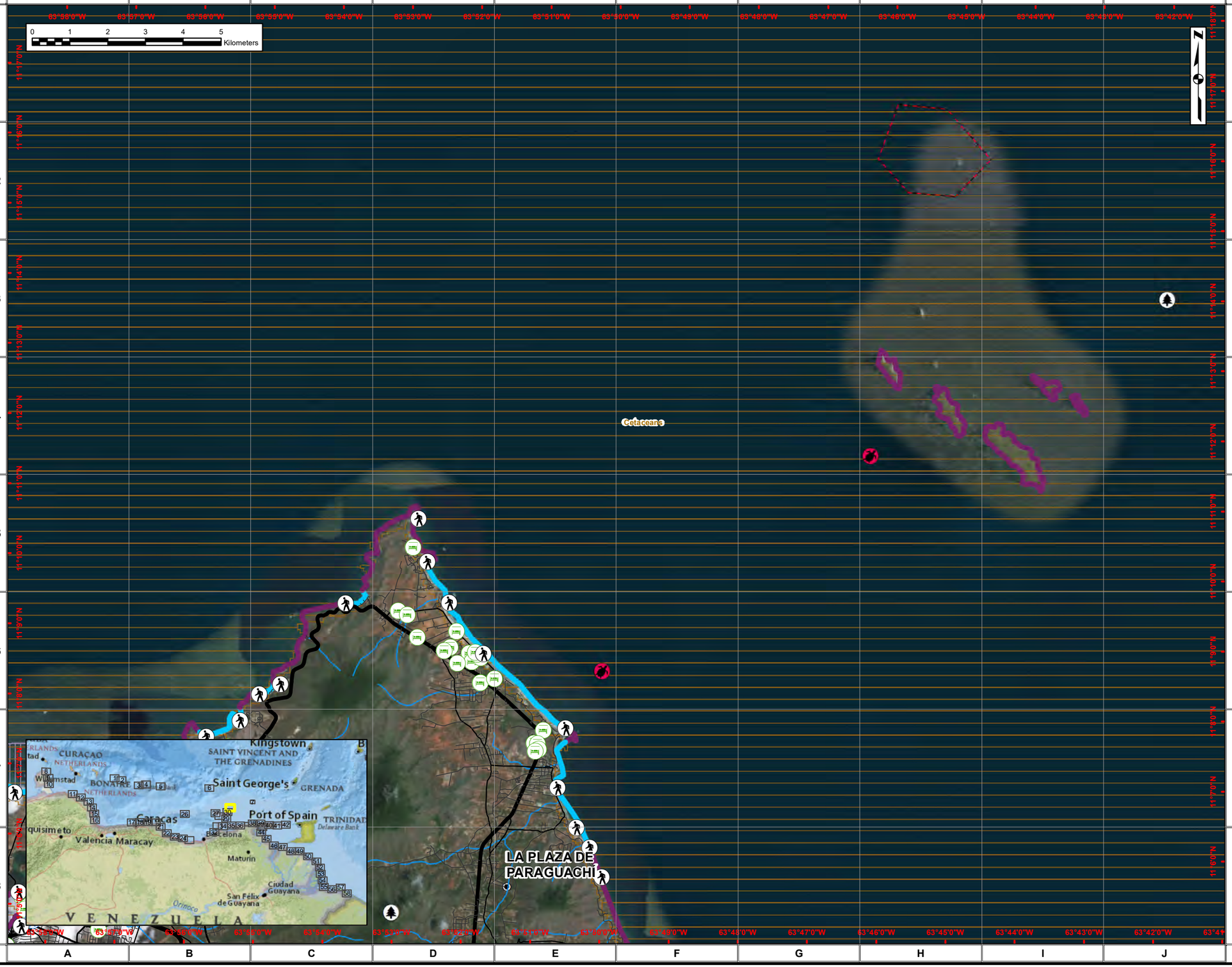

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- Turtle Nesting
- Marine Mammals
- Seagrass
- Lagoon

Onshore National Protected Areas

- IUCN Category Not Reported
- School
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Margarita (North)
Map 31 of 58
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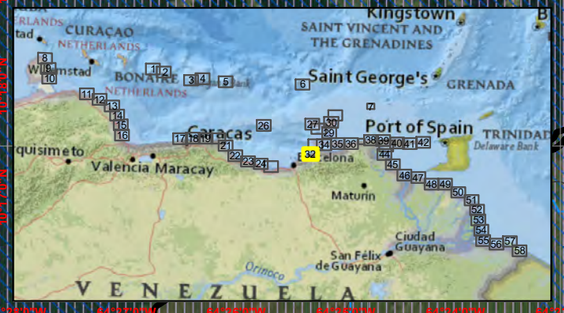
0 1 2 3 4 5 Kilometers

Cetaceans

Mochima

Macizo Montañoso del Turimiquire



Legend

- Turtle Nesting
- Marine Mammals
- Seagrass
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category V, VI
- Police Stations
- School
- College
- Fishing Dock or Landing
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Mochima
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 9A - Sheltered tidal flats
- 9C - Hypersaline tidal flats
- 10A - Salt and brackish water marshes
- Marine Mammals
- Seagrass
- Hospitals
- Police Stations
- School
- College
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Wreck
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Punta Arenas
Map 33 of 58
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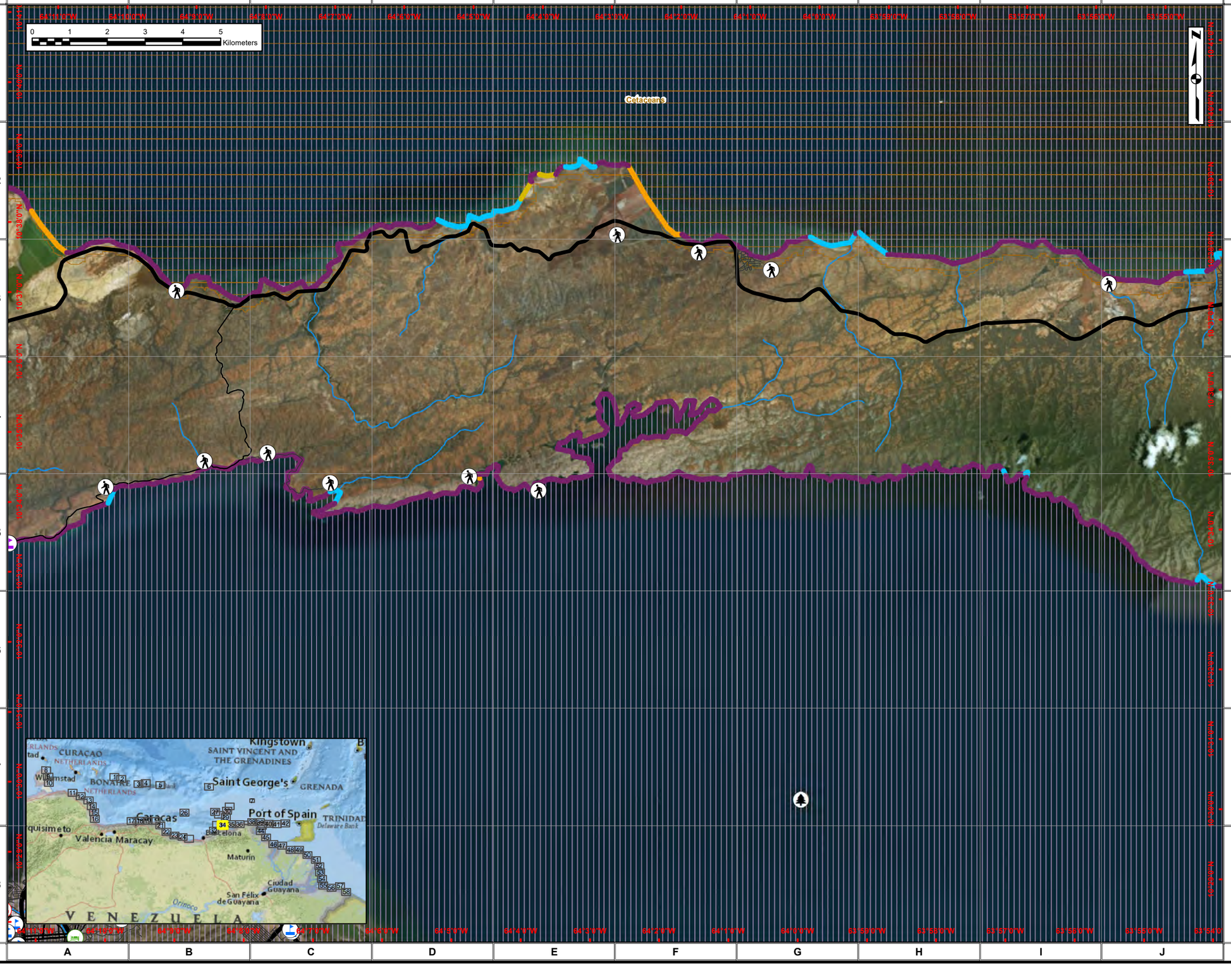

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 9C - Hypersaline tidal flats
- Marine Mammals
- Seagrass

Onshore National Protected Areas

- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- College
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Cumana
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals
- Seagrass
- Fishing Dock or Landing
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Cruz Salmeron Acosta
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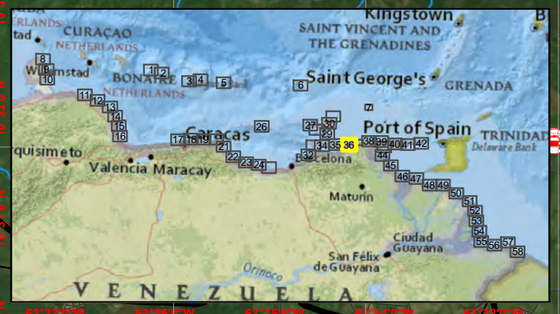
0 1 2 3 4 5 Kilometers

American & West Indian Manatee

Cetaceans



Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 10A - Salt and brackish water marshes
- Marine Mammals
- Seagrass
- Lagoon
- Police Stations
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Rock

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Saucedo to La Esmeralda
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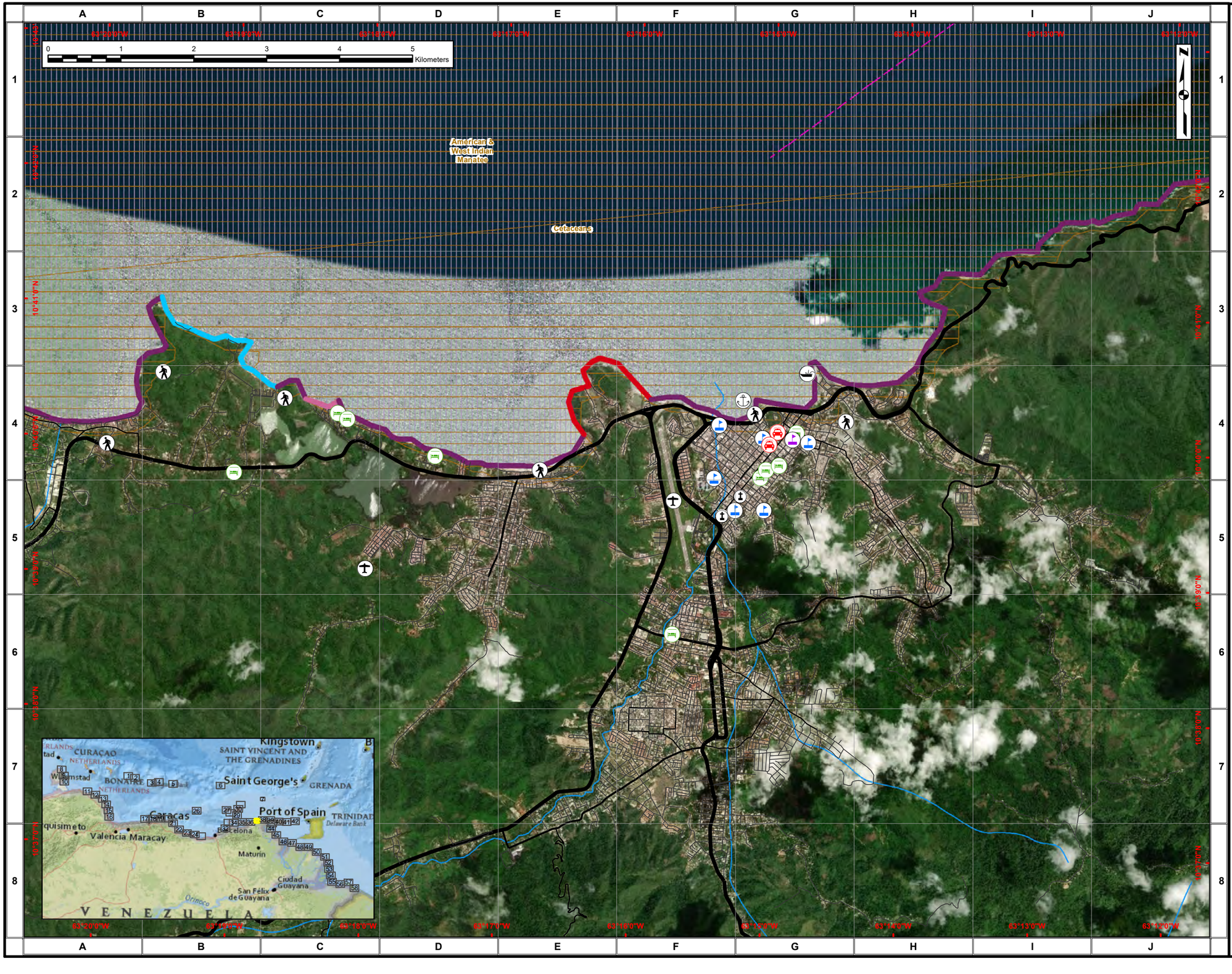

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 10A - Salt and brackish water marshes
- 10B - Freshwater marsh
- Marine Mammals
- Seagrass
- Police Stations
- School
- College
- Port or Marina
- Fishing Dock or Landing
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Carupano
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 10B - Freshwater marsh
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Marine Mammals
- Seagrass
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - El Morro de Puerto Santo
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 3/4 - Sandy beaches or slopes
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Seagrass
- IUCN Category I, II
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (West)
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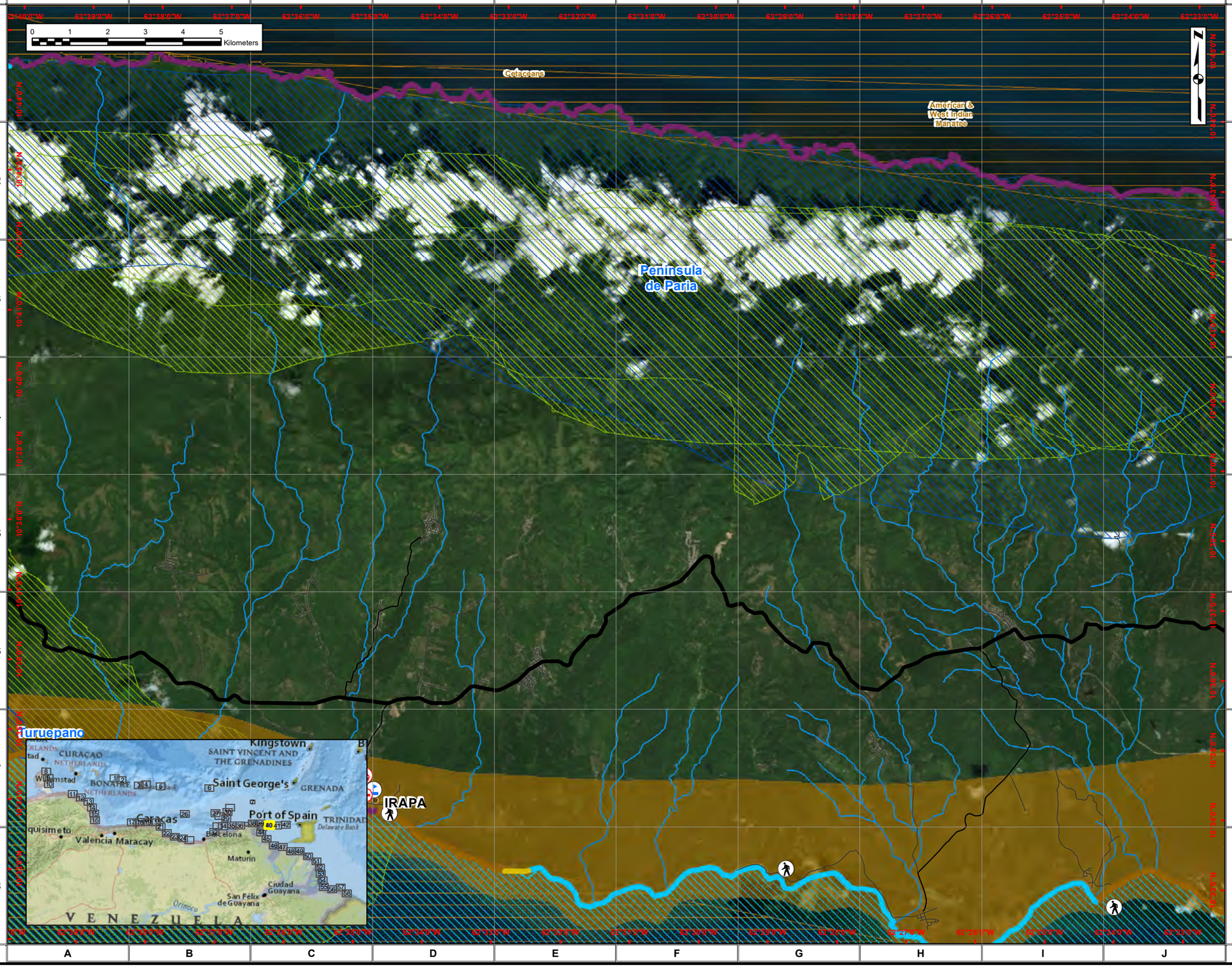

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category I, II
- Hospitals
- Police Stations
- School
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (West-Central)
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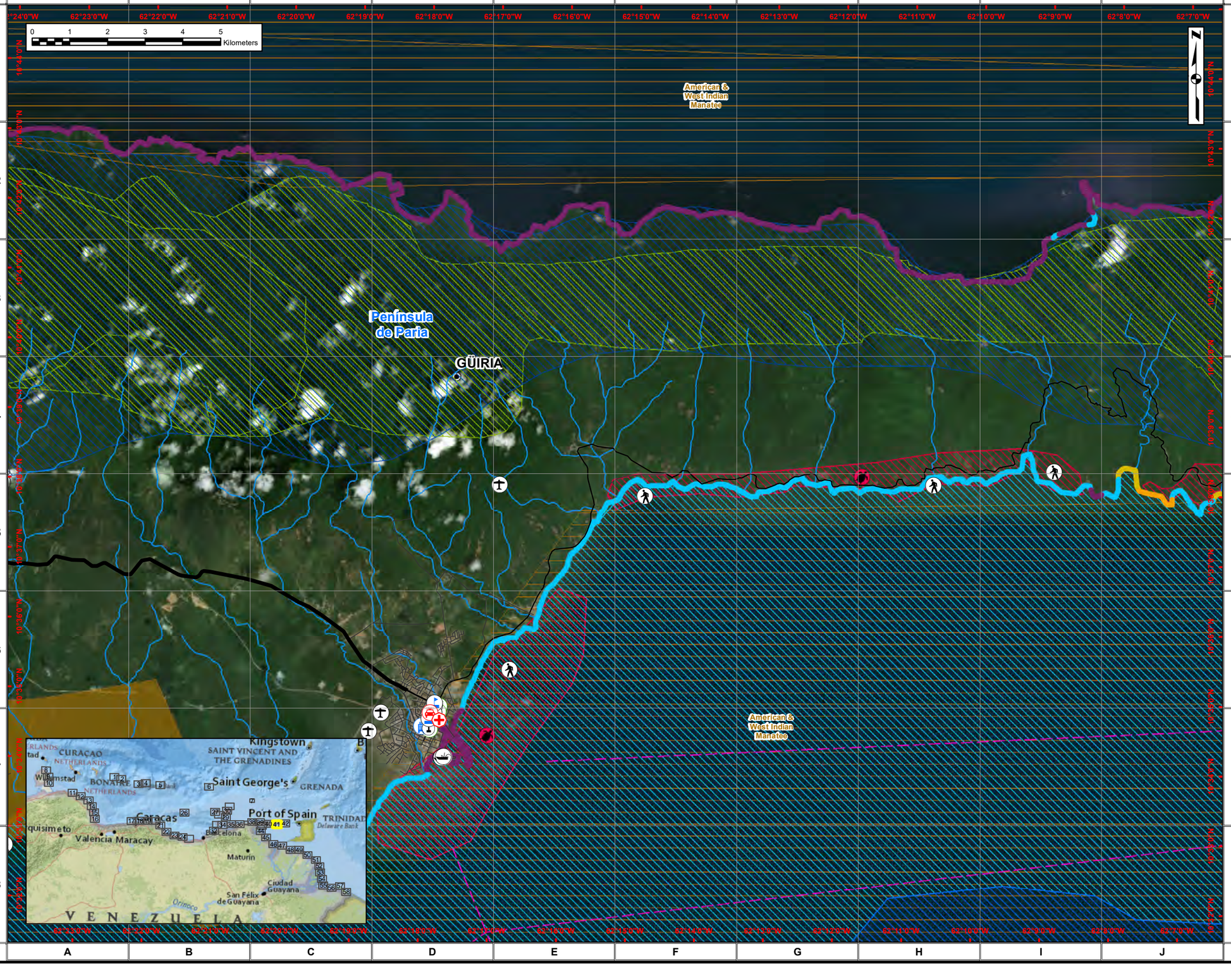

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- IUCN Category I, II
- Hospitals
- Police Stations
- School
- Port or Marina
- Fishing Dock or Landing
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (East-Central)
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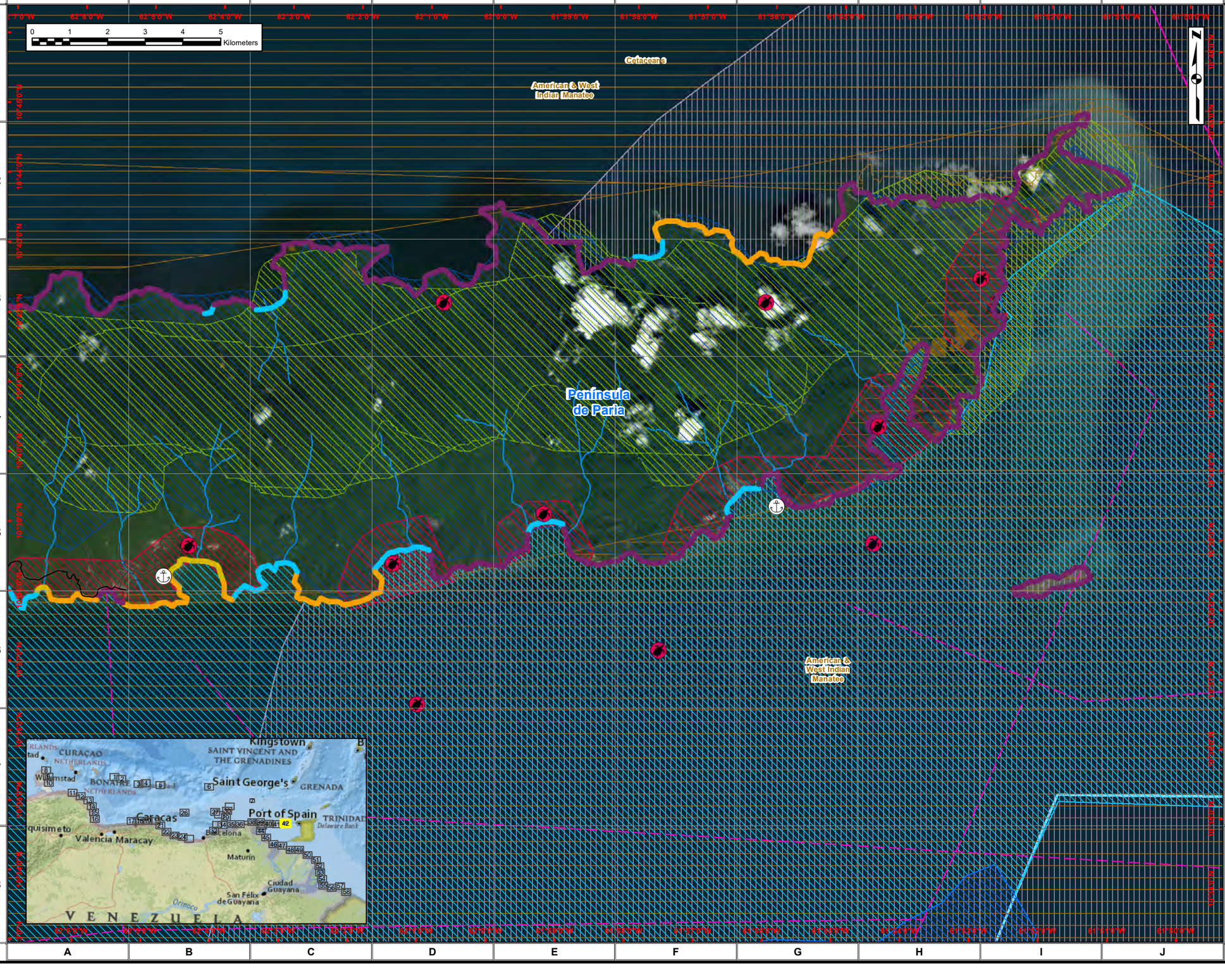

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- Seagrass
- IUCN Category I, II
- Port or Marina
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Shipping Route
- Territorial Waters Boundary

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (East)
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Legend

Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Turuepano (North)
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Legend

Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category Not Reported
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Turuepano (South)
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Legend

Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals

Onshore National Protected Areas

- IUCN Category Not Reported
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Gulf of Paria (Rio de San Juan)
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals

Onshore National Protected Areas

- IUCN Category Not Reported
- Hospitals
- School
- Amerindian Village
- Places of Worship
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Gulf of Paria (Isla Cotorra)
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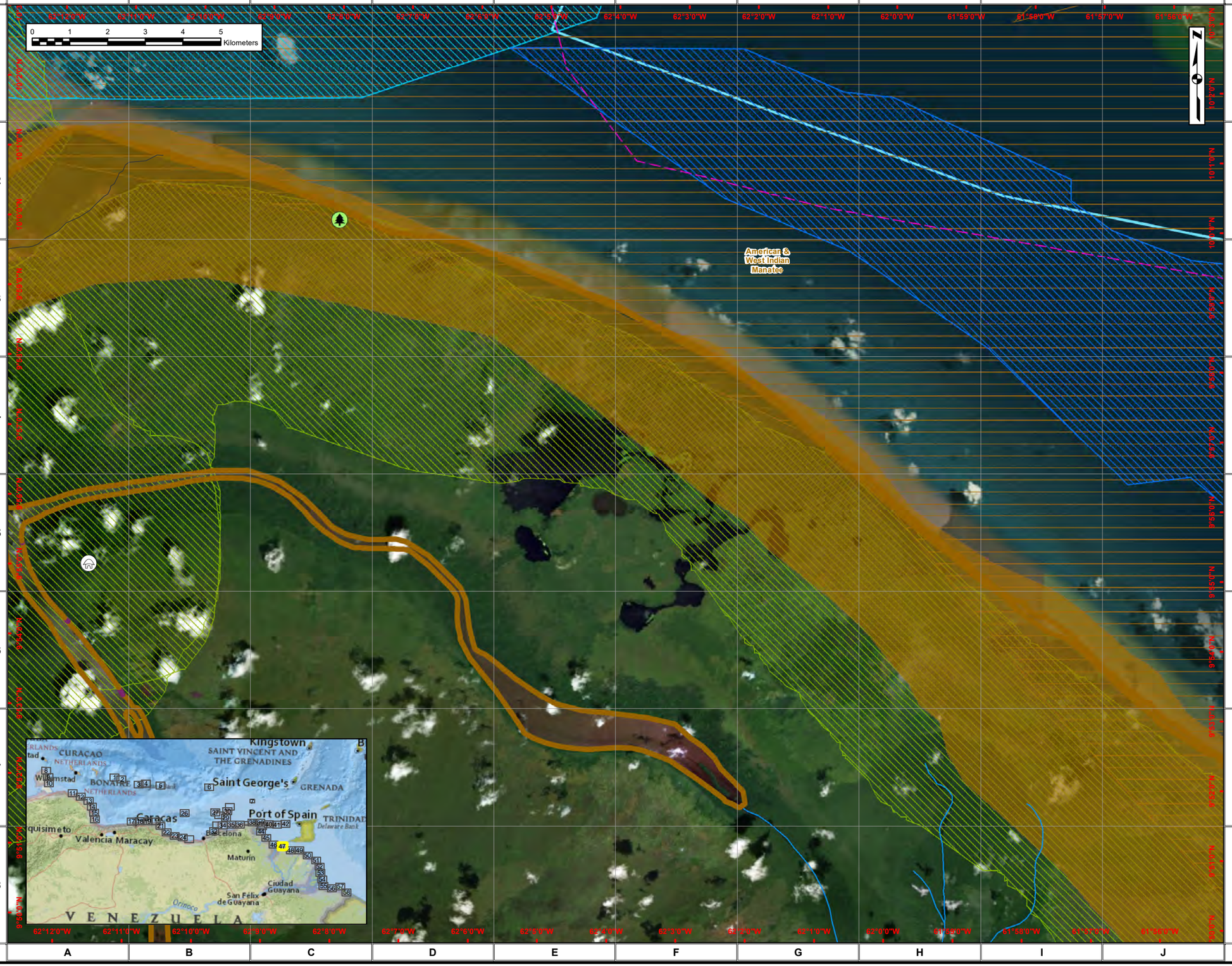

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals

Onshore National Protected Areas

- IUCN Category V & VI
- Amerindian Village
- Access Roads and Tracks
- Rivers
- Shipping Route
- Territorial Waters Boundary

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Gulf of Paria (Columbus Channel)
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Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Tucupita (West)
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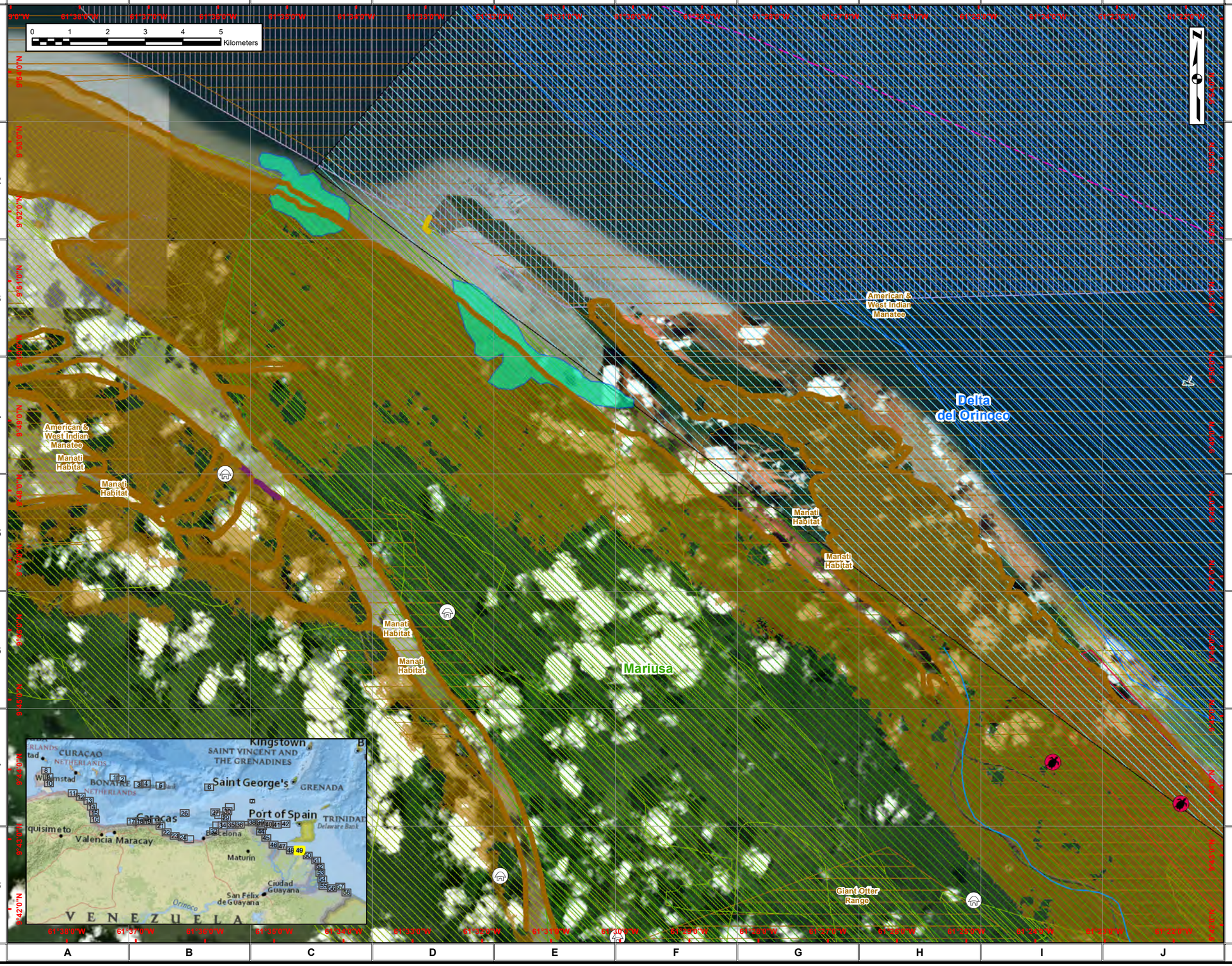

Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 7 - Exposed tidal flats
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- Seagrass
- Lagoon
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category I, II
- Amerindian Village
- Rivers
- Wreck
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 1
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Legend

Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- Seagrass
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category I, II
- Amerindian Village
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 2
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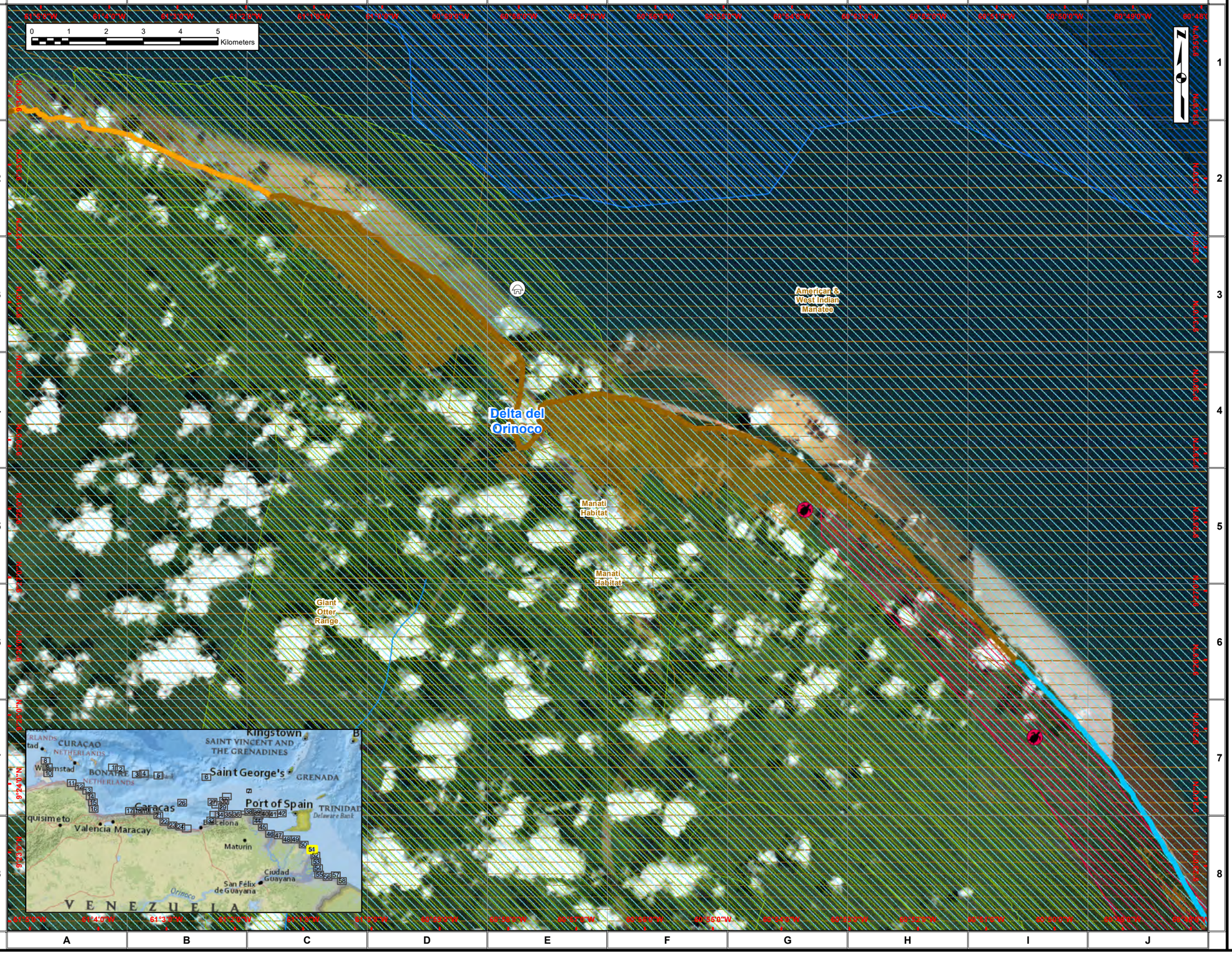

Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 3
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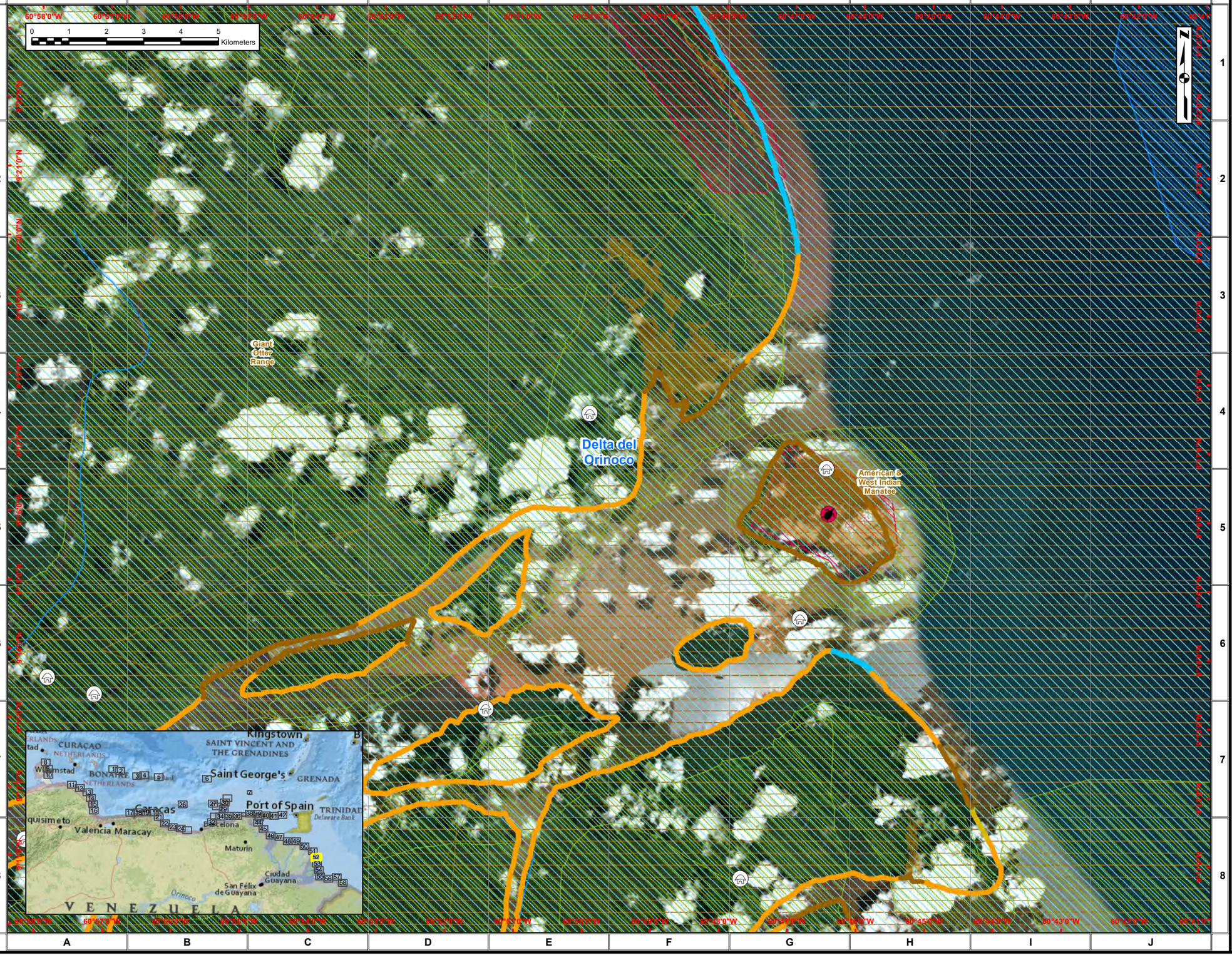

Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 4
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Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI
- Nesting Birds
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 5
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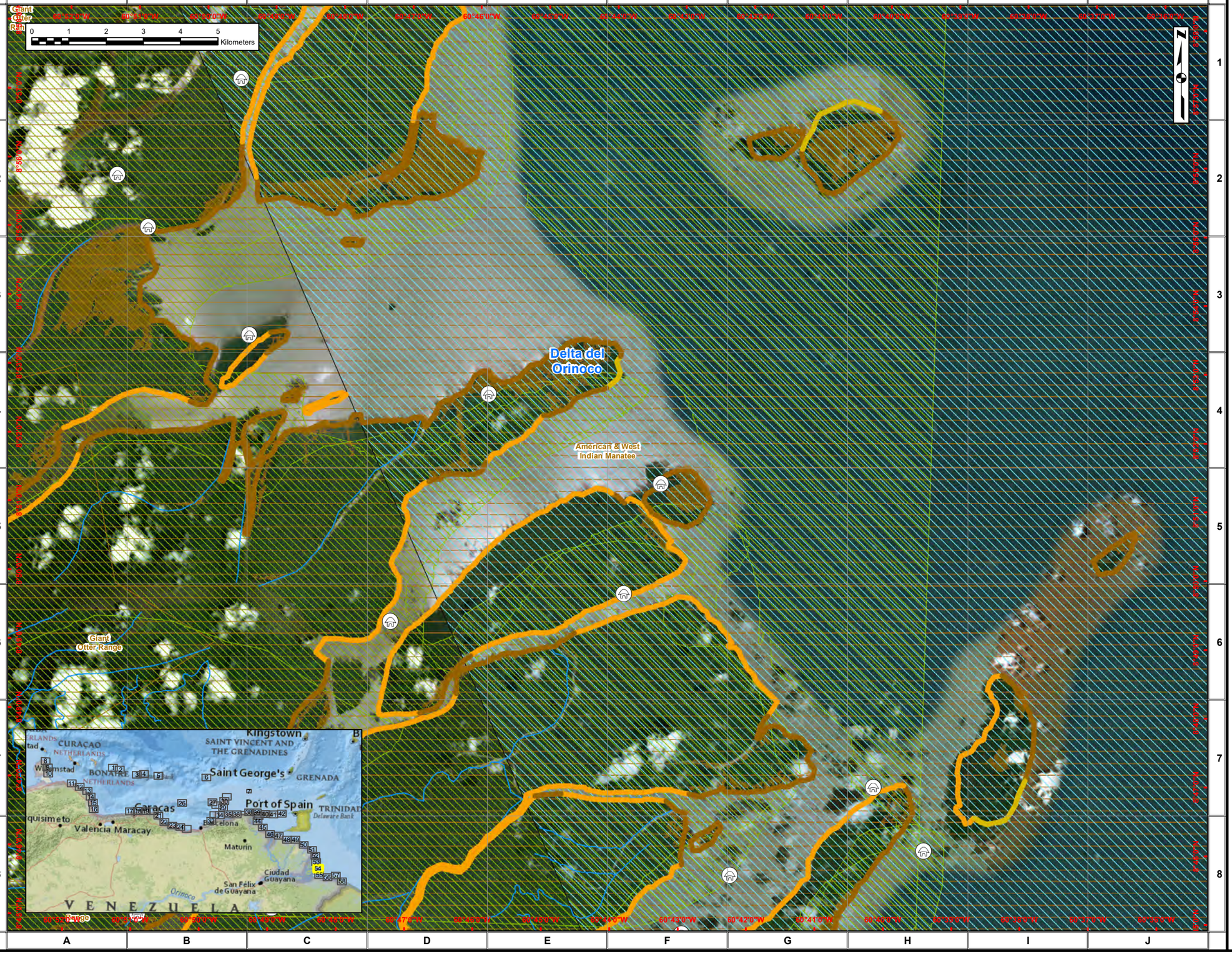

Legend

Shoreline Sensitivity (ESI)

- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 6
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Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category V, VI
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 7
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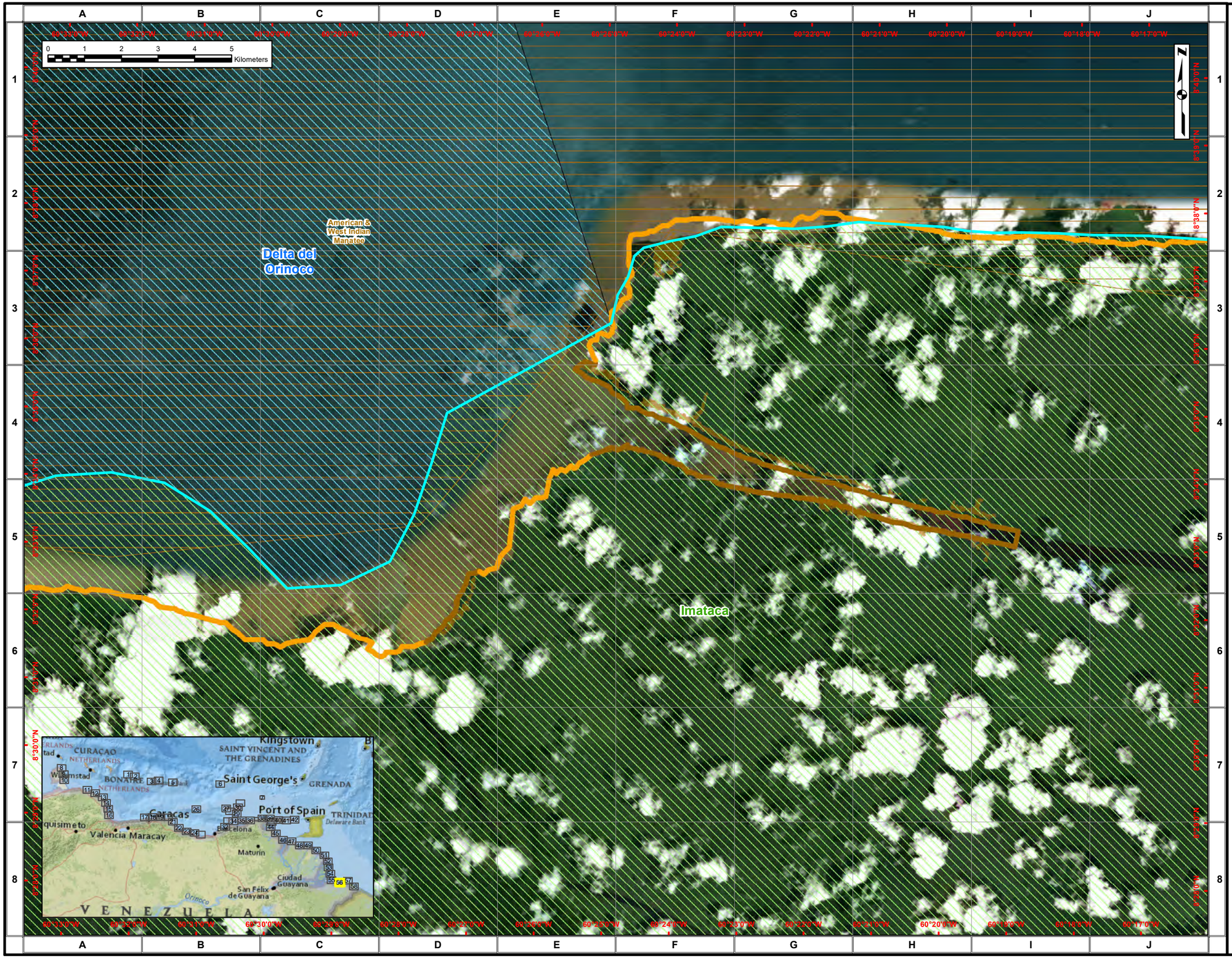

Legend

Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category V, VI

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 8
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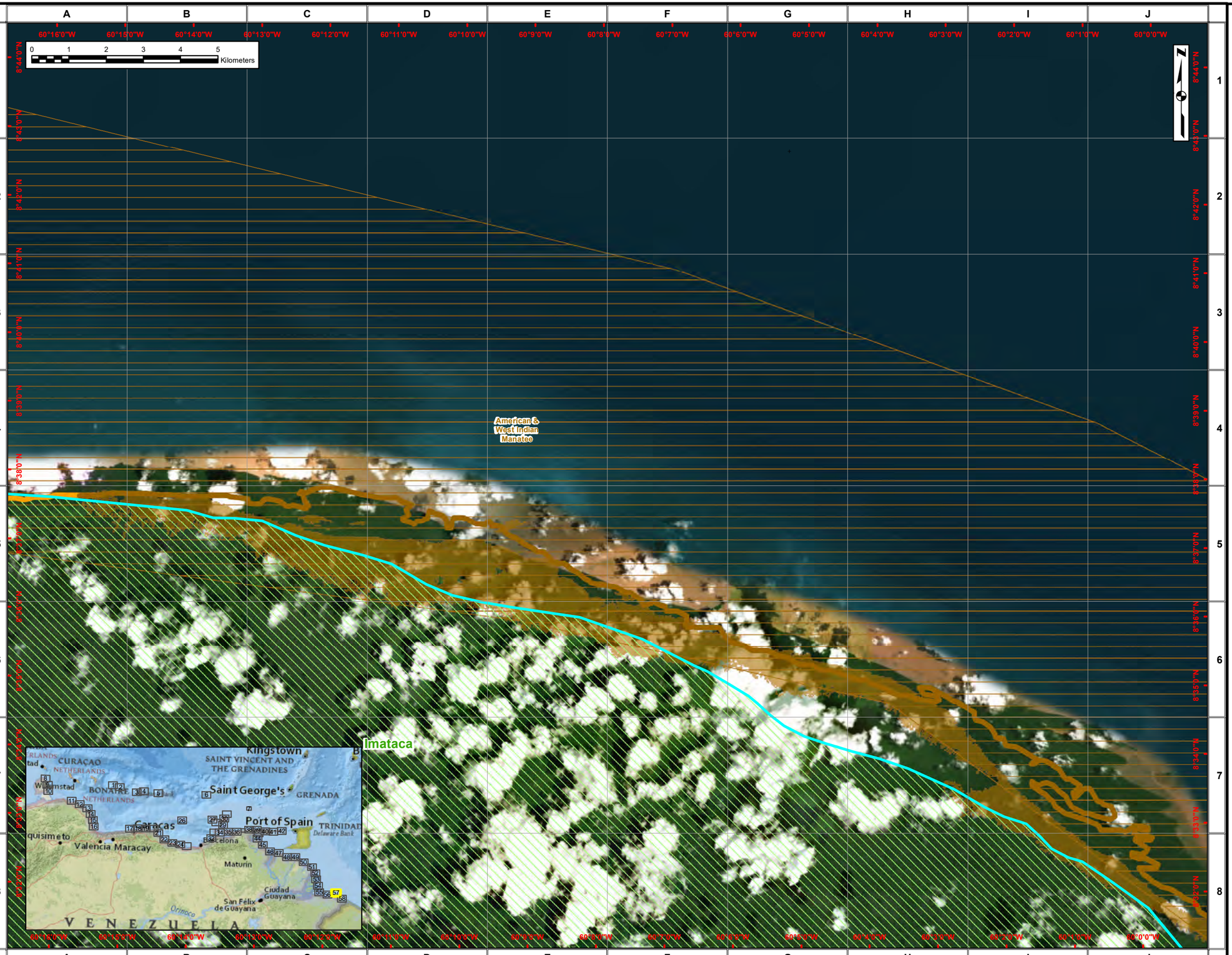

Legend

Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals

Onshore National Protected Areas

- IUCN Category V, VI

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals
- IUCN Category V, VI

Onshore National Protected Areas

- IUCN Category V, VI
- Rivers
- Underwater Danger /Underwater Hazard

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Grenada

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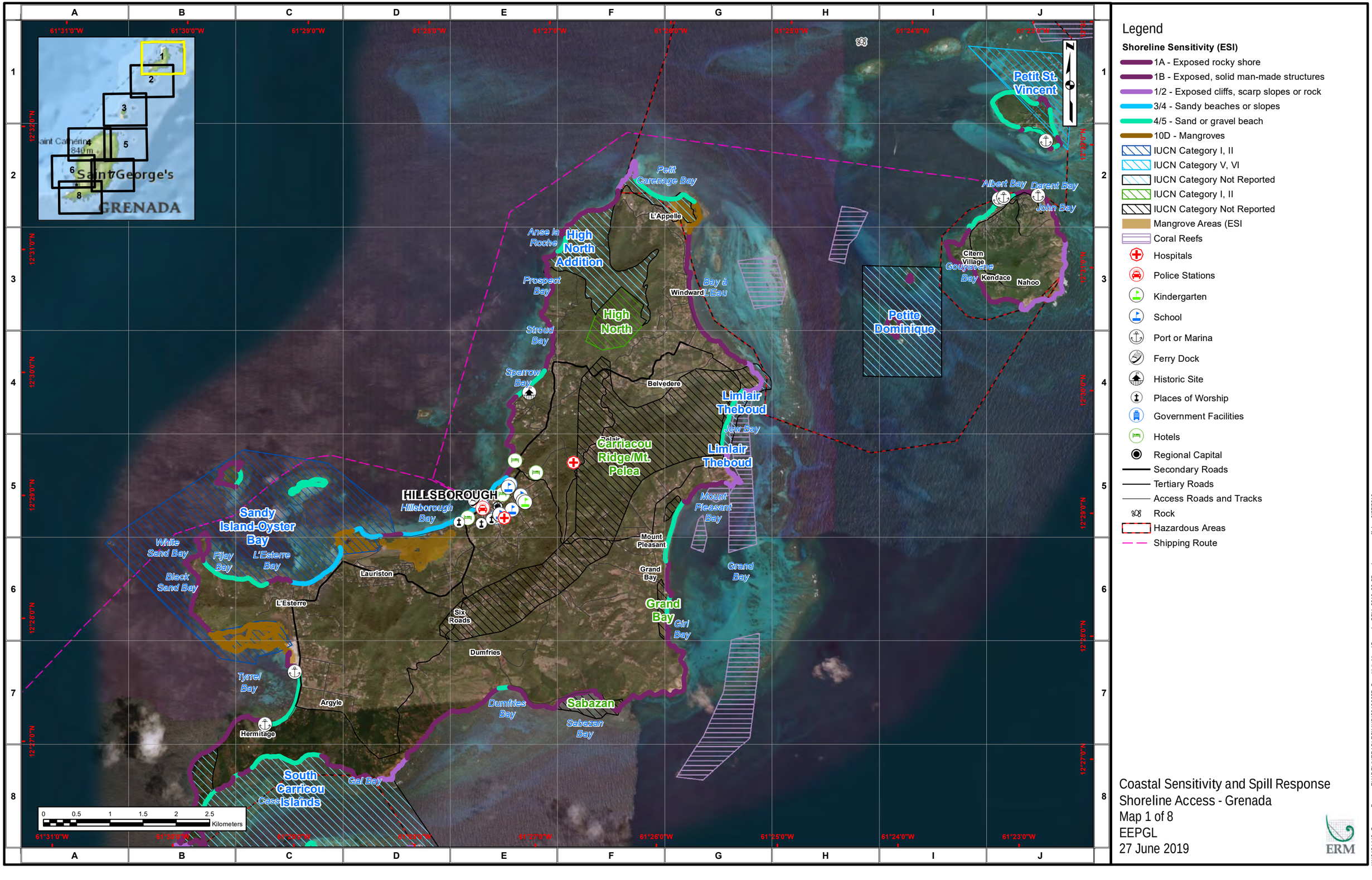

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 4/5 - Sand or gravel beach
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Hospitals
- Police Stations
- Kindergarten
- School
- Port or Marina
- Ferry Dock
- Historic Site
- Places of Worship
- Government Facilities
- Hotels
- Regional Capital
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
Map 1 of 8
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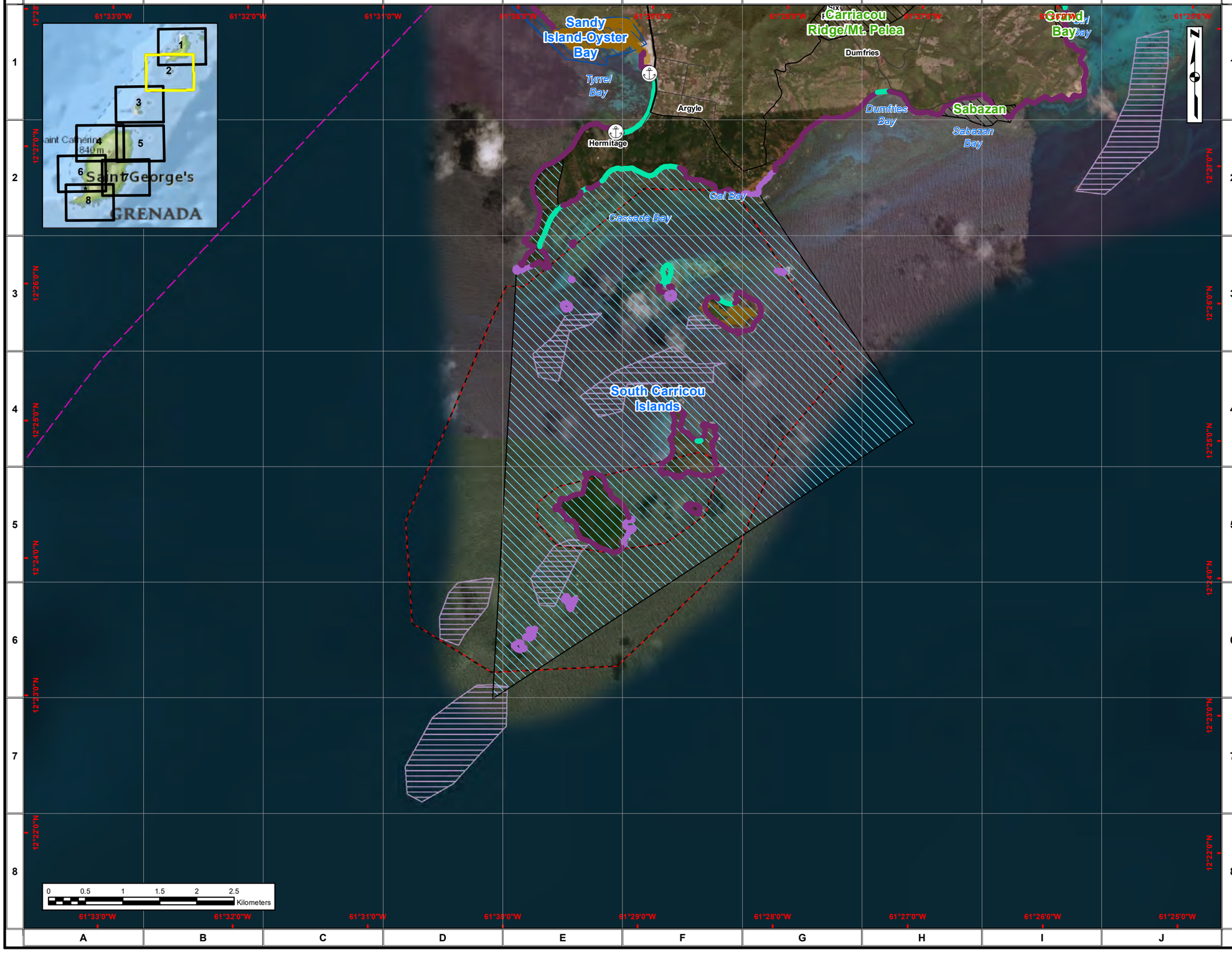

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category Not Reported
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Port or Marina
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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Ronde Island Group

Whale Bay

0 0.5 1 1.5 2 2.5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- IUCN Category Not Reported
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Seagrass
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category Not Reported
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Port or Marina
- Historic Site
- Burial Grounds (Georgetown)
- Places of Worship
- Hotels
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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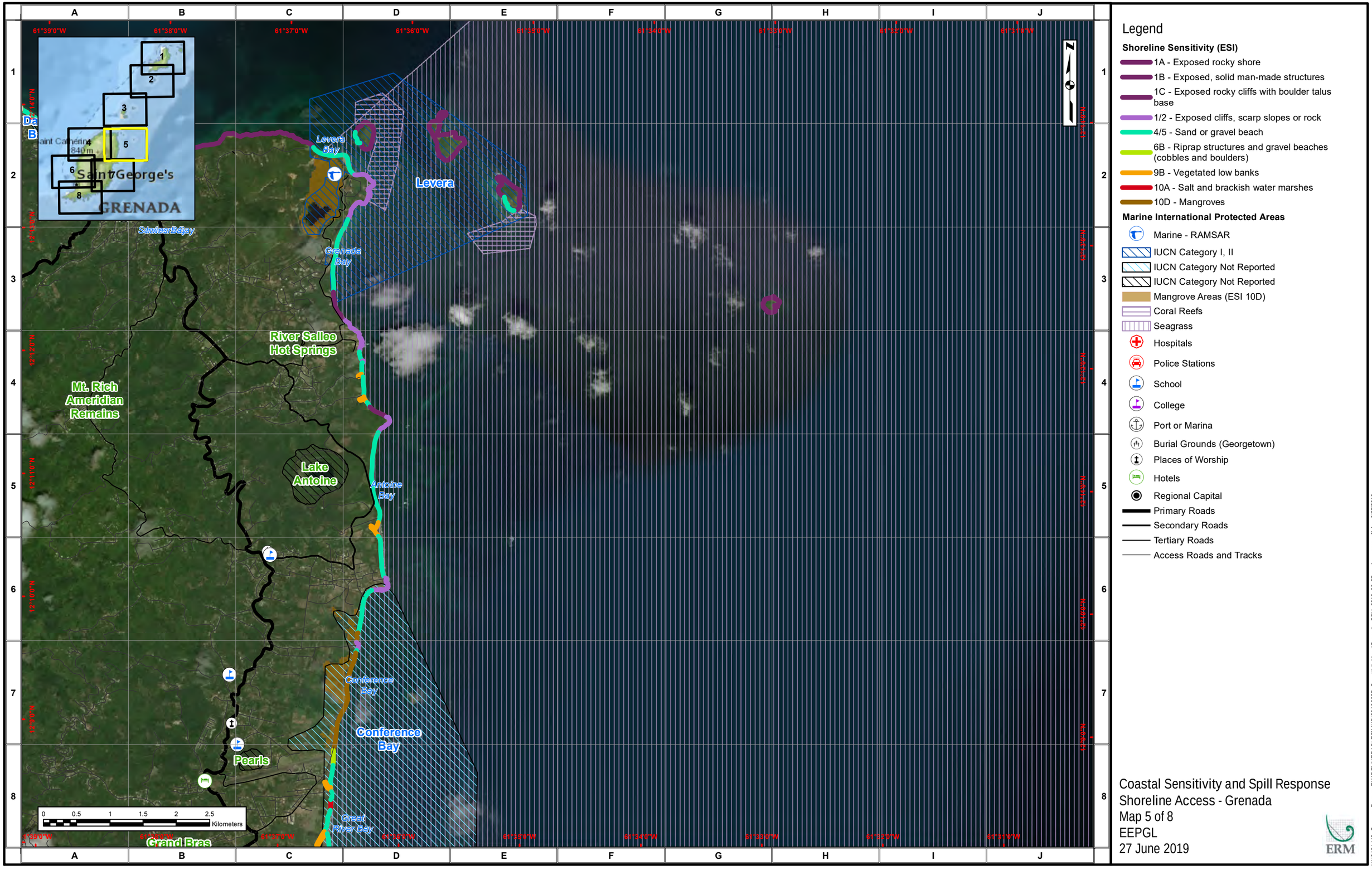

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II
- IUCN Category Not Reported
- IUCN Category Not Reported
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- College
- Port or Marina
- Burial Grounds (Georgetown)
- Places of Worship
- Hotels
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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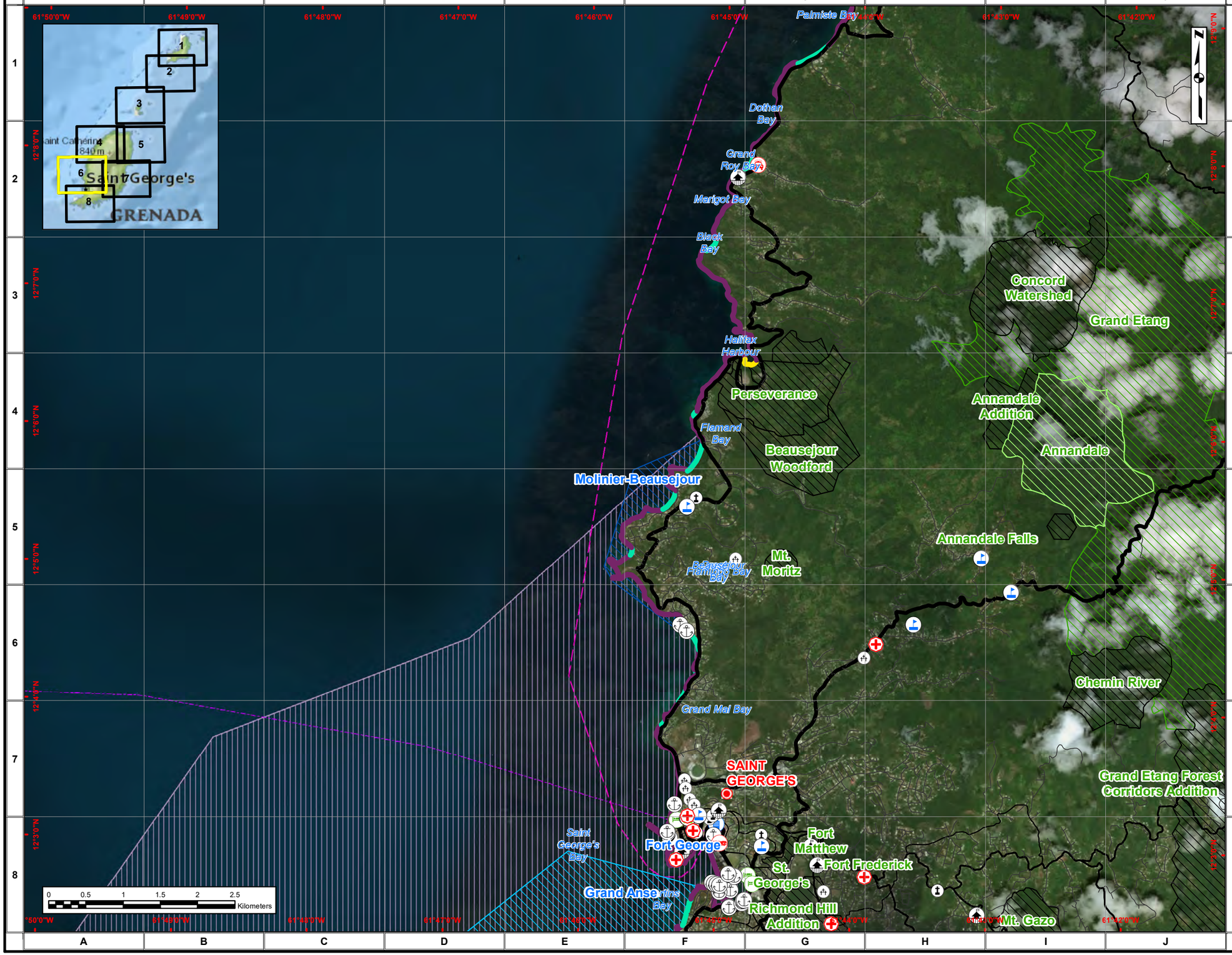

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 4/5 - Sand or gravel beach
- 8A - Sheltered scarps in bedrock, mud or clay
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- Seagrass
- Hospitals
- Police Stations
- Fire Stations (Georgetown)
- Kindergarten
- School
- Port or Marina
- Ferry Dock
- Historic Site
- Burial Grounds (Georgetown)
- Places of Worship
- Government Facilities
- Hotels
- Capital City
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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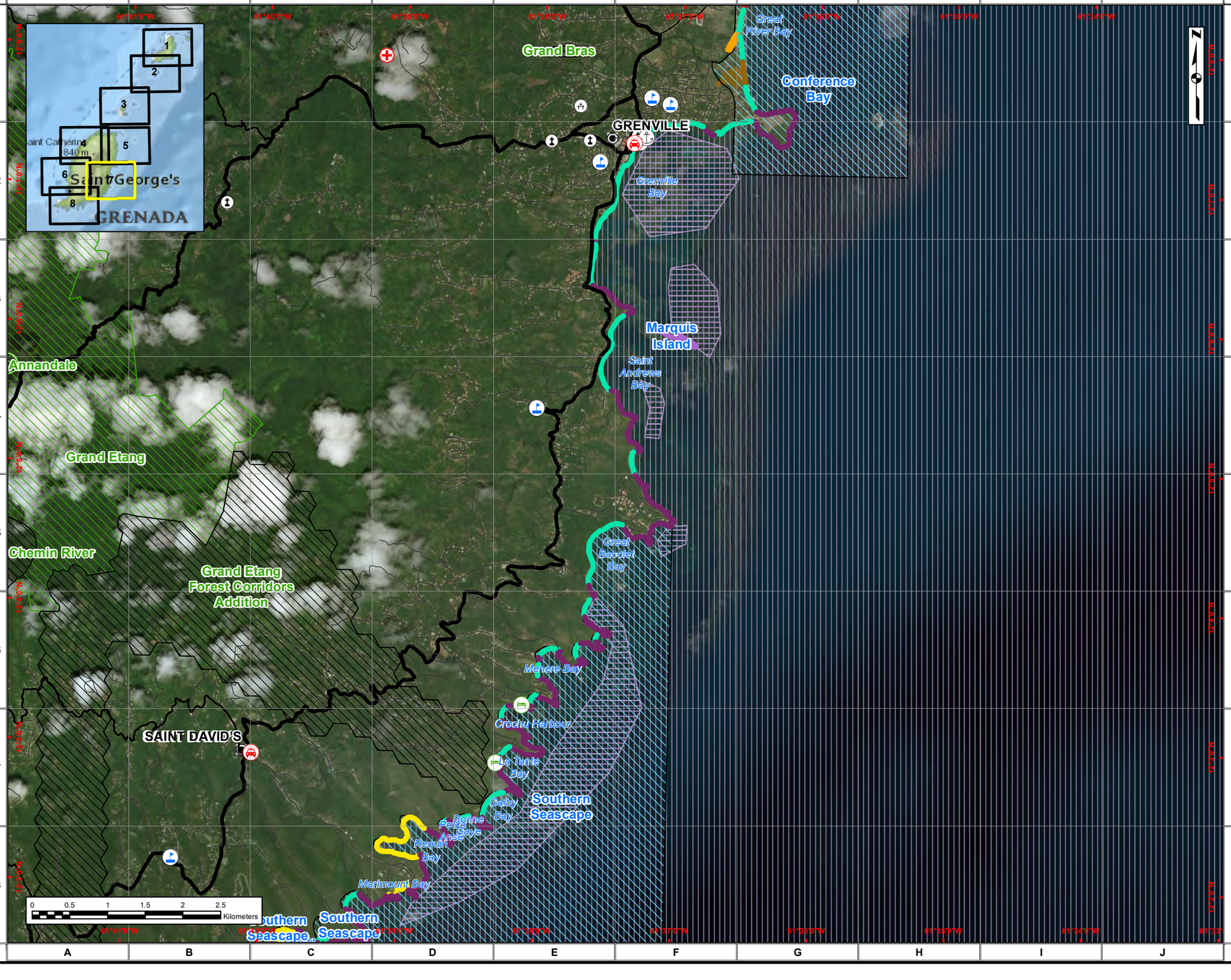

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8A - Sheltered scarps in bedrock, mud or clay
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- Port or Marina
- Ferry Dock
- Burial Grounds (Georgetown)
- Places of Worship
- Hotels
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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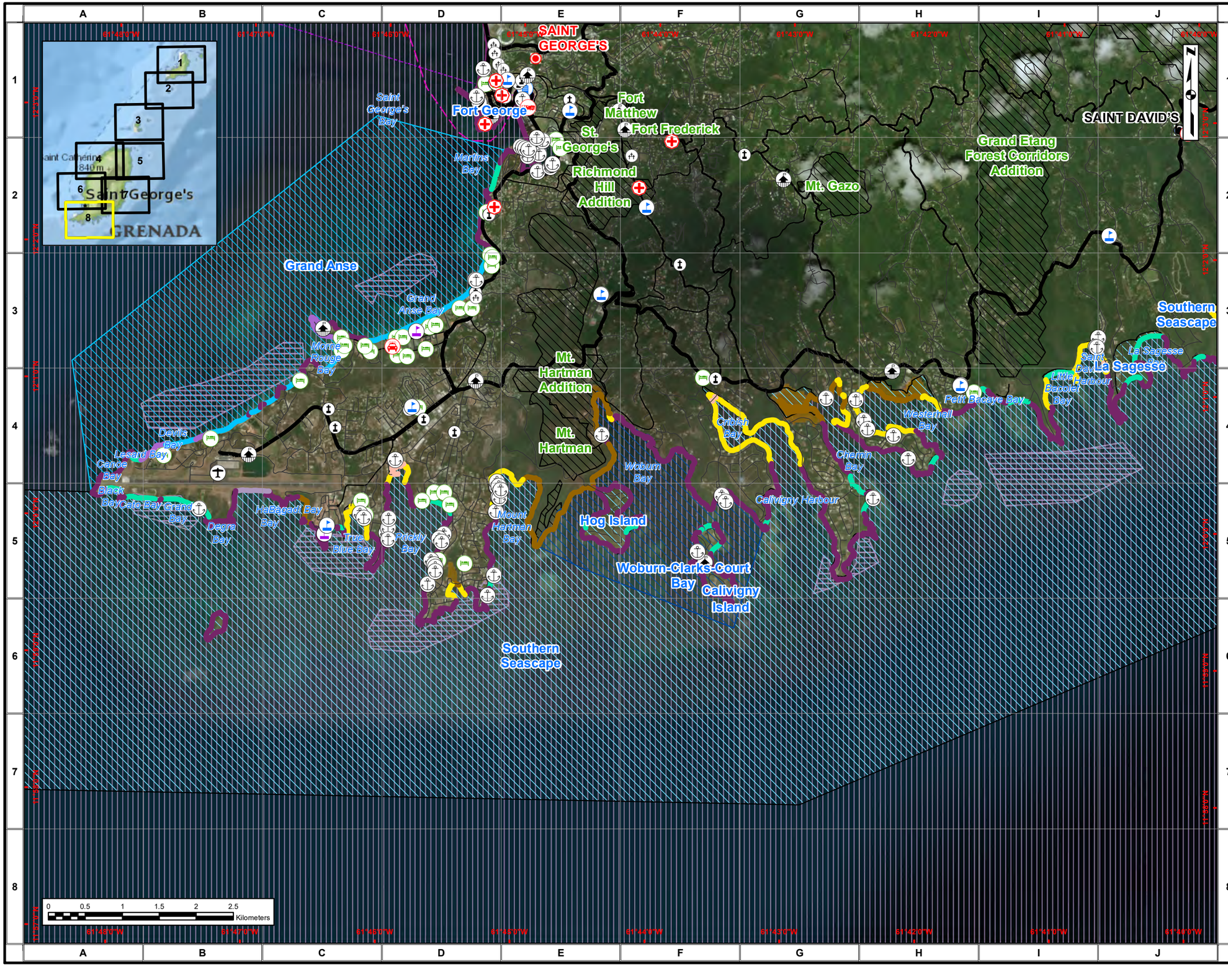

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 1/2 - Exposed cliffs, scarp slopes or rock
- 2B - Exposed scarps and steep slopes in clay
- 3/4 - Sandy beaches or slopes
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8A - Sheltered scarps in bedrock, mud or clay
- 8B - Sheltered, solid man-made structures
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- Fire Stations (Georgetown)
- Kindergarten
- School
- College
- Port or Marina
- Ferry Dock
- Historic Site
- Burial Grounds (Georgetown)
- Places of Worship
- Government Facilities
- Hotels
- Capital City
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Wreck
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response Shoreline Access - Grenada

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St. Vincent and The Grenadines

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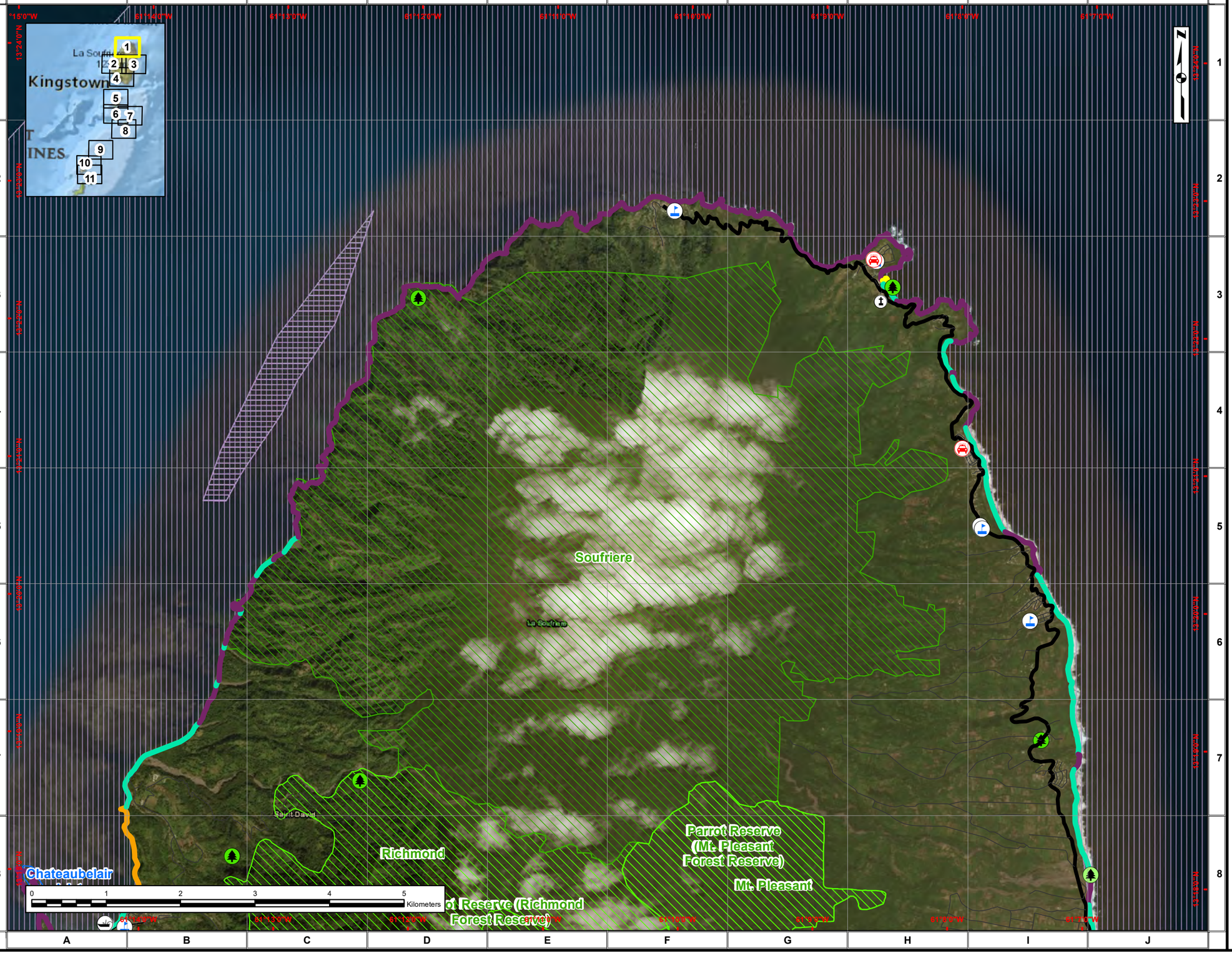

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- IUCN Category III, IV

Onshore National Protected Areas

- IUCN Category III & IV
- IUCN Category V & VI
- IUCN Category I, II
- IUCN Category III, IV
- Coral Reefs
- Seagrass
- Police Stations
- School
- Fishing Dock or Landing
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8A - Sheltered scarps in bedrock, mud or clay
- 8D - Sheltered rocky rubble shores
- 9B - Vegetated low banks
- IUCN Category III, IV

Onshore National Protected Areas

- IUCN Category III & IV
- IUCN Category V & VI
- IUCN Category III, IV
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- Port or Marina
- Fishing Dock or Landing
- Historic Site
- Places of Worship
- Government Facilities
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Underwater Danger /Underwater Hazard
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
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Souffriere

Parrot Reserve (Mt. Pleasant Forest Reserve)

Mt. Pleasant

Parrot Reserve (Richmond Forest Reserve)

Charlotte

Georgetown

Parrot Reserve (Colonarie Forest Reserve)

Colonarie

Dalaway

Parrot Reserve (Dalaway Forest Reserve)

Gumberland

Kingstown

0 1 2 3 4 5 Kilometers

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 4/5 - Sand or gravel beach

Onshore National Protected

- IUCN Category III & IV
- IUCN Category V & VI
- IUCN Category I, II
- IUCN Category III, IV
- Seagrass
- Police Stations
- School
- Places of Worship
- Primary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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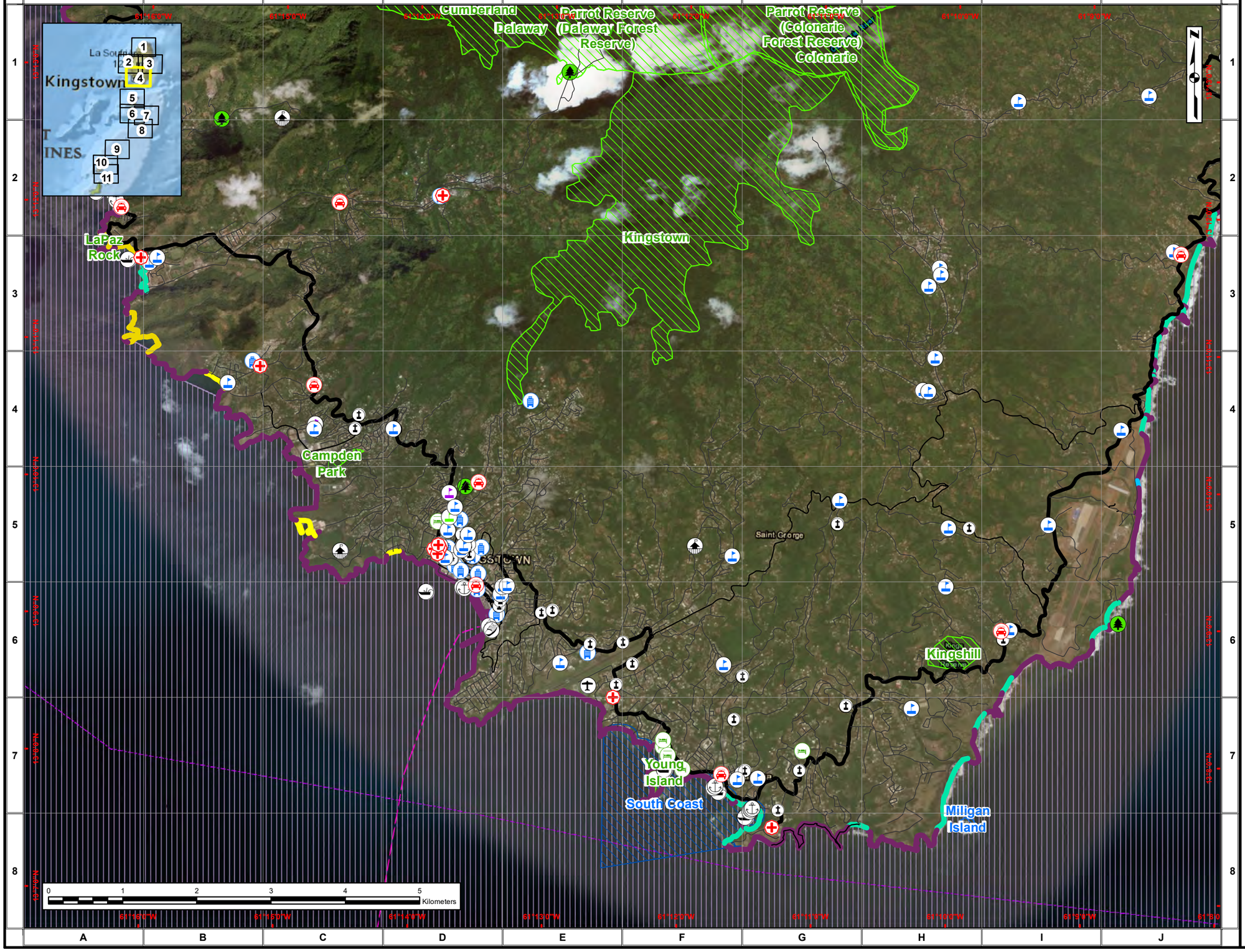

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 3/4 - Sandy beaches or slopes
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8A - Sheltered scarps in bedrock, mud or clay
- 8D - Sheltered rocky rubble shores
- IUCN Category I, II
- IUCN Category III, IV

Onshore National Protected

- IUCN Category III & IV
- IUCN Category III, IV
- Seagrass
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Port or Marina
- Fishing Dock or Landing
- Ferry Dock
- Historic Site
- Burial Grounds
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response Shoreline Access

St. Vincent and The Grenadines

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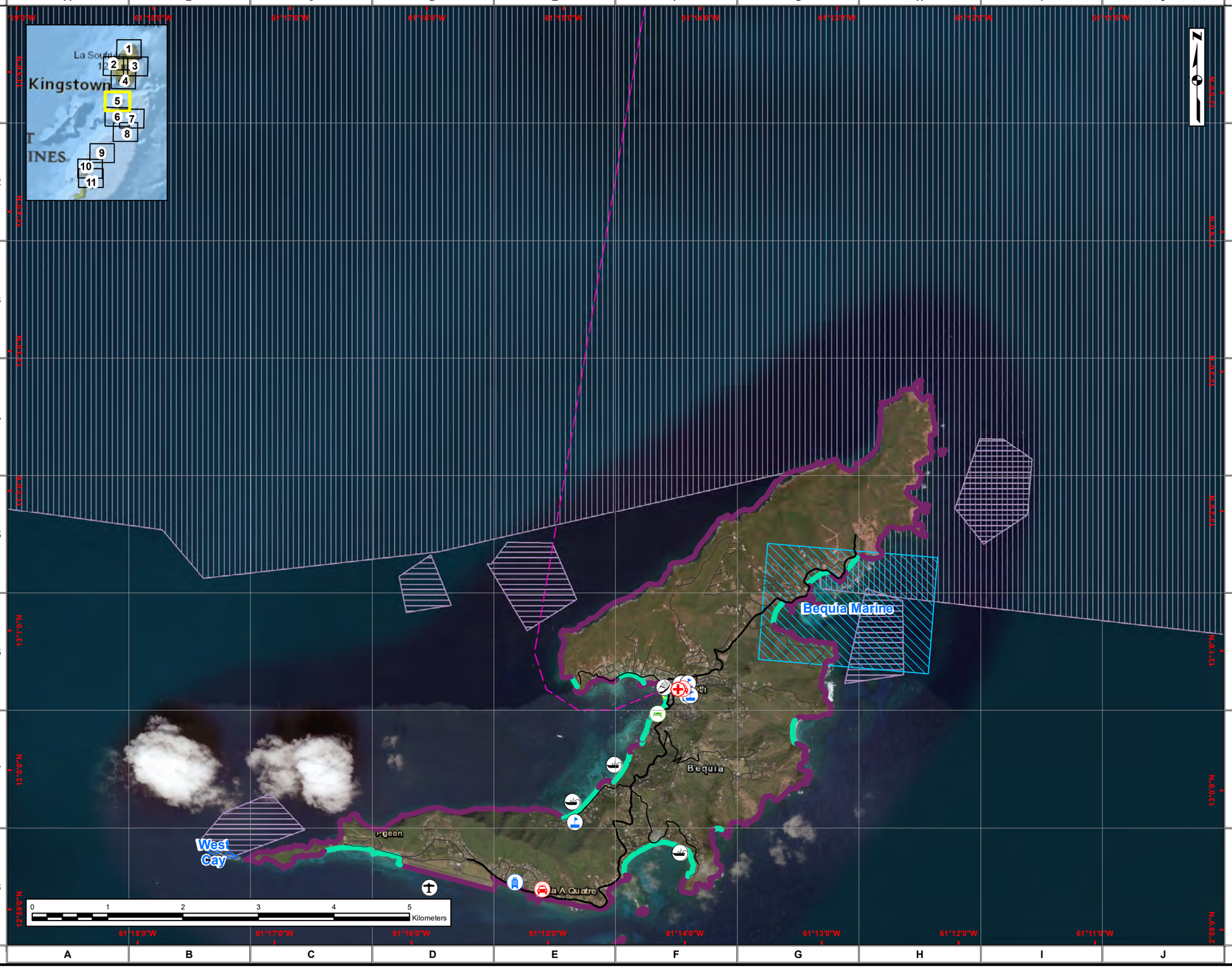

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- Fishing Dock or Landing
- Ferry Dock
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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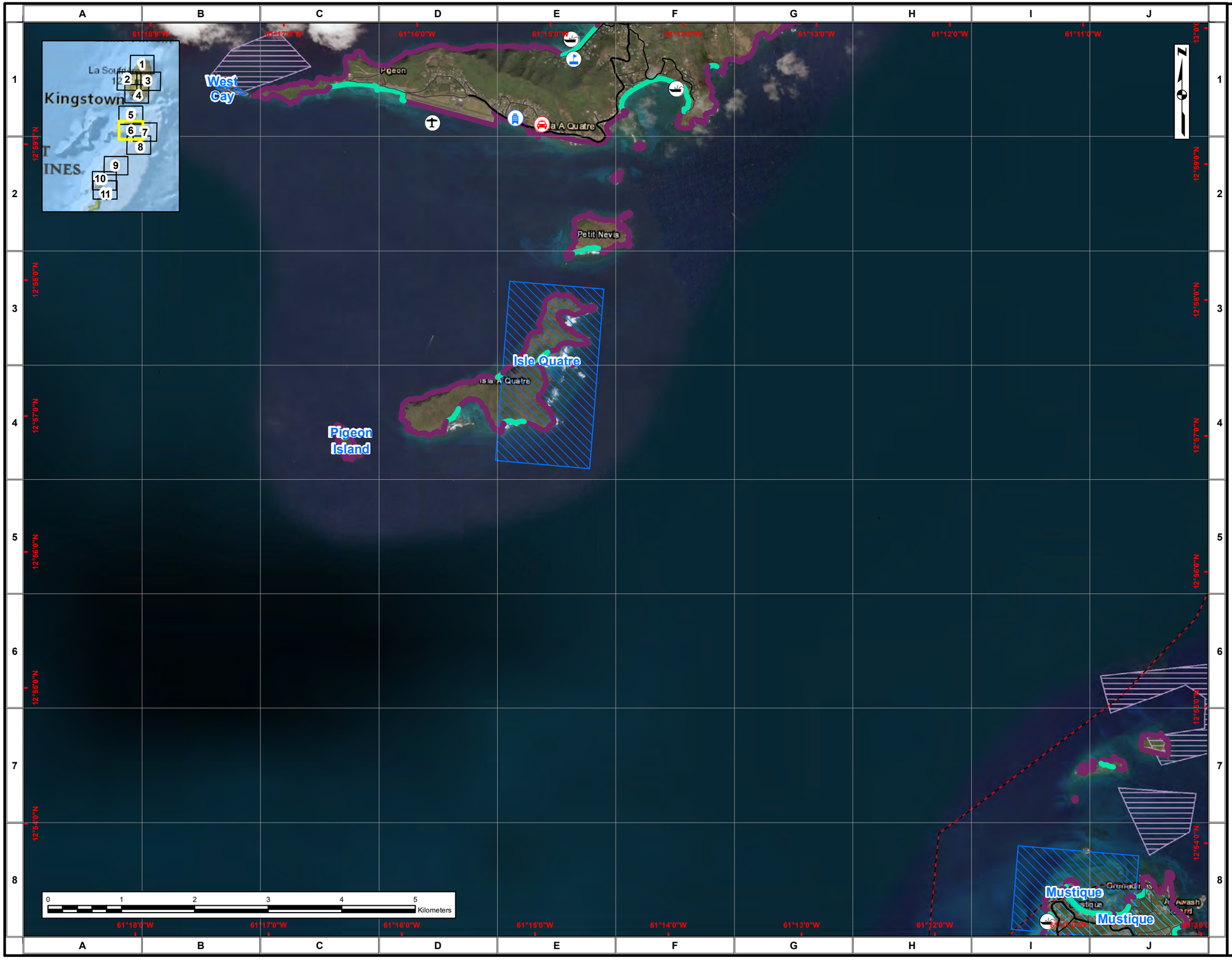

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- Police Stations
- School
- Fishing Dock or Landing
- Government Facilities
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- School
- Fishing Dock or Landing
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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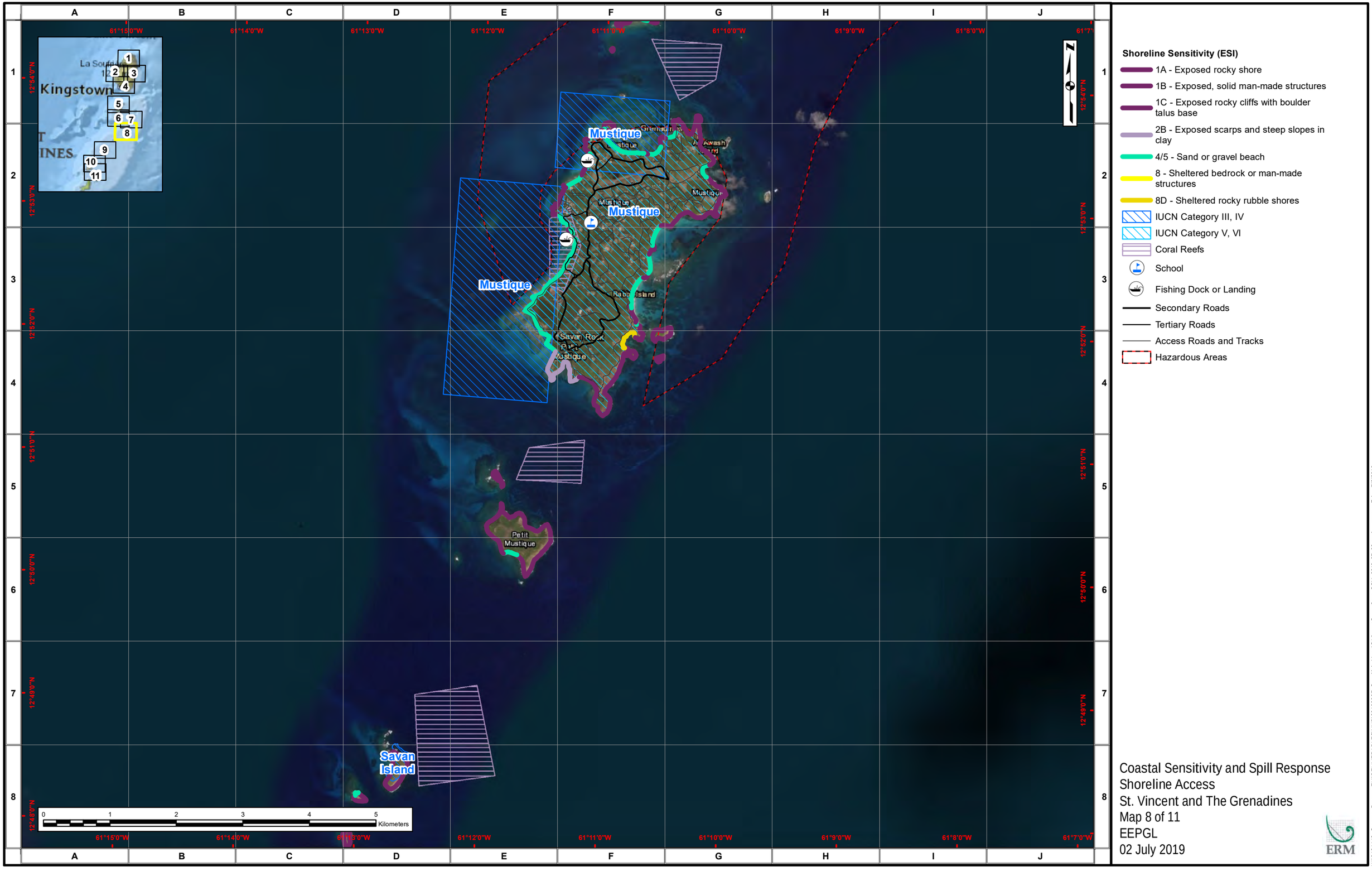

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 8 of 11
EEPGL
02 July 2019

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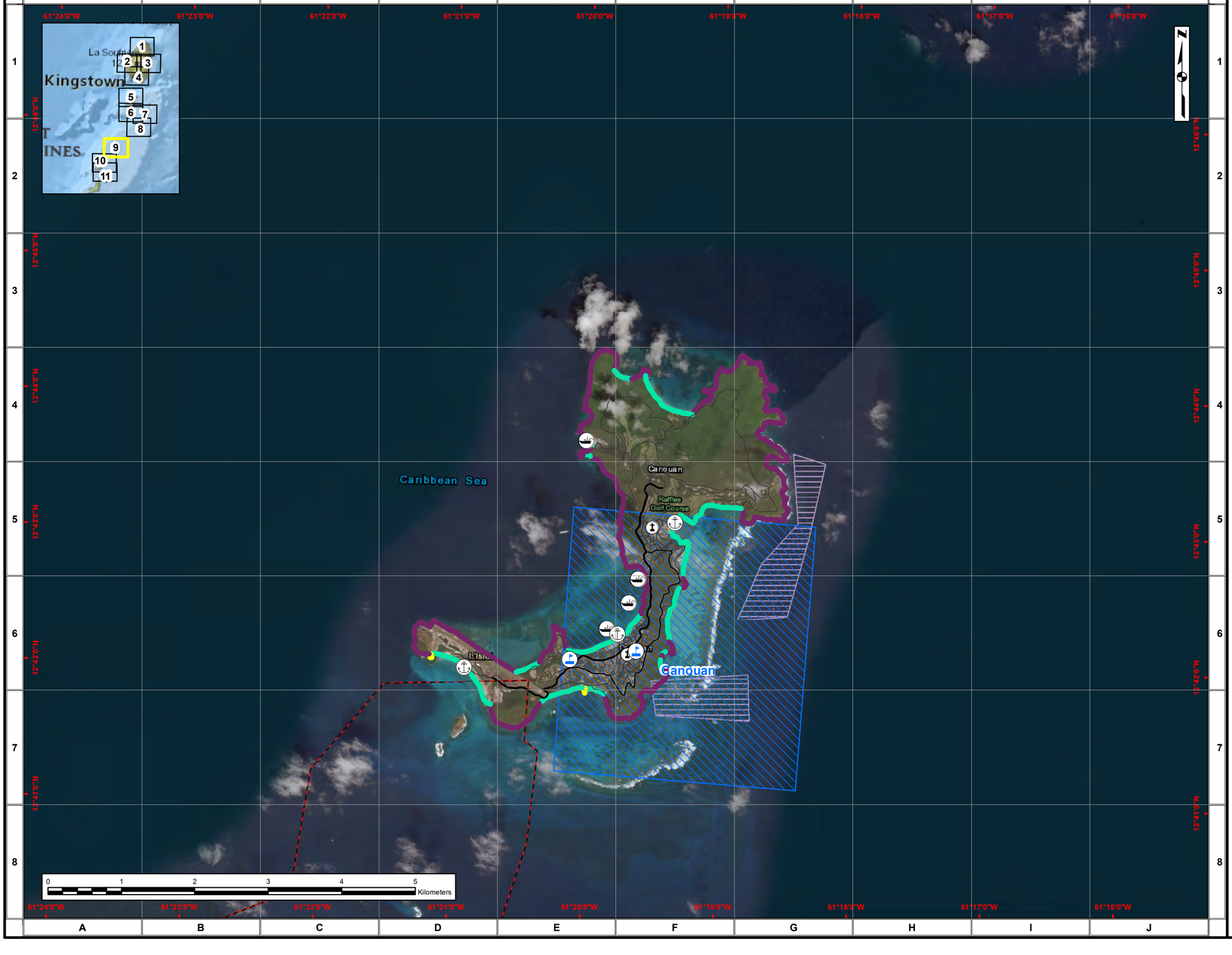

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- Coral Reefs
- School
- Port or Marina
- Fishing Dock or Landing
- Places of Worship
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 9 of 11
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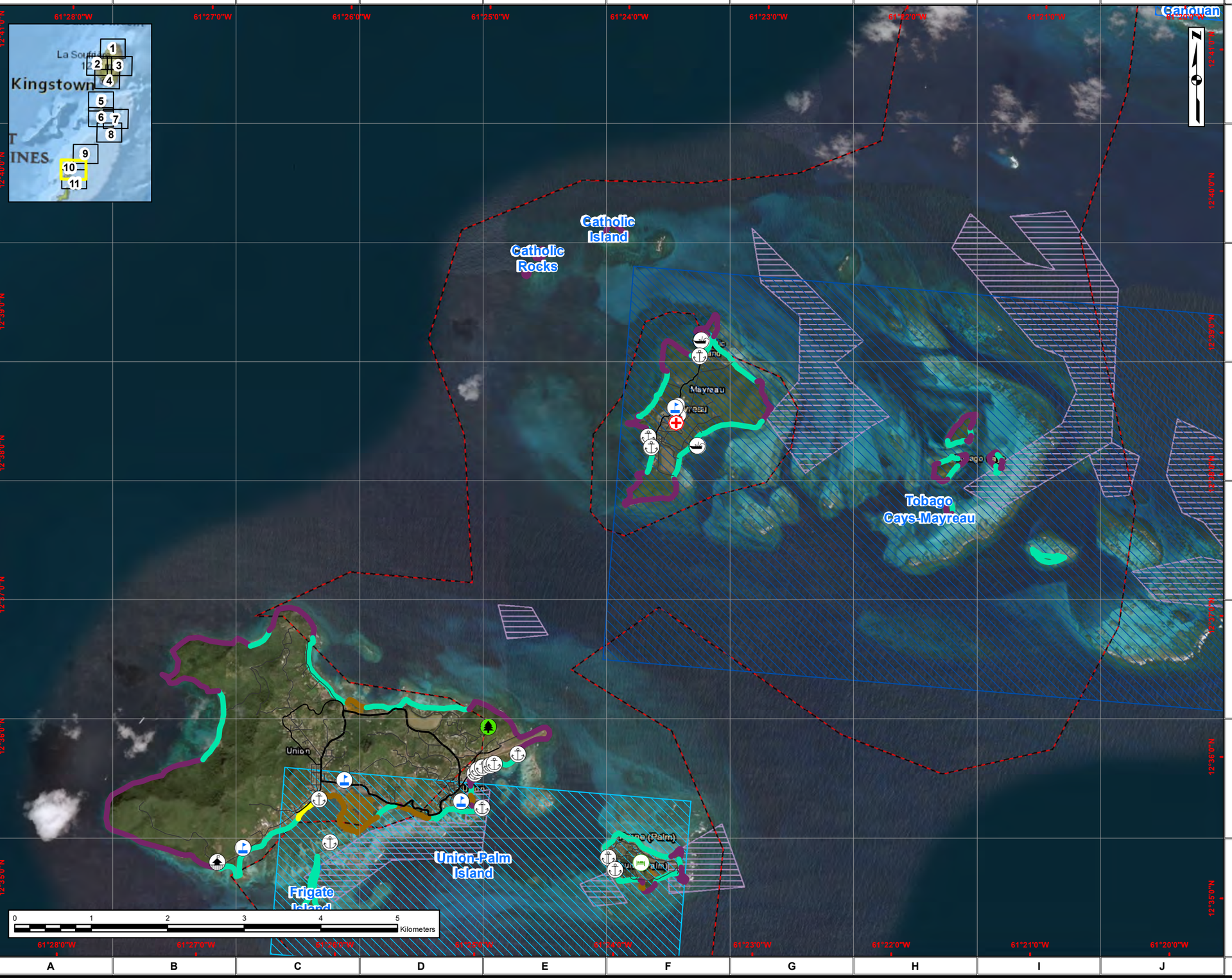

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI

Onshore National Protected

- IUCN Category III & IV
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Hospitals
- School
- Port or Marina
- Fishing Dock or Landing
- Historic Site
- Burial Grounds
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 10 of 11
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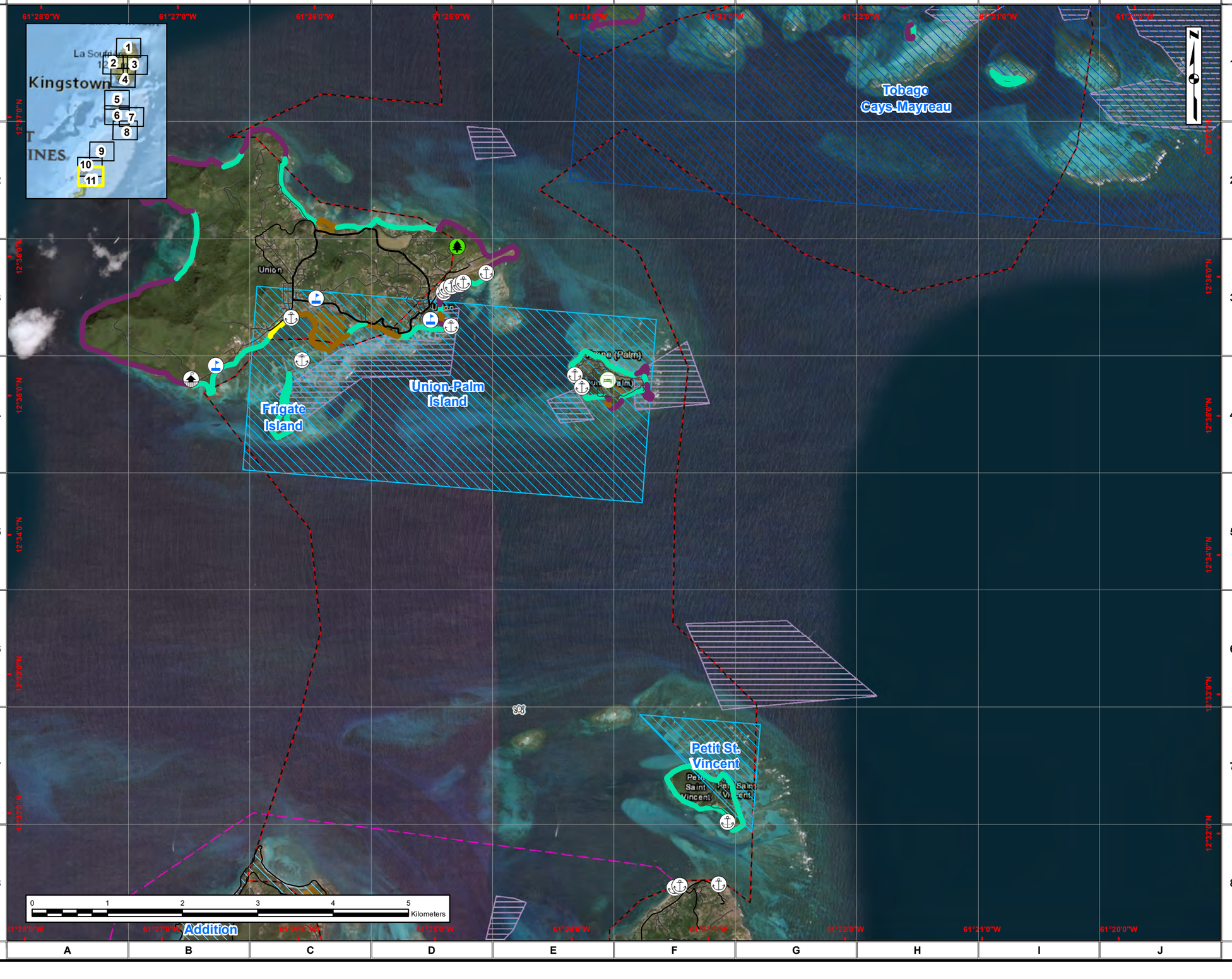

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI
- IUCN Category Not Reported

Onshore National Protected

- IUCN Category III & IV
- Mangrove Areas (ESI 10D)
- Coral Reefs
- School
- Port or Marina
- Historic Site
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 11 of 11
EEPGL
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Bonaire

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Bonaire

Klein Bonaire Island & adjacent sea

Bonaire

Het Lac

Het Pekelmeer

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area

Marine National Protected Areas

- IUCN Category I & II
- IUCN Category I, II
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves

Coastal Sensitivity and Spill Response
Shoreline Access
Bonaire
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Washington-Slagbaai (Bonaire)

De Slagbaai

Het Gotomeer

Bonaire

Bonaire

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category I, II
- International Onshore Protected Area
- IUCN Category I, II
- Hospitals
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks

Coastal Sensitivity and Spill Response
Shoreline Access
Bonaire
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Curaçao

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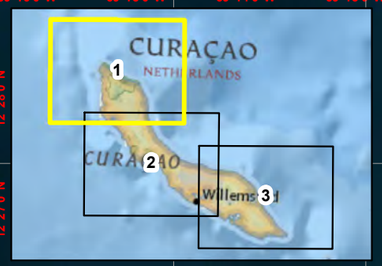

Shete Boka Park

Curacao

Northwest Curaçao

Northwest Curaçao

Hoffi Pastoor

0 1 2 3 4 5 Kilometers

Legend

- International Onshore Protected Area
- IUCN Category I, II
- IUCN Category Not Reported
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches

Coastal Sensitivity and Spill Response
Shoreline Access
Curaçao
Map 1 of 3
EEPGL
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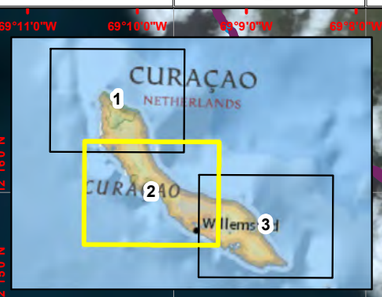

Hoffi Pastoor
Northwest Curaçao
Daaibooi
Hermanus
Rif Sint Marie
Malpais/Sint Michiel
Muizenberg
Kabouterbos
Oostpunt

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category Not Reported
- International Onshore Protected Area
- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Curaçao
Map 2 of 3
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Legend

- IUCN Category Not Reported
- International Onshore Protected Area
- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Curaçao
Map 3 of 3
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Aruba

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Legend

- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Aruba
Map 1 of 2
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Bubali Pond Bird Sanctuary

Arikok National Park

Arikok National Park

Het Spaans Lagoen

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Wreck
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Aruba
Map 2 of 2
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Dominican Republic

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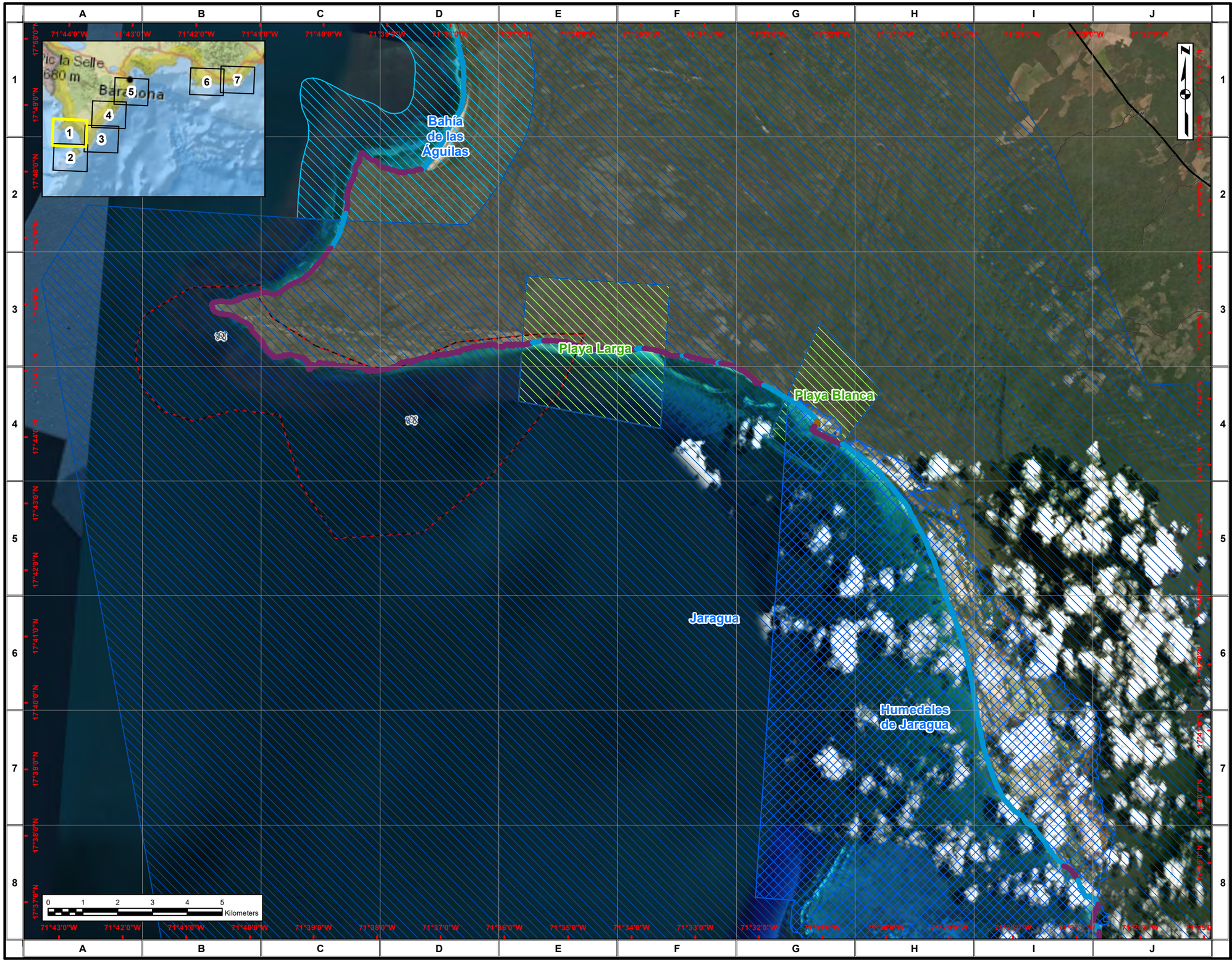

Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category V, VI
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Secondary Roads
- Access Roads and Tracks
- Rock
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 1 of 7
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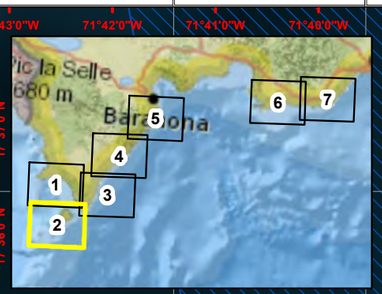

Humedales de Jaragua

Jaragua

Arrecifes del Suroeste

N

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 2 of 7
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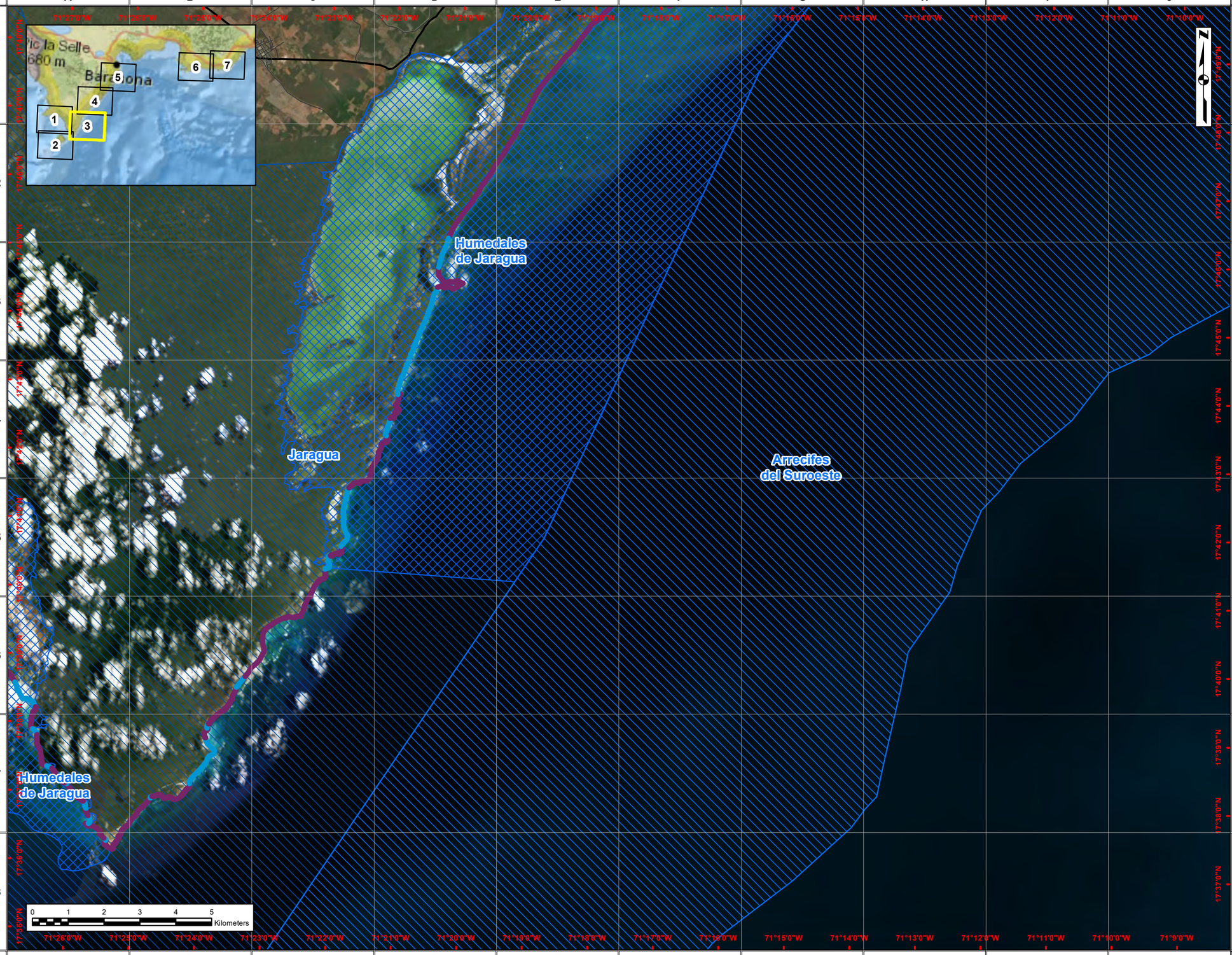

Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Secondary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 3 of 7
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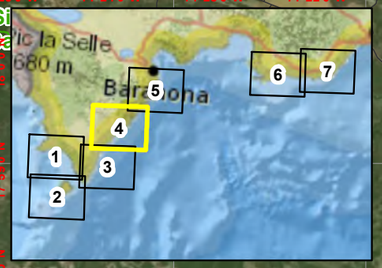

Mirador del Paraíso

Arrecifes del Suroeste

Humedales de Jaragua

Jaragua

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 4 of 7
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Monumento Natural Miguel Domingo Fuerte

Mirador del Paraíso

Arrecifes del Suroeste

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category III, IV
- IUCN Category III, IV
- IUCN Category V, VI
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
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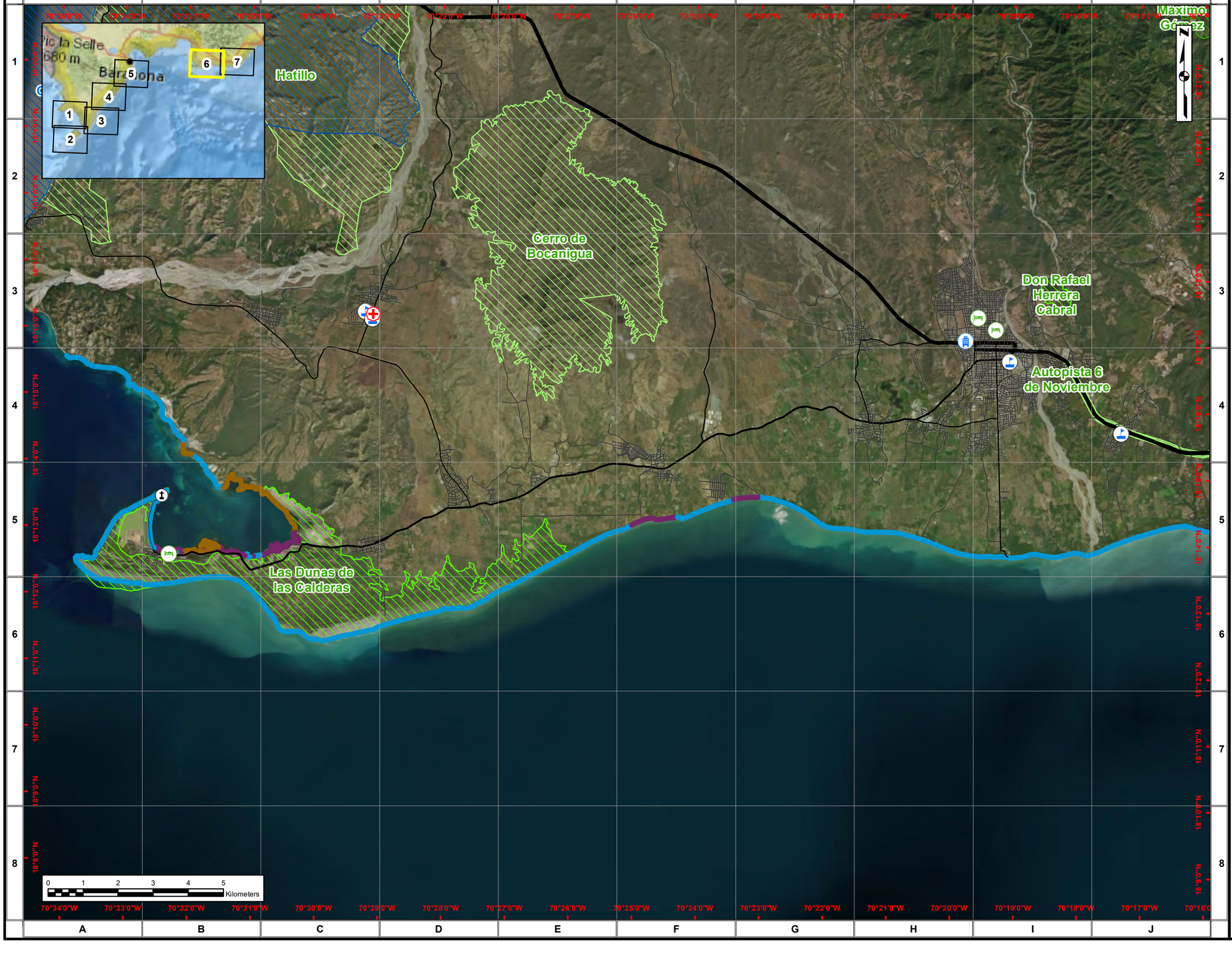

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 6 of 7
EEPGL
27 June 2019

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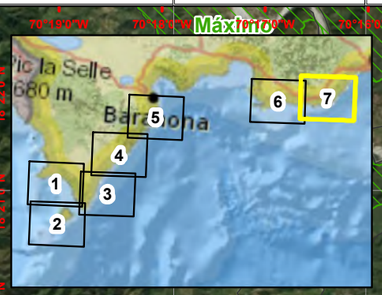

Boca de Nigua

Don Rafael Herrera Cabral

Autopista 6 de Noviembre

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category V, VI
- IUCN Category I, II
- IUCN Category V, VI
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 7 of 7
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Haiti

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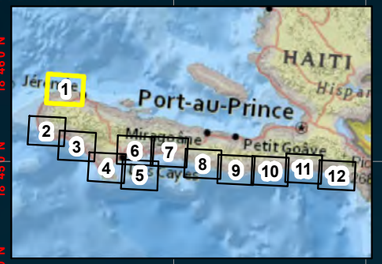

Legend

- Hospitals
- Police Stations
- School
- College
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 1 of 12
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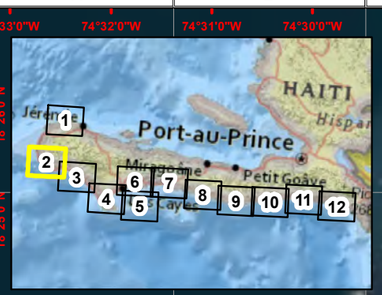

Legend

- Hospitals
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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Legend

- IUCN Category I, II
- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9A - Sheltered tidal flats
- 10D - Mangroves
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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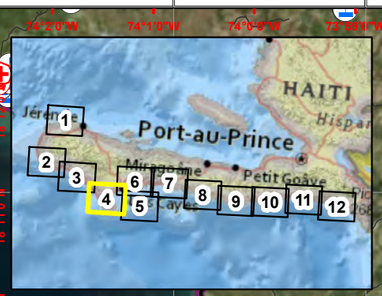

Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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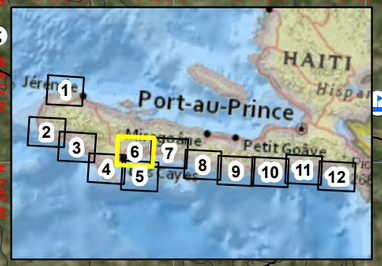

Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 6 of 12
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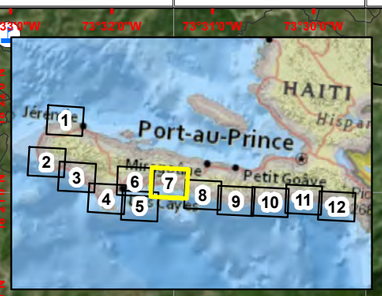

Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 7 of 12
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27 June 2019

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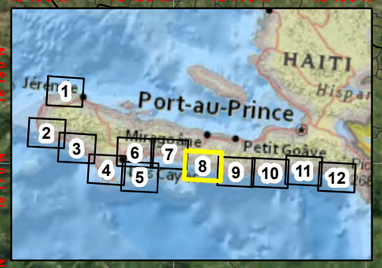

Legend

- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Places of Worship
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

N

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 8 of 12
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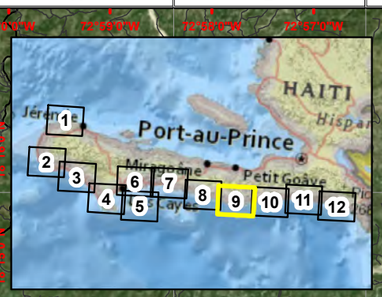

Legend

- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 9 of 12
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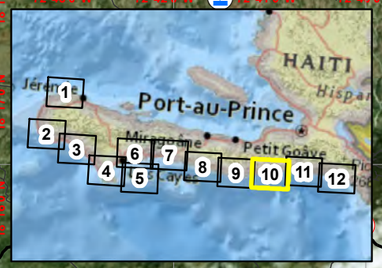

Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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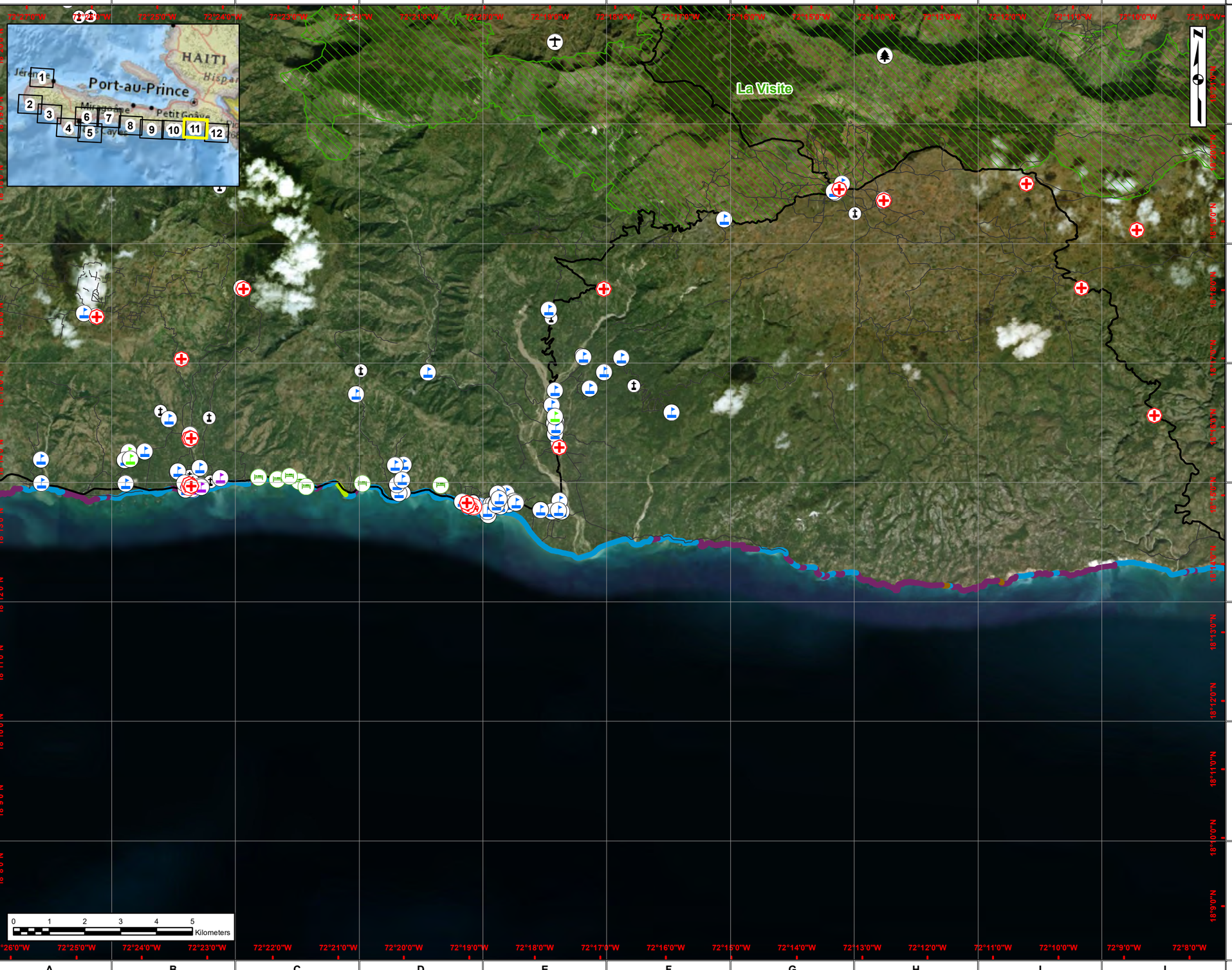

Legend

Onshore National Protected Areas

- IUCN Category Not Reported
- IUCN Category I, II
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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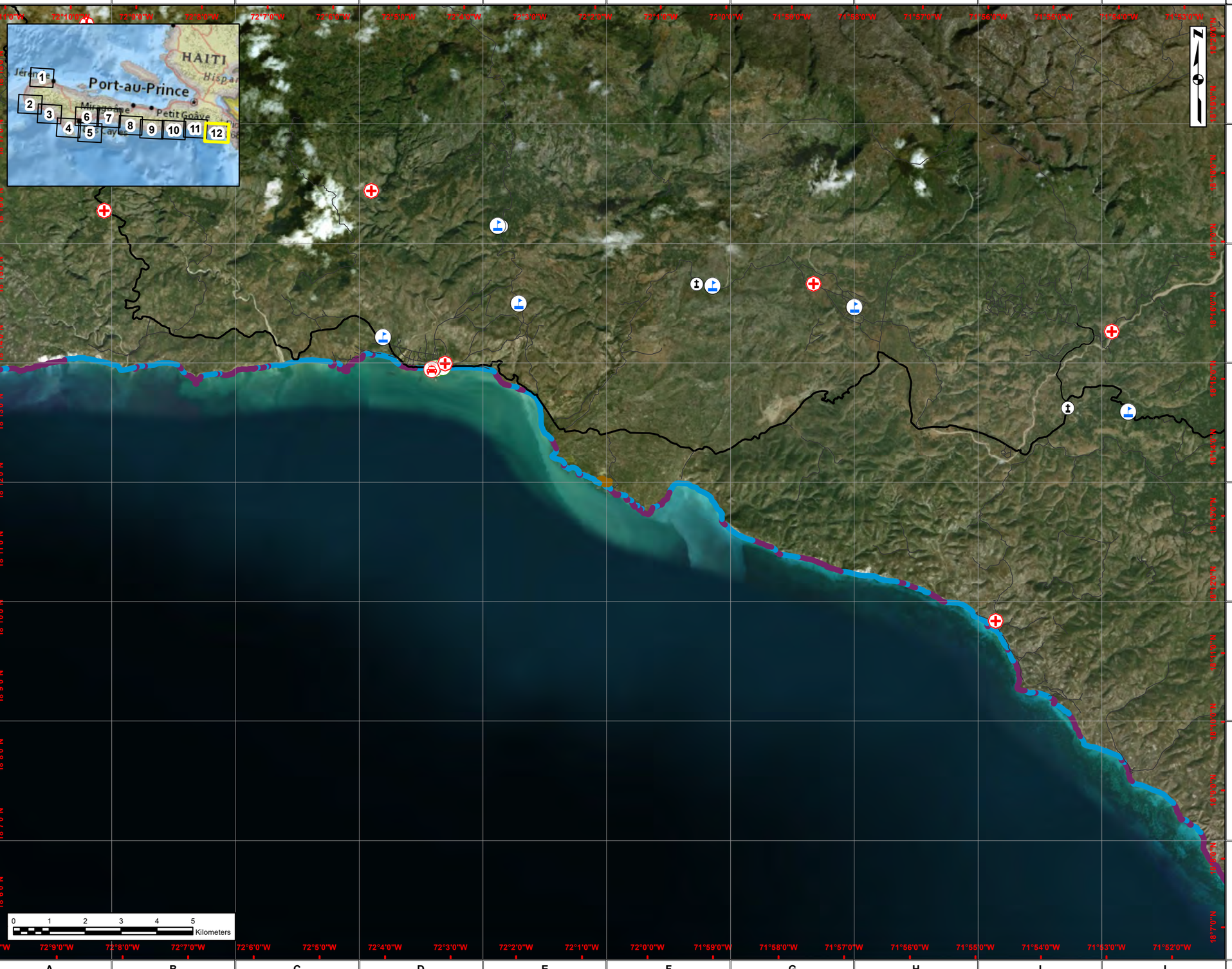

Legend

- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 12 of 12
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Jamaica

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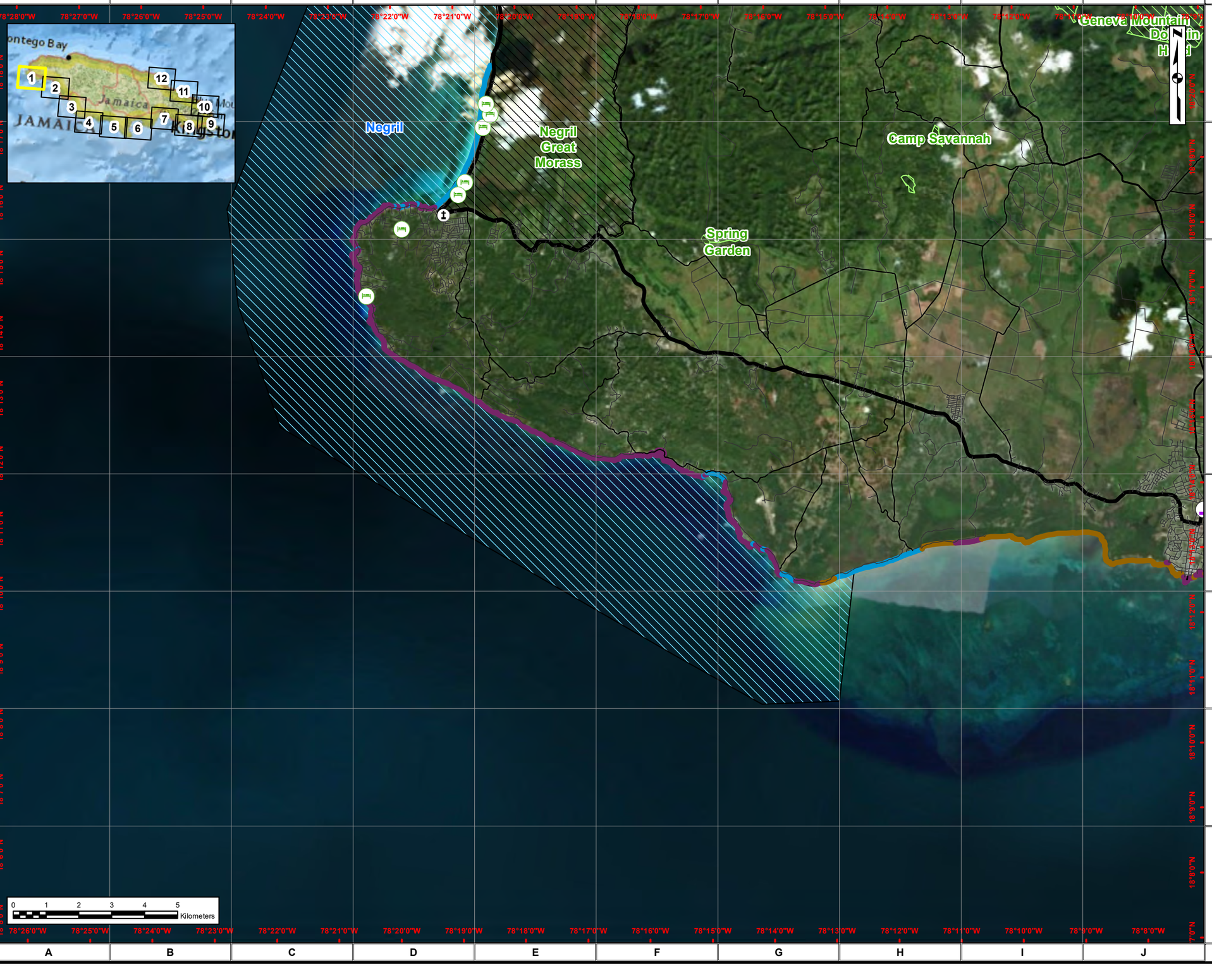

Legend

- IUCN Category Not Reported
- IUCN Category V, VI
- IUCN Category Not Reported
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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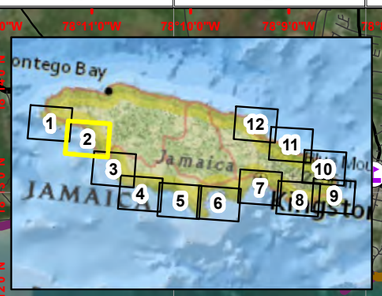

Deans Valley

Bluefields Bay

Bog

Petersville

Croydon

Black River Lower Morass

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category III, IV
- IUCN Category V, VI
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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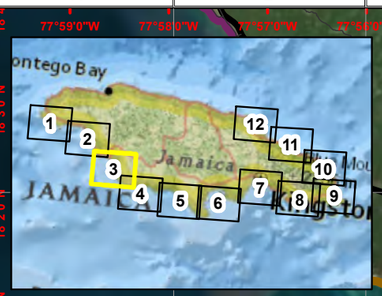

Galleon - Black River

Black River Lower Morass

Legend

- IUCN Category III, IV
- International Onshore Protected Area
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Reefs

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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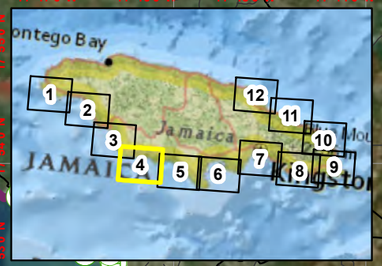

Lovers Leap

New Forest

Alligator Pond/Gut River/Canoe Valley

Legend

- IUCN Category Not Reported
- IUCN Category V, VI
- Hospitals
- Police Stations
- Kindergarten
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- Places of Worship
- Hotels
- Tertiary Roads
- Access Roads and Tracks
- Reefs

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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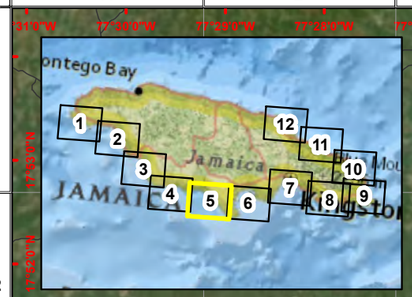

Alligator Pond/Gut River/Canoe Valley

Portland Bight Wetlands and Cays

Portland Bight

Peak Bay

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category V, VI
- IUCN Category Not Reported
- International Onshore Protected Area
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
Map 5 of 12
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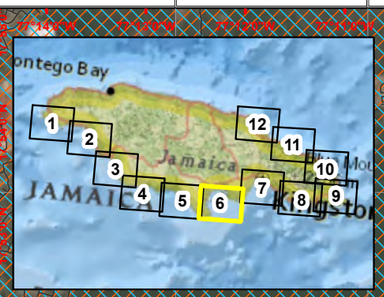

Galleon Harbour

Portland Bight Wetlands and Cays

Salt Harbour (revised)

Salt Harbour (revised)

Peak Bay

Peak Bay

Peak Bay

Portland Bight

Healthshire

Three Bay Area

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category III, IV
- IUCN Category V, VI
- International Onshore Protected Area
- IUCN Category V, VI
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Wreck
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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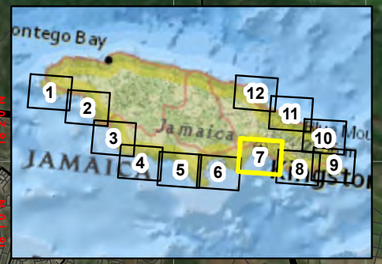

Hermitage
Blue Mountain Forest Reserve
Hope River Stream
Newton
Blue and John Crow Mountains
Petersfield
Trumpet Tree
Chesterfield
Flamstead
Orchard
Elleston Run (Dallas Mountain)
Good Hope
Rockfort
Palisadoes
Palisadoes - Port Royal
Portland Bight Wetlands and Cays
Healthshire
Portland Bight

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Flamstead
Orchard
Blue and John Crow Mountains
Blue and John Crow Mountains
Blue Mountain Forest Reserve
Spring Estate
Spring Pen
Norris
Lloyds
Citron Valley
Jamaica
JAMAICA
Montego Bay
1
2
3
4
5
6
7
8
9
10
11
12
N
0 1 2 3 4 5 Kilometers

Legend

- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- Police Stations
- Kindergarten
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Blue Mountain (Ecclesdown Addition)

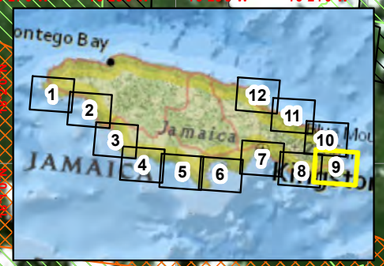
Ecclesdown

Blue and John Crow Mountains

Blue Mountain Forest Reserve

Grange Hill

Citron Valley



Legend

- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Reefs

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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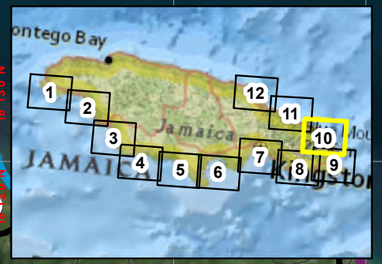

Fellowship

Cambridge Back Lands

Windsor and Seaman's Valley

Blue and John Crow Mountains

Blue Mountain Forest Reserve

Blue and John Crow Mountains

Blue Mountain (Ecclesdown Addition)

Ecclesdown

0 1 2 3 4 5 Kilometers

Legend

- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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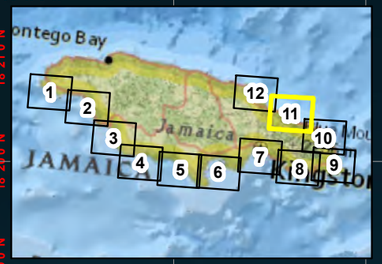

Legend

- IUCN Category V, VI
- IUCN Category Not Reported
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Hotels
- Primary Roads
- Secondary Roads
- Access Roads and Tracks

Dover
Fort George
Haycock Hill
Fort Stewart
Kildare
Caenwood
Chepstowe
Blue Mountain Forest Reserve
Airy
Blue and John Crow Mountains

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
Map 11 of 12
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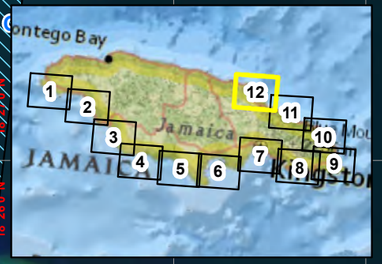

Oracabessa
Fish

Nutfield

Tremolesworth

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category III, IV
- IUCN Category V, VI
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Colombia

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Legend

- School
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Access Roads and Tracks
- Wreck
- Rock
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 1 of 4
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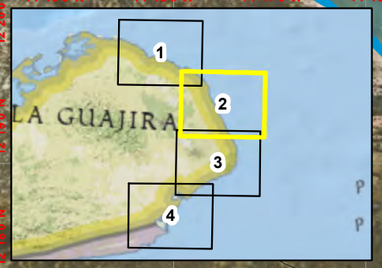

Macuira

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category I, II
- Hospitals
- College
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Hotels
- Access Roads and Tracks
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 2 of 4
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27 June 2019

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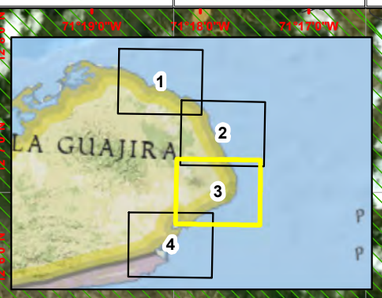

Macuira

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category I, II
- School
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 3 of 4
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27 June 2019

ERM

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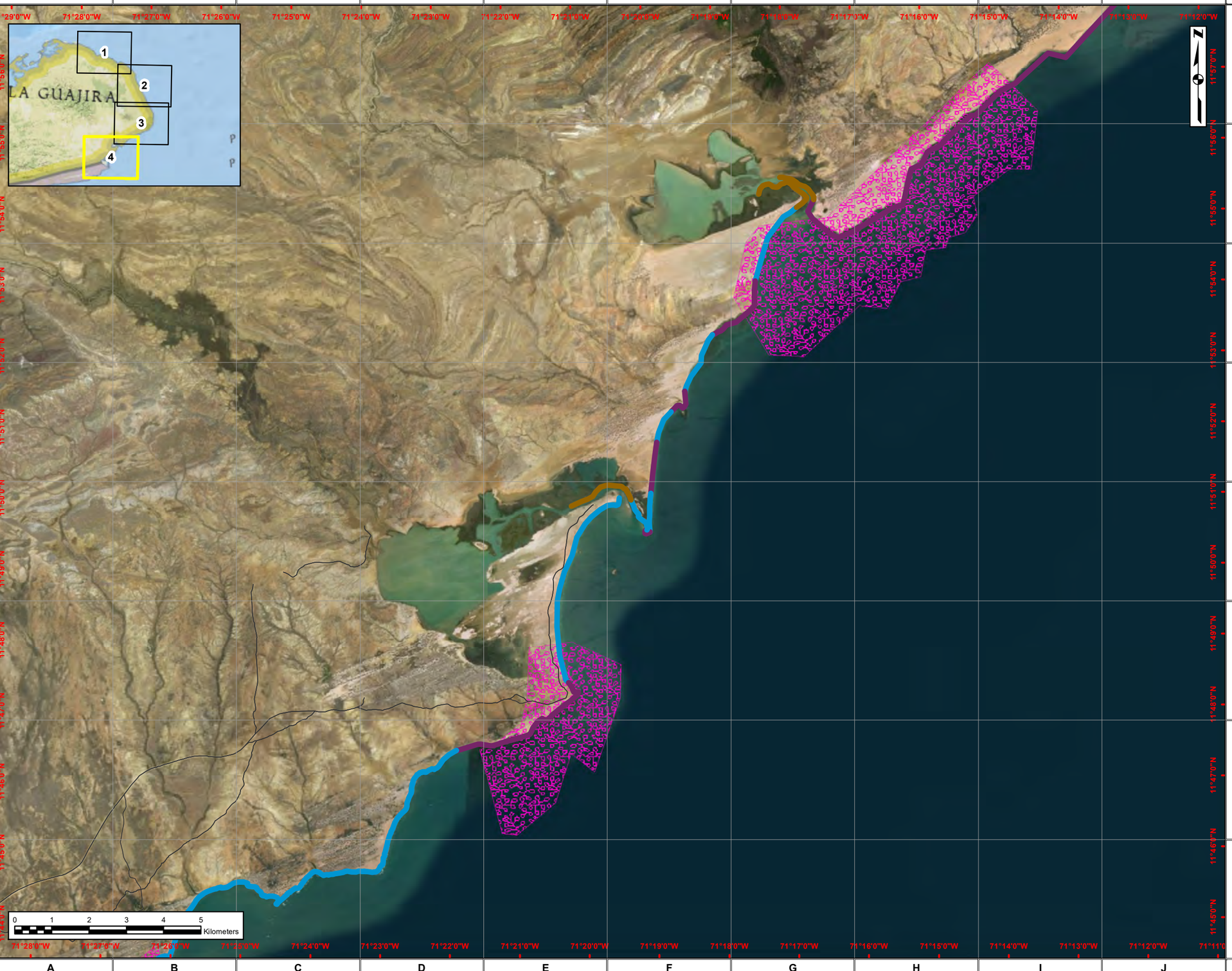

Legend

- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 4 of 4
EEPGL
27 June 2019

ERM

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APPENDIX P

Flora and Fauna of Shell Beach

Resubmitted without changes

March 2022

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BIODIVERSITY

Source: Guyana Marine Turtle Conservation Society (GMTCS). 2011. Shell Beach Protected Area Process. Report on the Proposed Shell Beach Protected Area Delineation Process (SBPA). Final Report. Appendix IV: Biodiversity[1]

LIST OF BIODIVERSITY FOUND WITHIN THE SHELL BEACH AREA

AVIFAUNA OF SHELL BEACH

Source: Mendonca, Sean, Michelle Kalamandeen, and Robin S. McCall. 2006. A Bird's Eye View: Coastal Birds of Shell Beach. Proceedings of International Conference on the Status of Biological Sciences in Caribbean and Latin American Societies.

Scientific Name	Common Name
Actitis macularia	Spotted Sandpiper
Agelaius icterocephalus	Yellow-hooded Blackbird
Amazilia chionopectus	White-Chested Emerald
Amazilia fimbriata	Glittering-throat Emerald
Amazilia spp.	Amazilia Hummingbird
Amazona amazonica	Orange-winged Parrot
Amazona ochrocephala	Yellow-crowned Parrot
Anhinga anhinga	Anhinga
Ara ararauna	Blue & Gold Macaw
Ara chloropterus	Red & Green Macaw
Ara manilata	Red-bellied Macaw
Ara nobilis	Red-shouldered Macaw
Aramides cajanea	Gray-necked Woodrail
Ardea alba	Great Egret
Ardea cocoi	Cocoi Heron
Ardei cocoi	White-necked Heron
Arenaria interpres	Ruddy Turnstone
Arundinicola leucocephala	White-headed Marsh Tyrant
Asturina nitida	Gray Hawk
Attila spadiceus	Bright-rumped Attila
Bubo virginianus	Great Horned Owl
Bubulcus ibis	Cattle Egret
Busarellus nigricollis	Black-collared Hawk
Buteo magnirostris	Roadside Hawk
Buteogallus aequinoctialis	Rufous Crab-hawk

[1] In instances where either scientific or common names were not included in the source document, they have been included where possible.

Scientific Name	Common Name
Buteogallus anthracinus	Common Black Hawk
Butorides striatus	Striated Heron
Cacicus cela	Yellow-rumped Cacique
Cacicus haemorrhous	Red-rumped Cacique
Cairina moshata	Muscovy Duck
Calidris minutilla	Least Sandpiper
Calidris pusilla	Semipalmated Sandpiper
Camptostoma obsoletum	Southern beardless Tyrannulet
Campylopterus largipennis	Gray-breasted Sabrewing
Cathartes aura	Turkey Vulture
Cathartes burrovianus	Yellow-headed Vulture
Celeus flavus	Cream-colored Woodpecker
Cercomacra spp	Slaty Antwren
Cercomacra tyrannina	Dusky Antshrike
Certhiaxis cinnamomea	Yellow-throated Spinetail
Certhiaxis cinnamomea	Yellow-chinned Spinetail
Ceryle torquata	Ringed Kingfisher
Charadrius collaris	Collared Plover
Charadrius wilsonia	Wilson's Plover
Chelidoptera tenebrosa	Swallow-wing Puffbird
Chlorestes notatus	Blue-chinned Sapphire
Chloroceryle aenea	American Pygmy Kingfisher
Chloroceryle aenea	Pygmy Kingfisher
Chloroceryle amazona	Amazon Kingfisher
Chloroceryle americana	Green Kingfisher
Chloroceryle inda	Green & Rufous Kingfisher
Chlorophanes spiza	Green Honeycreeper
Ciconia maguari	Maguari Stork
Circus buffoni	Long-winged Harrier
Cissopis leveriana	Magpie Tanager
Claravis prestiosa	Blue Ground-dove
Coccyzus melacoryphus	Dark-billed Cuckoo
Cochlearius cochlearius	Boat-billed Heron
Coereba flaveola	Bananaquit
Columba plumbea	Plumbeous Pigeon
Columba subvinacea	Ruddy Pigeon
Columbina talpacoti	Ruddy Ground-dove
Conirostrum bicolor	Bicolored Conebill
Conirostrum leucogenys	White-eared Conebill
Coragyps atratus	Black Vulture
Crotophaga ani	Smooth-billed Ani
Crotophaga major	Greater Ani

Scientific Name	Common Name
Cyanocorax cayanus	Cayenne Jay
Cymbilaimus lineatus	Fasciated Antshrike
Daptrius ater	Black Caracara
Dendrocyna autumnalis	Black-bellied Whistling-duck
Dendrocyna longicauda	Long-tailed Woodcreeper
Dendroica aestiva	Yellow Warbler
Dryocopus lineatus	Lineated Woodpecker
Egretta caerulea	Little Blue Heron
Egretta thula	Snowy Egret
Egretta tricolor	Tricolored Heron
Elaenia flavogaster	Yellow-bellied Elaenia
Elanoides forficatus	Swallow-tailed Kite
Elanus leucurus	White-tailed Hawk
Eudocimus ruber	Scarlet Ibis
Euphonia violacea	Violaceous Euphonia
Eurypga helias	Sunbittern
Falco peregrinus	Peregrine Falcon
Falco rufigularis	Bat Falcon
Falco sparverius	American Kestrel
Fluvicola pica	Pied Water-tyrant
Formicarius analis	Black-faced Ant-thrush
Frederickena viridis	Black-throated Antshrike
Fregata magnificens	Magnificent Frigatebird
Galbula albirostris	Yellow-billed Jacamar
Geranospiza caerulescens	Crane Hawk
Glaucis hirsuta	Rufous-breasted Hermit
Glyphorynchus spirurus	Wedge-billed wood creeper
Harpia harpyja	Harpy Eagle
Heliornis fulica	Sun Grebe
Herpetotheres cachinnans	Laughing Falcon
Hirundo rustica	Barn Swallow
Hoploxypterus cayanus	Pied Plover
Ibycter americanus	Red-throated Caracara
Icterus chrysocephalus	Moriche Oriole
Icterus nigrogularis	Yellow Oriole
Jacana jacana	Wattled Jacana
Larus atricilla	Laughing Gull
Leptotila rufaxilla	Gray-fronted Dove
Leptotila verreauxi	White-tipped Dove
Lipaugus vociferans	Screaming Piha
Lophotriccus galeatus	Helmeted Pygmy-tyrant
Manacus manacus	White-bearded Manakin

Scientific Name	Common Name
Megarynchus pitangua	Boat-billed Flycatcher
Melanerpes cruentatus	Yellow-tufted Woodpecker
Mesembrinibis cayennensis	Green Ibis
Micrastur ruficollis	Barred Forest-falcon
Milvago chimachima	Yellow-headed Caracara
Momotus momota	Blue-crowned Motmot
Morphnus guianensis	Crested Eagle
Myiarchus ferox	Short-crested Flycatcher
Myiarchus swainsoni	Swainson's Flycatcher
Myiodynastes maculatus	Streaked Flycatcher
Myiopagis gaimardi	Forest Elaenia
Myiozetetes cayanensis	Rusty-margined Flycatcher
Myrmceciza atrothorax	Black-throated Antbird
Myrmornis torquata	Wing-banded Antbird
Myrmotherula brachyura	Pygmy Antwren
Numenius phaeopus	Whimbrel
Nyctanassa violacea	Yellow-crowned Night-heron
Nyctibius grandis	Great Pootoo
Nycticorax nycticorax	Black-crowned Night-heron
Nyctidromus albicollis	Common Paraque
Odontophorus gujanensis	Marbled Woodquail
Ortalis motmot	Little Chacalaca
Oryzoborus angolensis	Chestnut-bellied Seedeater
Otus choliba	Tropical Screech-owl
Pandion haliaetus	Osprey
Pelecanus occidentalis	Brown Pelican
Penelope jacquacu	Spix's Guan
Phaeothlypis flaveola	River Warbler
Phaethornis superciliosus	Longtailed Hermit
Phaetusa simplex	Large-billed Tern
Phalacrocorax brasilianus	Neotropical Cormorant
Philohydor lictor	Lesser Kiskadee
Phoenicopterus ruber	American Flamingo
Piaya cayana	Squirrel Cuckoo
Piaya melanogaster	Black-bellied Cuckoo
Piaya minuta	Little Cuckoo
Picumus spp	Piculet
Pionus menstruus	Blue-headed Parrot
Pipile pipile	Common Piping-guan
Pipra aureola	Crimson-hooded Manakin
Pitangus sulphuratus	Greater Kiskadee
Pitylus spp	Grosbeak

Scientific Name	Common Name
Porzana carolina	Sora Crake
Progne chalybea	Gray-breasted Martin
Psarocolius decumanus	Crested Oropendula
Psarocolius viridis	Green Oropendula
Pteroglossus aracari	Black-necked Aracari
Pulsatrix perspicillata	Spectacled Owl
Querula purpurata	Purple-throated Fruitcrow
Quiscalus lugubris	Carib Grackle
Ramphastos tucanus	Red-billed Toucan
Ramphastos vitellinus	Channel-billed Toucan
Ramphocelus carbo	Silver-beaked Tanager
Rostrhamus sociabilis	Snail Kite
Rynchops niger	Black Skimmer
Sakesphorus canadensis	Black-crested Antshrike
Saltator coerulescens	Grayish Saltator
Sarcoramphus papa	King Vulture
Scaphidura oryzivora	Giant Cowbird
Seiurus noveboracensis	Northern Waterthrush
Sterna anaethetus	Bridled Tern
Sterna antillarum	Least Tern
Sterna maxima	Royal Tern
Sterna nilotica	Gull-billed Tern
Sterna superciliaris	Yellow-billed Tern
Sturnella militaris	Red-breasted Blackbird
Sublegatus arenarum	Northern Scrub-flycatcher
Tachornis squamata	Fork-tailed Palm-swift
Tachycineta albiventer	White-winged Swallow
Tachyphonus rufus	White-lined Tanager
Tangara mexicana	Turquoise Tanager
Tapera naevia	Striped Cuckoo
Thamnophilus doliatus	Barred Antshrike
Thamnophilus murinus	Mouse-coloured Antshrike
Thraupis episcopus	Blue-gray Tanager
Thraupis palmarum	Palm Tanager
Thryothorus coraya	Coraya Wren
Thryothorus leucotis	Buff-breasted Wren
Tiaris obscura	Dull-colored Grassquit
Tigrisoma lineatum	Rufescent Tiger Heron
Tinamus major	Great Tinamou
Todirostrum cinereum	Common Tody Flycatcher
Todirostrum maculatum	Spotted Tody Flycatcher
Tringa flavipes	Lesser Yellowlegs

Scientific Name	Common Name
Tringa melanoleuca	Greater Yellowlegs
Tringa solitaria	Solitary Sandpiper
Troglodytes aedon	Southern House Wren
Trogon viridis	White-tailed Trogon
Turdus leucomelas	Pale-breasted Thrush
Tyrannus dominicensis	Gray Kingbird
Tyrannus melancholicus	Tropical Kingbird
Tyrannus savana	Fork-tailed Flycatcher
Vanellus chilensis	Southern Lapwing
Vireo olivaceus	Red-eyed Vireo
Volatinia jacarina	Blue-black Grassquit
Xiphorhynchus guttatus	Buff-throated Woodcreeper

HERPETOFAUNA OF SHELL BEACH

Sources: (1) Kalamandeen, Michelle and Phillip DaSilva. 2005. A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.

(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques. 2004. Shell Beach Biodiversity Assessment: a Summary Report.

Reptiles

Scientific Name	Common Name
Ameiva ameiva	Ameiva Lizard
Anolis sp.	Anolis Lizard
Bothrops atrox	Labaria
Caiman crocodilus	Spectacled Caiman
Chelonia mydas	Green Turtle
Cnemidophorus gramivagus	Whiptail Lizard
Cnemidorphous lemniscatus	Rainbow Whiptail Lizard
Constrictor constrictor	Boa Constrictor
Corallus hortulanus	Cook's Tree-boa
Dermochelys coriacea	Leatherback Turtle
Drymarchon corais	Tiger Snake
Eretmochelys imbricata	Hawksbill Turtle
Eunectus marinus	Anaconda
Gonatodes humeralis	Trinidad Gecko
Gonatodes sp.	Gecko
Helicops angulatus	Water Labaria
Hydropis sp.	Sea Snake
Iguana iguana	Green Iguana
Kentropyx calcarata	Striped Forest Whiptail
Kinosternon scropiodes	Mud Turtle
Leptotyphlops sp.	Blind Snake
Liophis cobella	Water Snake
Mabuya mabuya	Mabuya
Plica plica	Tree Lizard
Rhinoclemmys punctularia	Labaria Turtle
Thecadactylus rapicauda	Turnip-tailed Gecko
Tupinambis negropunctatus	Tegu

Amphibians

Scientific Name	Common Name
Dendrosophus marmorata	Marbled Treefrog
Dendrosophus minuta	Lesser Treefrog
Hyla crepitans	Emerald-eyed Treefrog
Hyla spp1	Treefrog sp.
Hyla spp2	Treefrog sp.
Hyla spp3	Treefrog sp.
Hyla spp4	Treefrog sp.
Leptodactylus mystaceus	Basin White-lipped Frog
Leptodactylus sp.	White-lipped Frog sp.
Pipa pipa	Suriname Toad
Psuedes paradox	Paradox Frog
Rhinella marina	Cane Toad
Scinax ruber	Red-snouted Treefrog

MAMMALS OF SHELL BEACH

Sources: (1) Kalamandeen, Michelle and Phillip DaSilva. 2005. A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.

(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques. 2004. Shell Beach Biodiversity Assessment: a Summary Report

Scientific Name	Common Name
Alouatta macconnelli	Red Howler Monkey
Artibeus obscurus	Dark Fruit-eating Bat
Artibeus sp.	Neotropical Fruit Bat sp.
Artibeus spp 2	Neotropical Fruit Bat sp.
Ateles paniscus	Spider Monkey
Bradypus tridactylus	Three-toed Sloth
Cebus olivaceus	Wedge-capped capuchin
Cebus paella	Brown Capuchin
Dasyprocta leporina	Agouti
Eira Barbara	Tayra
Glossophaga soricina	Common long-tongued Bat
Inia geoffrensis	Porpoise
Lontra longicaudis	Southern River Otter
Nasua nasua	Coati
Noctilio leporinus	Bulldog Bat
Panthera onca	Jaguar
Pithecia pithecia	White-face Saki
Procyon cancrivorus	Raccoon
Pteronura brasiliensis	Giant River Otter
Saccopteryx bilineata	Two-lined Riverside Bat
Saimiri sciureus	Squirrel Monkey
Tamandua tetradactyla	Southern Tamandua
Trichechus manatus	Manatee
Unidentified genera	Deer
Unidentified genera	Long-nosed Bat
Unidentified genera	Rat
Uroderma bilobatum	Common Tent-making Bat

FISHES OF SHELL BEACH

Sources: (1) Kalamandeen, Michelle and Phillip DaSilva. 2005. A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.

(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques. 2004. Shell Beach Biodiversity Assessment: a Summary Report

Scientific Name	Common Name
Anableps anableps	Foureye
Anableps sp[2]	Blinker
Bagre marinus	Catfish
Batrachoides surinamensis	Pacu
Bothus ocellatus	Flounder
Boulengerella cuvieri	Swordfish
Brycon falcatus	Curimai
Caranx hippos	Couvalli
Cathorops spixii	Spring Courass
Centropomus undecimalis	Snook
Chaetodipterus sp.	Spadefish
Cichla ocellaris	Lukanani
Cichlasoma sp.	Patwa
Crenicichla sp.	Sunfish
Cynoscion ocoupa	Grey Snapper
Cynoscion virescens	Trout
Rhinoptera bonasus	Cownose Stingray
Dasyatis sp.	Stingray
Diapterus rhombeus	Sea Patwa
Epinephelus itajara	Jewfish
Genyatremus luteus	Annafoke
Heptranchias perlo	Sharpnose Sevengill Shark
Sciades parkeri	Gillbacker
Hexanematichthys proops	Kokwari
Hoplerythrinus unitaeniatus	Yarrow
Hoplias malabaricus	Houri
Hoplosternum sp.	Hassa
Hypophthalmus edentatus	Highwater
Hypostomus sp	Seahassa
Lobotes surinamensis	Paggie
Lutjanus campechanus	Red Snapper
Lutjanus griseus	Gray Snapper

[2] Presumed to be of the Anableps genus

Scientific Name	Common Name
Macrodon ancylodon	Bangamary
Manta birostris	Manta Ray
Megalops atlanticus	Cuffum
Mugil cephalus	Mullet
Mugil liza	Quamina
Myleus rubripinnis	Katabac
Nebris microps[3]	Butterhead
Notarius grandicassis	Tampocker
Oncorhynchus mykiss	Rainbow Trout
Paralonchurus brasiliensis	Banded Croaker
Parauchenipterus galeatus	Imeri
Pimelodus blochii	Cassi
Plagioscion sp	Basha
Plagioscion squamosissimus	Crocrer Basha
Poecilia reticulata	Guppy
Pomacanthus arcuatus	Grey Anglefish
Pseudodoras (Oxydoras) niger	Yadaro
Sciades parkeri	Gillbacker
Sciades passany	Cuma Cuma/Black Cuirass[4]
Sciades proops	Hardhead Cuirass
Scomberomorus brasiliensis	Mackerel
Serrasalmus rhombeus	Black Pirai
Stellifer rastrifer	Rockhead
Unidentified genera	Cock-a-net
Unidentified genera	Wabaru

[3] Presumed to be butterfish
[4] Presumed to possibly be Mud Cuirass

PLANTS OF SHELL BEACH

Sources: (1) Kalamandeen, Michelle and Phillip DaSilva. 2005. A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.

(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques. 2004. Shell Beach Biodiversity Assessment: a Summary Report

Scientific Name	Common Name
Avicennia germinans	Black Mangrove
Canavalia rosea	Bay Bean/Horse Bean/Sea Bean
Carapa guianensis	Crab-wood
Carica papaya	Papaya
Cecropia sp.	Cecropias sp.
Ceiba pentandra	Kapok
Chrysobalanus sp.	Kaunta
Cissus verticillatus	Grapevine sp.
Cocos nucifera	Coconut
Cucurbita moschata	Squash
Cuscuta umbellata	Flatglobe Dodder
Cyperus sp.	Flatsedge/Nutsedge sp.
Eperu falcata	Soft Wallaba
Eschiwella sp.	Kakaralli
Euterpe sp.	Manicole
Goupia glabra	Kabukalli
Guilandina bonduc	Grey Nicker/Nickar Bean
Hibiscus pernambucensis	Sea Hibiscus
Ipomoea pes-caprae	Beach Morning Glory
Jatropha gossypiifolia	Bellyache-bush/Black Physicnut
Languncularia racemose	White Mangrove
Manihot esculenta	Cassava
Mauritia flexuosa	Ite Palm
Mora excelsa	Mora
Morindra citrifolia	Noni
Parahancornia sp.	Dukalli
Pterocarpus sp.	Corkwood
Rhizophora mangle	Red Mangrove
Sesuvium portulacastum	Shoreline Purslane
Terminalia catappa	Almond
Thespesia populnea	Portia Tree

MACROINVERTEBRATES OF SHELL BEACH

Source: Kalamandeen, Michelle and Phillip DaSilva. 2005. A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.

Scientific Name	Common Name
Aratus pisonii	Tree Crab
Atta sp.	Machusi Ant
Avicularia sp.	Tarantula
Cardisoma guanhumi	Bundari Crab
Danaus plexipus	Monarch Butterfly
Euedes sp.	Butterfly
Euptichia sp.	Buttefrly
Eurema sp.	Butterfly
Morpho menelaus	Blue Morpho Butterfly
Ocypode quadrata	Ghost Crab
Parides sp.	Butterfly
Thelpusa sp.	Grasshopper
Minuca rapax	Fiddler Crab
Unidentified genera	Ladybug
Unidentified genera	Millipede
Unidentified genera	Mosquito
Unidentified genera	Roach
Unidentified genera	Sand Wasp
Unidentified genera	Scorpion
Unidentified genera	Spider
Unidentified genera	Bee
Unidentified genera	Field Cricket
Unidentified genera	Fly
Unidentified genera	Centipede
Unidentified genera	Coconut Worm
Unidentified genera	Dragonfly

SUPPLEMENT 1: ADDITIONAL AVIFAUNA DOCUMENTED DURING 3–13 APRIL 2018 COASTAL BIRD SURVEY IN REGION 1 AND 24-25 JANUARY 2019 NEARSHORE BIRD SURVEY IN REGION 1

Additional bird species (other than those listed in the above table *Avifauna of Shell Beach*) were observed during an April 2018 coastal bird survey conducted in Region 1 that was conducted in coordination with coastal mapping and ecosystem services work and a January 2019 nearshore bird survey conducted within 5 kilometers of the shoreline in Region 1 up to the mouth of the Waini River. The April 2018 and January 2019 surveys did not replicate the survey that produced the observations in the table above (*Avifauna of Shell Beach*) in terms of survey area or level of effort. In addition, some of the observations reflected in the April 2018 survey were made some distance inland of Shell Beach. However, as all observations from the April 2018 and January 2019 surveys were collected within 20 kilometers from the coastline of Shell Beach, it is considered reasonably possible that these species could be present at times within the Shell Beach Protected Area.

Scientific Name	Common Name
Arremon taciturnus	Pectoral Sparrow
Atalotriccus pilaris	Pale-eyed Pygmy-tyrant
Attila cinnamomeus	Cinnamon Attila
Buteo nitidus	Grey-lined Hawk
Buteogallus urubitinga	Great Black Hawk
Caracara cheriway	Crested Caracara
Cathartes burrovianus	Lesser Yellow-headed Vulture
Cathartus melambrotus	Greater Yellow-headed Vulture
Celeus elegans	Chestnut Woodpecker
Chaetura cinereiventris	Gray-rumped Swift
Columba livia domestica	Rock Pigeon
Columbina passerina	Common Ground-Dove
Diopsittaca nobilis	Northern Red-shouldered Macaw
Euphonia finschi	Finsch's Euphonia
Eupsittula pertinax	Brown-throated Parakeet
Geothlypis aequinoctialis	Masked Yellowthroat
Glabula galbula	Green-tailed Jacamar
Hylophilus pectoralis	Ashy-headed Greenlet
Hylophilus thoracicus	Lemon-chested Greenlet
Hypocnemoides melanopogon	Black-chinned Antbird
Ictinia plumbea	Plumbeous Kite
Legatus leucophaius	Piratic Flycatcher
Leptodon cayanensis	Gray-headed Kite

Scientific Name	Common Name
Lophornis ornatus	Tufted Cocquette
Mimus gilvus	Tropical Mockingbird
Molothrus bonariensis	Shiny Cowbird
Mycteria americana	American Woodstork
Myiarchus tyrannulus	Brown-crested Flycatcher
Myiothlypis rivularis	Riverbank Warbler
Myrmotherula axillaris	White-flanked Antwren
Myrmoborus leucophrys	White-browed Antbird
Patagioenas cayennensis	Pale-vented Pigeon
Phaeomyias murina	Mouse-colored Tyrannulet
Phaethornis ruber	Reddish Hermit
Rhamphastus tucanus	White-throated Toucan
Rhytipterna simplex	Grayish Mourner
Rupornis magnirostris	Zone-tailed Hawk
Sclateria naevia	Silvered Antbird
Sporophila lineola	Lined Seedeater
Sporophila minuta	Ruddy-breasted Seedeater
Sterna sandvicensis	Sandwich Tern
Synallaxis albescens	Pale-breasted Spinetail
Tachornis squamata	Neotropical Palm-swift
Tachyphonus luctuosus	White-shouldered Tanager
Thalurania furcata	Fork-tailed Woodnymph
Tityra cayana	Black-tailed Tityra
Tyrannulus elatus	Yellow-crowned Tyrannulet
Zimmerius acer	Guianan Tyrannulet
Oceanites oceanicus	Wilson’s Storm-Petrel

SUPPLEMENT 2: ADDITIONAL FISH SPECIES DOCUMENTED DURING 24–25 JANUARY 2019 NEARSHORE FISH SURVEY OF REGION 1

Additional fish species (other than those listed in the above table *Fishes of Shell Beach*) were recorded during a nearshore fish survey conducted in the nearshore zone (within 5 kilometers of the shoreline) of Region 1 in January 2019.

Scientific Name	Common Name
Albula vulpes	Bonefish
Amphiarius rugispinis	Softhead Sea Catfish
Anchoa spinifer	Spicule Anchovy
Anchoa sp.	Unidentified Anchovy
Bagre bagre	Coco Sea Catfish
Cathorops arenatus	White Spring Cariss
Centropomus ensiferus	Swordspine Snook
Micropogonias furnieri	Bashaw
Pseudauchenipterus nodosus	Cocosoda Catfish
Sciades couma	Sciades Sea Catfish

SUPPLEMENT 3: ADDITIONAL FISH SPECIES DOCUMENTED DURING OTHER SURVEYS

Additional fish species (other than those listed in the above table *Fishes of Shell Beach*) documented during various other fish surveys conducted between 1943–2017.

Sources:

(1) Lowe-McConnell, R.H. 1962. The fishes of the British Guiana continental shelf, Atlantic coast of South America, with notes on their natural history. J. Linn. Soc. Zool. (London) 44(301):667-700.(2) MA Kolmann, AA Elbassiouny, EA Liverpool, NR Lovejoy. 2017. DNA barcoding reveals the diversity of sharks in Guyana coastal markets. Neotropical Ichthyology 15 (4). doi.org/10.1590/1982-0224-20170097

(2) Pritchard, P.C.H., 1943. Sea turtles of the Guianas. Bulletin of the Florida State Museum.

Scientific Name	Common Name
Apogon sp.	Cardinalfish
Diaphus garmani	Garman's Lanternfish
Pristis sp.	Saw Fish
Sphyrna lewini	Scalloped Hammerhead
Sphyrna mokarran	Great Hammerhead
Sphyrna tudes	Golden Hammerhead
Sphyrna tiburo	Bonnethead Shark
Sphyrna media	Scoophead Shark
Rhizoprionodon porosus	Caribbean Sharpnose Shark

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APPENDIX Q

Final Analysis Report—2018-2020 Shell Beach Turtle Tracking Project

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March 2022

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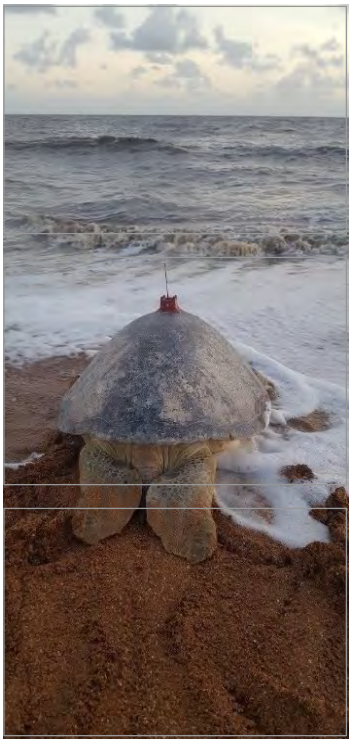

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Final Analysis Report— 2018 - 2020 Shell Beach Sea Turtle Tracking Study

March 2021

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
ArcGIS	Area coordinate system using geographic information system
CLS	Collecte Localisation Satellites
EEPGL	Esso Exploration and Production Guyana Limited
EMC	Environmental Management Consultants
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
ES	Executive Summary
GIS	geographic information system
GPS	global positioning system
ID	identification
km	kilometer
km^2	Square kilometers
m	meter
PAC	Protected Areas Commission
SBPA	Shell Beach Protected Area
SD	standard deviation
SSH	sea surface height

EXECUTIVE SUMMARY

In 2016, Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorization for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On 1 June 2017, the EPA approved the Environmental Impact Assessment submitted as part of the Application for Environmental Authorization and issued an Environmental Permit for the Liza Phase 1 Development Project. As a condition of the Environmental Permit, the Guyana EPA required EEPGL to "work with appropriate sea turtle conservation organizations and/or academia in Guyana and the region to expand existing sea turtle telemetry programs where practicable." Following on the initial success of sea turtle-related field research organized and completed in 2018, EEPGL decided to continue the program in 2019 even though such a continuation was not required as part of any permitting condition.

Since the early 1960s, four species of sea turtles have been documented nesting seasonally along the remote shores of the Shell Beach Protected Area (SBPA). This important terrestrial habitat is now protected under a Guyanese law (Protected Areas Act 2011) that, together with legislation protecting the turtles at sea (Fisheries Act 2002), strengthens conservation actions aimed at ensuring species survival. However, little information exists to date on Guyana's marine turtle populations at sea. Environmental Resources Management (ERM), EEPGL's environmental consultant, enlisted the assistance of Environmental Management Consultants (EMC) and the Chelonian Research Institute to develop a scope of study, engage with appropriate entities, and conduct the field work for a sea turtle tracking and telemetry program to satisfy the above-referenced Environmental Permit condition. The methodology for the program was developed in partnership with local entities to build on prior work conducted in Guyana and elsewhere in the Caribbean region. It represents current best practice in terms of minimizing stress to turtles, minimizing potential disruption of their reproductive behaviors, and supporting data acquisition objectives. The goal of this study was to obtain empirical data focused on characterizing the turtles' inter-nesting and movement behaviors in both the horizontal (spatial) and vertical (depth) dimensions, with the potential for capturing their migrations to foraging grounds.

The 2018 Expedition included two deployments to the SBPA. The first deployment was undertaken from 21 to 27 March 2018; the second deployment was undertaken from 8 to 14 June 2018. A third mobilization to the SBPA ("the 2019 Expedition") was conducted from 7 to 17 May 2019. The field teams worked in close collaboration with Protected Areas Commission (PAC) rangers and local community members during all field activities in the SBPA. Pursuant to the permits issued by the PAC, the details of the three deployments and preliminary analyses of the telemetry data were submitted to the PAC in a series of four reports issued from May 2018 to May 2019. This report provides an expanded analysis of the tracking data obtained through mid-May 2020, when the last transmitter (of the two green turtles [*Chelonia mydas*] and five leatherback turtles [*Dermochelys coriacea]* tagged in 2019) ceased operating, as well as a

comprehensive summary of the data obtained from the 2018 and 2019 Expeditions and associated tracking.

Methodology, Data Acquisition, Processing, and Analyses

During the studies, nightly patrols of the northern-most section of the SBPA, known as Almond Beach, were carried out by PAC rangers to monitor the beach for sea turtle nesting. When a turtle was encountered, the rangers notified the rest of the awaiting team to approach. Rangers measured the turtle and checked for flipper tags, noting any scars or unique physical attributes. If no flipper tag was present, an Inconel tag was applied to the left front flipper (green turtles) or to a rear flipper (leatherbacks) to uniquely identify the turtle in future nesting events. Between 21 and 27 March 2018, four adult, female green turtles were tagged with satellite transmitters immediately after they had finished laying their eggs. Between 9 and 14 June 2018, three adult, female leatherback turtles were tagged with satellite transmitters, but attachment was done during egg deposition when the turtle was in a calm, trance-like state rather than upon completion of nesting. Between 7 and 17 May 2019, two adult, female green turtles were tagged with satellite transmitters after they had finished laying eggs. During this period, five adult, female leatherback turtles were tagged with satellite transmitters, but attachment was done during egg deposition rather than upon completion of nesting.

The information collected by the satellite tags was transmitted as encoded, fixed-frequency radio signals each time the turtle surfaced to breathe. Raw sensor data, such as dive profiles and Fastloc global positioning system (GPS) locations, were also transmitted through the Argos System, but required additional processing to decode the data. Processed and filtered data were then analyzed in the Albers Equal Area coordinate system using geographic information system (ArcGIS) and statistical (R) software programs.

Tag Performance

The quantity and quality of data received during satellite tracking is strongly influenced by the animal's behavior and this was evident among all 14 turtles tagged in this program. Data reception from all deployed transmitters exceeded expectations given the satellite coverage at Guyana's low latitude. Variability in data acquisition appeared to be related to movement behavior, producing similar numbers of locations, sensor data messages, and tag durations among green turtles. Leatherback data were more variable among individuals - likely to be directly related to tracking duration.

The tracking duration of all tag models was shorter than projected by battery life and programming alone. This could be due to a variety of factors such as animal behavior, biofouling, predation, incidental capture of the animal, antenna damage, discharged battery, or attachment failure. Incidental capture of the animal can probably be ruled out, as there was no sudden increase in a series of high-quality locations that are typically associated with an animal being on land or in a boat.

Inter-nesting Period

While all individuals showed strong nesting-site fidelity to their capture locations throughout this period, three different inter-nesting movement behaviors were identified:

1. Remained in the immediate vicinity of Almond Beach, making small near-shore loops;
2. Moved moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops; and
3. Moved large distances, making small near-shore loops in the vicinity of Almond Beach and larger offshore loops between Venezuela, Trinidad, and Guyana.

Turtles returned to nest between zero and six times, exclusively on Almond Beach, in typical intervals of approximately 12 days, with the exception of one green turtle (Violet), who also nested across the Barima-Waini river mouth and nested at longer time intervals than the other turtles. All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements among nests. With respect to the size of the area used by the turtles during the inter-nesting period, there were no significant differences between species or among individuals; however, the leatherback turtles occupied waters at a farther distance from shore during inter-nesting than the green turtles.

The greatest density of recorded green turtle locations during inter-nesting occurred in less than 5 meters of water and less than 10 meters for leatherback turtles. The leatherback turtles occupied deeper water (35 meters as an average for the 2018-tagged turtles and 91 meters as an average for the 2019-tagged turtles) than did the green turtles (7 meters as an average for the 2018-tagged turtles and 5 meters as an average for the 2019-tagged turtles). Green turtles recorded dives up to 16.7 meters whereas the leatherbacks recorded dives up to 202 meters, but data indicated that most dives were within the upper 20 meters of the water column.

Generally, the turtles' inter-nesting habitat use was concentrated within the territorial seas of Guyana in the immediate vicinity of Almond Beach, but also included the territorial seas of Venezuela and Trinidad. The three leatherbacks and one of the green turtles demonstrated more itinerant movement behaviors. Karin, a green turtle, exhibited the farthest movements during her inter-nesting period, extending along 261.7 kilometers of coastline, venturing 50 kilometers offshore of the Orinoco River Delta in Venezuela on one of her loops, and reaching the Port of Galeota on the Trinidad coastline on another. Julie was the only leatherback with a flipper tag scar, and so was likely not a neophyte nester. She displayed the most moderate offshore movements (54 kilometers from shore) among the leatherback turtles during the nesting season, traveling along 104.9 kilometers of coastline between Guyana and Venezuela and staying within the 50-meter bathymetric contour. Denise, a leatherback turtle, moved the farthest distance from shore (111 kilometers), crossing the 100-meter bathymetric contour during three inter-nesting loops that spanned 120.4 kilometers of shoreline, including both Guyana and Venezuela.

Migration Period

All of the turtles tagged in the 2018 Expedition retained their tags until the onset of the migration period, but tag performance was variable once the turtles left the nesting area. All the green turtles tagged in 2018 headed southeast to Brazil, following a near-shore corridor across an average distance of 2,485 kilometers; all the leatherback turtles initially headed directly out to sea in a northeasterly direction, but none were tracked to their foraging areas. Both green and leatherback turtles used deeper waters during their migration periods, as compared to the water depths used during other tracking periods. Both green turtles fitted with dive-sensors displayed deep dives of up to 60 meters before or after major river mouths (i.e., Essequibo River, Guyana; Corentyne River, Suriname; Amazon and Pará rivers, Mearima River/Arraial Bay, and Parnaíba River, Brazil). The leatherbacks dove deeper, but generally remained in the upper 500 meters of the water column.

Unlike in 2018, all of the turtles tagged during the 2019 Expedition were tracked from their nesting sites on Almond Beach to or near their foraging grounds. Both green and leatherback turtles used deeper waters during their migration period than in prior tracking periods. As in 2018, both green turtles tagged in 2019 also headed southeast to Brazil by following a near-shore corridor across an average distance of 2,696.5 kilometers. Two leatherback turtles tagged in 2019 initially headed directly out to sea in a northeasterly direction and the three others headed due north. The leatherbacks foraged in two areas, one off the coastal southeastern United States and another offshore the Canadian Maritime Provinces. The leatherbacks tended to dive deeper than the green turtles during their migration, including one surprisingly deep dive to 1,400 meters; however, similar to 2018, they generally remained in the upper 500 meters of the water column.

Foraging Period

Three of the green turtles tagged in 2018 were tracked to their ultimate foraging destination, which were determined to be foraging grounds in the State of Ceará, Brazil. Two of three turtles overlapped geographically in area, adjacent to the Mundaú River Estuary Environmental Protection Area. These three green turtles displayed similar foraging habitat use (area) and movements (dispersal from foraging centroid) among individuals, and their locations were at similar distances from shore as during the inter-nesting period, although water depths in the foraging area were slightly deeper. The fourth green turtle and all of the leatherbacks tagged in 2018 did not reach the foraging grounds during their tracking periods.

Of the turtles tagged in 2019, both green turtles were tracked to their ultimate foraging ground destination in Brazil. Two of the leatherbacks (Christine and Rhoda) migrated to the southeastern United States and remained in near-shore waters, moving up and down the coast – likely in search of jellyfish. The rest of the leatherbacks (Teij, Kari, and Regina) migrated to the continental shelf waters of Canada before turning and heading south again into the open ocean. In some cases, they remained in these areas for prolonged periods, but in others they moved to another site quickly, likely depending upon the availability of prey resources that they

encountered. The leatherback turtles tagged in 2019 concentrated their foraging dives in the upper 30 meters of the water column.

Conclusions

The results of this study provided a wealth of new information about the sea turtles that nest in Guyana. Although sample sizes were small, they provided the first look into the at-sea behaviors of green and leatherback turtles in this region and elsewhere in the Atlantic Basin. The SBPA is an important yet under-described nesting area for green and leatherback sea turtles that migrate to disparate foraging grounds in Brazil and the Caribbean region, and the North Atlantic, respectively. The study shows that turtles may remain in the inter-nesting zone for several months, venturing northwest into the territorial seas of Venezuela and Trinidad and Tobago, laying multiple clutches of eggs, and displaying strong site fidelity. Data indicate that green turtles stayed near the nesting beach, generally within the 5-meter isobath, while leatherbacks ranged farther offshore, generally on the continental shelf (200-meter depth), with occasional forays over the continental slope (around 1,000-meter depth). During this period, turtles remained primarily in the upper 10 meters of the water column near to shore, but leatherbacks made occasional forays within the continental shelf between nests. After nesting, green turtles followed a narrow migration corridor along the coastline, avoiding the effects of the opposing Guiana and North Brazil western boundary currents to arrive at shallow water seagrass foraging sites in northern Brazil, where they remained for extended, yet undefined, periods. Leatherback turtles dispersed into the high seas after nesting, taking an initial northeasterly course. Figures ES-1 and ES-2 display the paths recorded for the turtles tagged in 2018 and 2019 for green and leatherback turtles, respectively, focused on the area adjacent to Guyana's shoreline.

Transmitter life was the primary limitation in this study. While significant efforts were made to maximize tag retention and life (as well as data quality and quantity), additional preparation of all tags with a coat of a more reliable antifouling product prior to future deployments may help extend transmitters' operational endurance.

Figure ES-1: 2018-tagged and 2019-tagged Green Turtle Paths

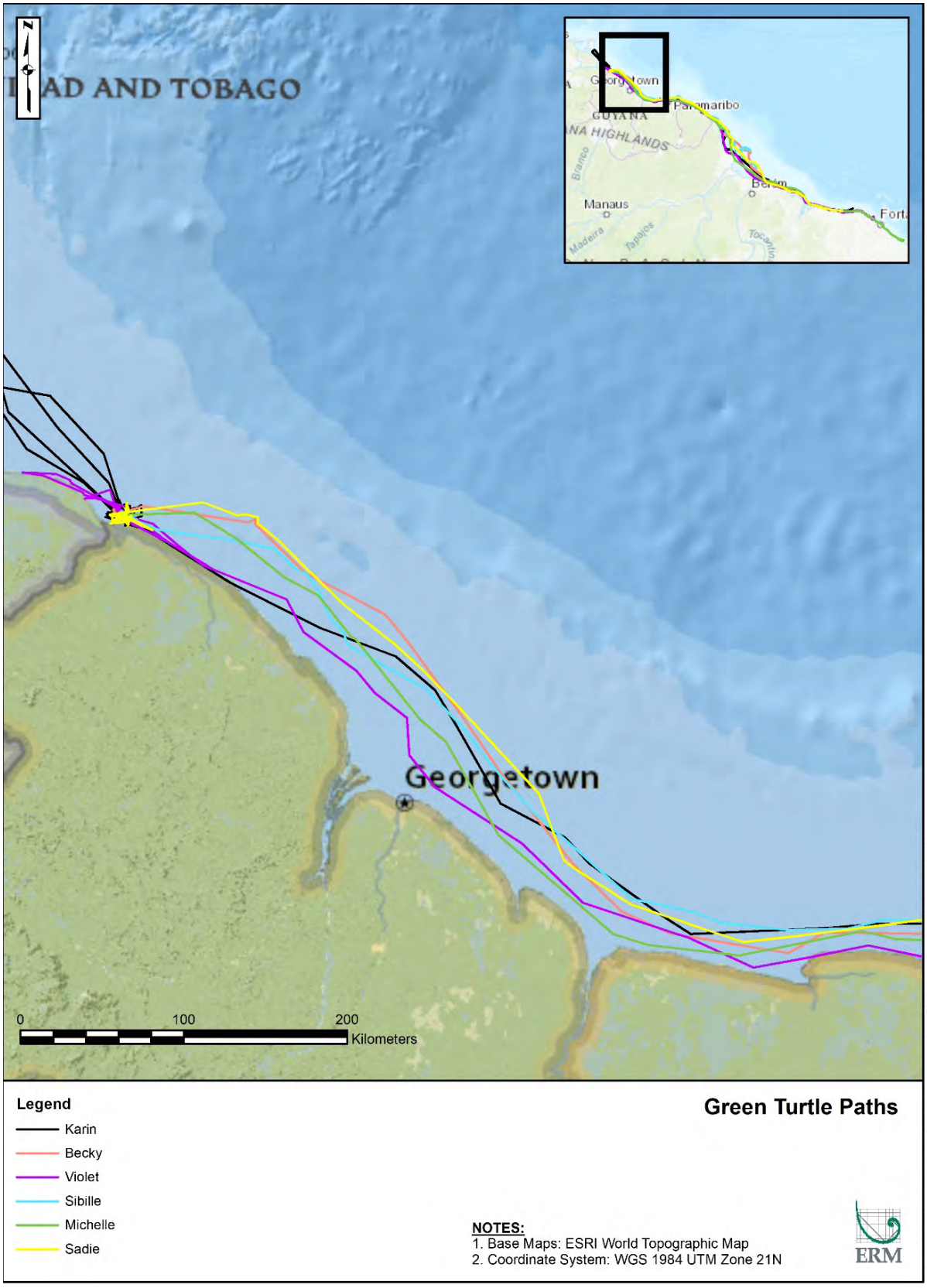
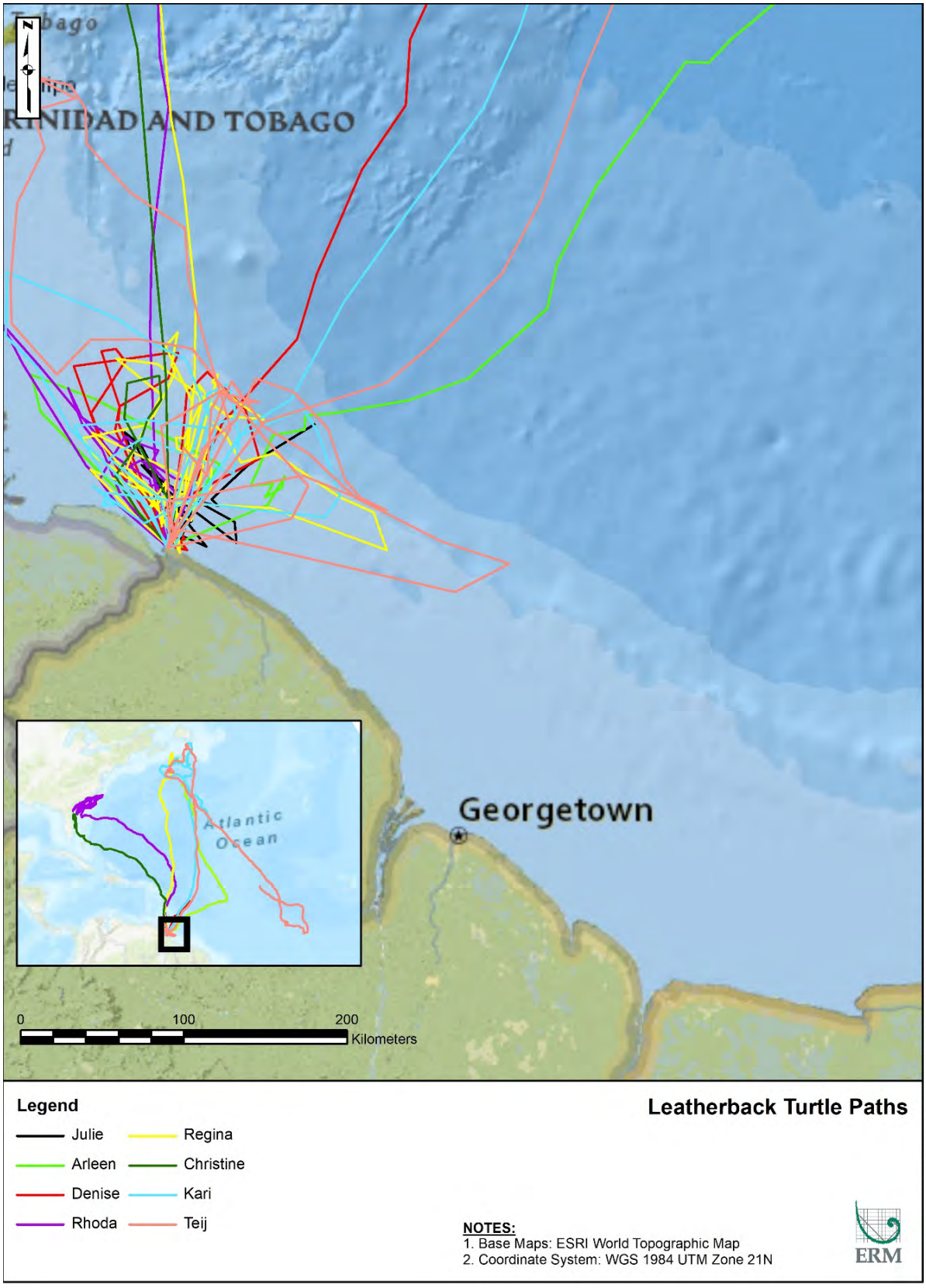


Figure ES-2: 2018-tagged and 2019-tagged Leatherback Turtle Paths



1. INTRODUCTION

Esso Exploration and Production Guyana Limited (EEPGL) retained a team of marine scientists, local experts, and environmental managers to conduct two research expeditions in Region 1 of Guyana in March and June 2018 to study the inter-nesting and at-sea behaviors of sea turtles at the Shell Beach Protected Area (SBPA). EEPGL retained the team for a third expedition in May 2019.

Sea turtles nest on land and exhibit natal philopatry[1], making this the most understood part of their life cycle. Since the early 1960s, under the pioneering field studies of Dr. Peter Pritchard—Chelonian Research Institute, four species of sea turtles have been documented to nest seasonally along the remote shores of the SBPA, including leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*) turtles. This important terrestrial habitat is now protected under Guyanese law (Protected Areas Act 2011) that, together with legislation protecting the turtles at sea (Fisheries Act 2002), strengthens conservation actions aimed at ensuring species survival. However, little information exists to date on the behavior of Guyana's marine turtle populations at sea.

The goal of this study was to provide empirical data on a cryptic aspect of these animals' lives. Specifically, the research design focused on characterizing the turtles' inter-nesting phenological[2] and movement behaviors in both the horizontal (spatial) and vertical (depth) dimensions, with the additional goal of tracking their migrations to foraging grounds. Due to turtles' exceptional dispersal capabilities and the unpredictability of encountering them at sea, the only way to gain such information is to deploy autonomous data tracking devices on wild animals. At present, this can be done at the only time and place when human beings can reliably expect to encounter them with a reasonable degree of predictability: when they come ashore to dig a nest and lay their eggs.

This report presents the methodology and results of the expeditions completed to tag turtles in at the SBPA in 2018 and 2019, and of the subsequent tracking of the tagged turtles during the 2018 to 2020 period.

1.1. Permitting and Regulatory Compliance

1.1.1. 2018 Expedition

As a condition of the Environmental Permit for the Liza Phase 1 Development Project, the Guyana Environmental Protection Agency (EPA) required EEPGL to "work with appropriate sea turtle conservation organizations and/or academia in Guyana and the region to expand existing sea turtle telemetry programs where practicable." Environmental Resources Management (ERM), EEPGL's environmental consultant, enlisted the assistance of The Ocean Foundation

[1] The tendency to return to their birthplace to breed
[2] Of or related to the timing of growth and breeding events

(specifically the Sea Turtle Census Initiative program) and Environmental Management Consultants (EMC) to consult with the Chelonian Research Institute and develop a scope of study, engage with appropriate entities, and conduct the field work for a sea turtle tracking and telemetry program. The methodology for the first year of study (referred to herein as the 2018 Expedition) was developed in partnership with local entities to build on prior work conducted in Guyana and elsewhere in the Caribbean region.

The 2018 Expedition included two deployments to the SBPA. The first deployment was undertaken from 21 to 27 March 2018; all field work was permitted through the Guyana Protected Areas Commission (PAC) and all conditions detailed in the PAC's "Letter of No Objection to ERM Conducting Turtle Telemetry Study in the Shell Beach Protected Area" dated 19 March 2018 were strictly followed. The second deployment was undertaken from 8 to 14 June 2018, for which all field work was conducted in accordance with the permit conditions detailed in the PAC's "No Objection to ERM Conducting 2nd Turtle Telemetry Study in the Shell Beach Protected Area" letter dated 31 May 2018 (PAC 2018). The field teams worked in close collaboration with PAC rangers and local community members during field activities in the SBPA. In accordance with the PAC's requirements, the details of the March and June 2018 deployments, along with preliminary analysis of the telemetry data for four green turtles and three leatherback turtles, were submitted to the PAC in separate reports in May 2018 (ERM 2018) and August 2018 (ERM and EMC 2018), respectively.

1.1.2. 2019 Expedition

Fieldwork continued in 2019 to build on the 2018 effort and increase the sample size for two sea turtle species. On behalf of EEPGL, ERM enlisted the assistance of EMC and scientists with the Chelonian Research Institute to refine the approach developed in 2018 and execute an additional round of tagging in the field. As was done in 2018, the methodology for the 2019 field effort (referred to herein as the 2019 Expedition) was developed in partnership with local entities. The field work component of the 2019 Expedition was undertaken from 7 to 17 May 2019 in accordance with a research permit providing Permission to Conduct Biodiversity Research from the EPA (Reference Number 050219 BR 008, dated 2 May 2019) (EPA 2019) in addition to a "Letter of No Objection" from the PAC dated 3 May 2019 (PAC 2019). All conditions in the EPA permit and the PAC letter were strictly followed. The field teams worked in close collaboration with PAC rangers and local community members during field activities in the SBPA.

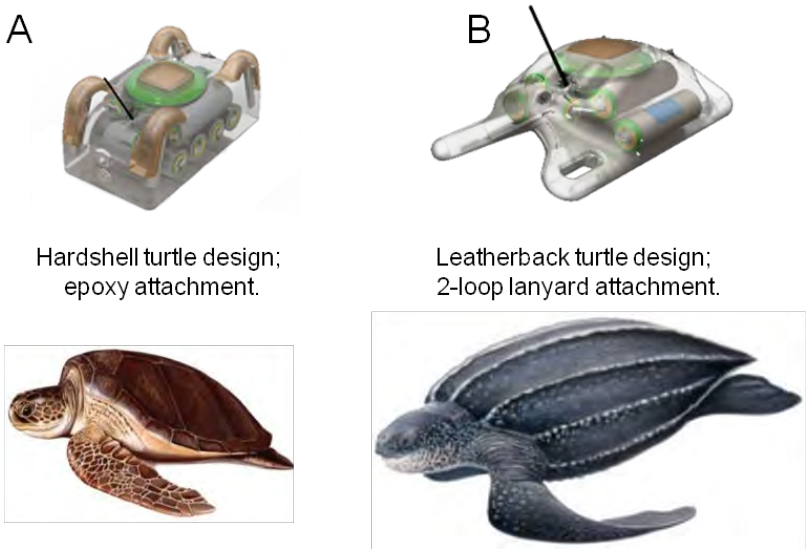
Pursuant to the letter of no objection issued by the PAC, the details of the 2019 Expedition, along with tagging information for two green turtles and five leatherback turtles, were submitted to the PAC in a report in late May 2019 (Stewart 2019).

2. METHODOLOGY

2.1. Tracking System Design

Wildlife Computers model MK10 SPLASH satellite transmitters were used to track sea turtles in this study and were programmed with species-specific behavioral configurations prior to going into the field. Satellite tag models were selected to enable species-specific attachment methodologies, and the tag model dictated the number and size of batteries encased in the mold (Figure 2-1). Furthermore, because there is a limit to the volume and frequency of data that can be transmitted through the Argos satellite system, the sampling rate of tags was set to balance the tradeoffs between successful transmissions, data acquisition, and battery life. All tags were programmed to transmit continuously (i.e., at all hours) and to produce Argos locations and haul-out[3] information. Half of the tags also transmitted locations derived using Fastloc GPS (global positioning system) technology, which has greater location accuracy but requires greater surface time to establish a location fix. The Fastloc tags were set to re-attempt GPS fixes at 3-hour intervals. The other half of the purchased tags transmitted dive information that was sampled at 10-second intervals and summarized into species-specific histogram bins over a 24-hour period, including depth (meters), duration (minutes), and temperature (degrees Celsius [°C]). These “dive-enabled” tags also transmitted hourly summaries of the percent dry time (i.e., surface intervals) every 24 hours, as well as time-series information summarized into 10-minute intervals.

Figure 2-1: Wildlife Computer Satellite Transmitter Designs



Note: Wildlife Computers satellite transmitters were designed to accommodate sea turtle species’ carapace morphologies and the attachment methodologies that are most appropriate to each species. A. Green turtle design MK10-BF-334 for epoxy attachment; mass 980 grams; 6 x lithium AA batteries. B. Leatherback turtle design MK10-BF-295 for 2-loop lanyard attachment; mass 233 grams; 4 x lithium AA batteries.

[3] Defined as more than 10 consecutive minutes dry (i.e., representing nesting, resting, or capture events)

To attach the transmitter tags to green turtles, a wooden box was assembled around the turtle after it had finished nesting to keep it on the beach during the lengthy transmitter attachment process, and a wet towel was placed over the animal's eyes to keep it calm. Rangers measured the turtle and checked for flipper tags, noting any scars or unique physical attributes. If no flipper tag was present, an Inconel tag was applied to the left front flipper to uniquely identify the turtle in future nesting events. The carapace was prepared for the transmitter attachment by washing it with fresh water and a scrub pad, removing epibionts,[4] sanding away any rough patches on the scute margins, and wiping it down with acetone. Two thin layers of cool-setting, two-part epoxy (Quickrete or Superbond) were then used to affix the transmitter to the two anterior vertebral scutes. For the initial expeditions, the pretreated transmitter and dried epoxy were then painted with antifouling paint (Torginol) before releasing the turtle. Based on findings of the 2018 Expedition, the transmitters for the 2019 Expedition were pretreated with Interlux InterProtect 2000E primer and three layers of Interlux Micron 66 antifouling paint. After the transmitters were affixed to the turtles and the epoxy had dried, the transmitters and epoxy were then painted with antifouling paint (Interlux Micron 66) before releasing the turtle.

Leatherbacks are far too large and powerful to be held on the beach in a box and epoxies do not adhere well to their "leathery" expandable carapace; therefore, rapid and direct attachment methods were required. Attachment was performed during egg deposition when the turtle was in a calm, trance-like state rather than upon completion of its nest. When located, rangers intercepted and measured the turtles, and checked for existing tags or scars (no flipper tags were identified). While the turtle was digging the egg chamber, the dorsal ridge of the carapace was cleaned with three treatments consisting of water, 70 percent isopropyl alcohol, and iodine. Following the deposition of three to four eggs, two 4.5-millimeter holes (10 centimeters apart, following treatment with topical analgesic) were drilled through the dorsal ridge at approximately two-thirds of the way posterior on the carapace using a cordless drill fitted with a sterile orthopedic drill bit. The drill holes were cleaned thoroughly using Vetericyn spray. Sterile plastic-coated wire lanyards were threaded through silicone Tygon tubing sheaths and inserted through the holes in the carapace. Equinox®35 fast-set silicone molding putty was mixed by hand and formed into a cushion that was placed between the dorsal ridge and the satellite transmitter. The wire lanyards were then threaded through the transmitter fittings, tightened, and secured with a metal crimp.

2.2. Field Expeditions

PAC rangers carried out nightly patrols (1900 to 0500 hours) of Almond Beach to monitor the beach for sea turtle nesting. When a turtle was encountered, the rangers notified the rest of the team with light signals to approach. During the June 2018 and May 2019 deployments, rangers were equipped with hand-held radios to relay information to the waiting team members. Care was taken to limit disturbance of wildlife and habitat during these patrols.

[4] Living organisms attached to the turtles, such as barnacles, bryzoans, algae, etc. These organisms must be removed to ensure secure attachment of the transmitters.

2.2.1. 2018 Expedition

Between 21 and 27 March 2018, four adult, female green turtles were tagged with satellite transmitters immediately after they had finished laying their eggs (Figure 2-2A and Figure 2-2B). The entire tagging process, from encounter to return to the water, took an average of 4.7 hours (+/- 0.3 hours) per turtle and occurred between 2000 and 0930 hours.

Figure 2-2: Sea Turtle Tagging at Almond Beach (March and June 2018)

Photos by CMM, KRS, and DC.

A. After nesting, green turtles were restricted to a wooden box during the multi-stage tag attachment procedure and shaded if the process extended past sunrise. B. Once the attachment was completed, the box was removed and the turtles were free to move down the beach. C. Leatherback turtles were tagged during nesting by threading wire lanyards through the dorsal ridge of the carapace. D. Attachment was complete before the turtle had begun covering the nest.

Between 9 and 14 June 2018, three adult female leatherback turtles were tagged with satellite transmitters (Figure 2-2C and Figure 2-2D). The entire tagging process, from encounter to attachment completion, took an average of 0.8 hours (+/- 0.5 hours) per turtle and occurred between 2140 and 0100 hours. In the case of the leatherbacks, the team did not wait to observe the turtle going back into the water because several turtles were encountered in rapid succession on the same night.

2.2.2. 2019 Expedition

Between 7 and 17 May 2019, two adult, female green turtles were tagged with satellite transmitters immediately after they had finished laying their eggs (turtle ID: Sadie) or after nesting attempt was abandoned (i.e., a false crawl; turtle ID: Michelle; Figure 2-3A). The entire tagging process, from encounter to return to the water, took an average of 3.5 hours per turtle (+/- 0.40) and occurred between 2333 and 0338 hours.

Figure 2-3: Sea Turtle Tagging at Almond Beach (May 2019)

Photos by NR and KRS

A. green turtle; B. leatherback turtle

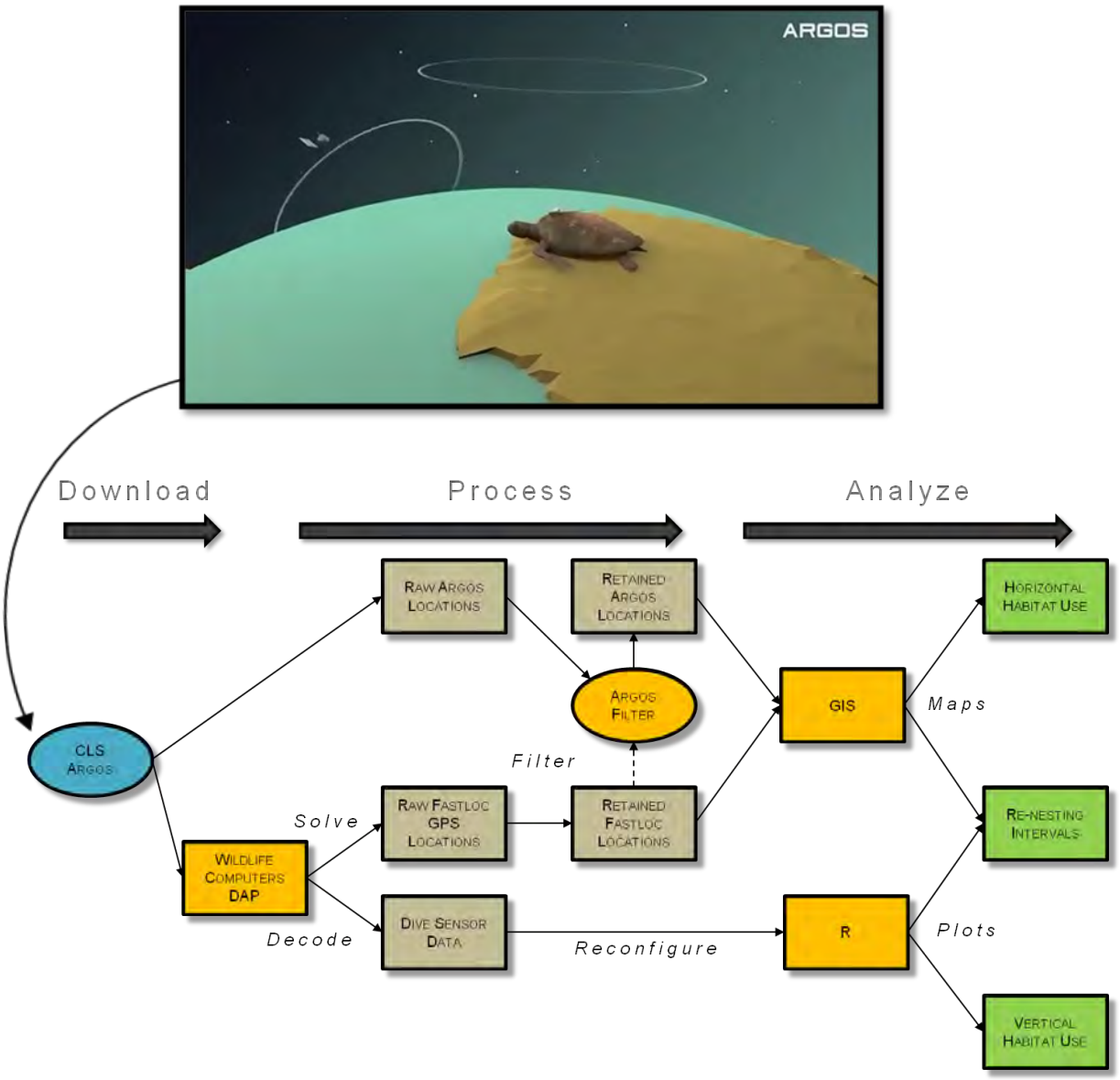
Between 7 and 17 May 2019, five adult female leatherback turtles were tagged with pretreated satellite transmitters. As described above, attachment of tags was done during egg deposition (Figure 2-3B). The entire process from encounter to attachment completion took an average of 1 hour (+/- 0.39) per turtle and occurred between 2045 and 0515 hours. As in the 2018 Expedition, the turtles were not always observed through the point of entering the water, but field workers did confirm later each night that each turtle had returned to the water successfully.

2.3. Data Acquisition, Processing, and Analyses

The satellite tracking and data relay system is operated by Collecte Localisation Satellites (CLS) Argos. The information collected by the satellite tag was transmitted as encoded, fixed-frequency radio signals each time the turtle surfaced to breathe. Data were only received if one of the polar-orbiting satellites equipped to receive Argos messages was passing overhead during this narrow window of time. Unlike GPS, which employs a constellation of fixed satellite positions to determine location, the Argos System uses Doppler Shift (i.e., the change in sound frequency) to calculate the estimated location of the signal. The Argos method resolves positions faster, but it is not without measurement error, resulting in varying levels of accuracy. Raw sensor data, such as dive profiles and Fastloc GPS locations, were also transmitted through the Argos System, but required additional processing through tag-manufacturer-specific software to decode the data (Figure 2-4). The best practices for wildlife tracking require filtering the raw location estimates through statistical algorithms before further analysis to remove implausible positions based on movement rates and turning angles. In this case, the high-precision GPS data were used to calculate site- and species-specific movement thresholds for setting the Argos location filtering algorithm. Fastloc GPS data were first filtered to remove locations derived from fewer than six satellites and with high residual errors. The hybrid Douglas Argos-Filter (Douglas et al. 2012) was then used on Argos locations, which optimally retains locations based on maximum redundancy thresholds (5 kilometers) and speed (5 kilometers per hour) and turning angle thresholds (25°) for migratory animals. Argos location estimates with error classes 2 and 3[5] were always retained, as were the first and last locations, and default parameter values were used for the hybrid method. Data were then analyzed in the Albers Equal Area coordinate system using geographic information system (ArcGIS) and statistical (R) software programs (Figure 2-4). Monthly mean ocean altimetry images[6] from the Global Ocean 1/12° Physics Analysis and Forecast dataset were downloaded from the Copernicus Marine Environment Monitoring Service website to evaluate movements in context with geostrophic[7] ocean currents. The final datasets were downloaded after all the tags had ceased transmissions.

[5] CLS Argos uses location class error codes that classify location estimates within a given distance from the true location. Location classes 2 and 3 have the highest estimated accuracy (less than 500 meters).
[6] Sea surface height, meridional, and zonal velocity
[7] Currents resulting from a balance between pressure gradients and Coriolis forces. Coriolis forces pertain to the rotation of currents that are deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

Figure 2-4: Flow and Treatment of Sea Turtle Satellite Tracking Data for Addressing Specific Research Objectives



3. RESULTS

3.1. Tag Performance

3.1.1. 2018 Expedition

The quantity and quality of data received during satellite tracking is strongly influenced by the animal's behavior. For example, individual sea turtles undergoing long-distance forays spend more time at the surface due to physiological requirements (i.e., the physical exertion required to sustain swimming for long periods requires more rapid and deeper breathing), and they typically produce more frequent and higher-quality location fixes than those individuals remaining within a smaller area and making vertical dives. This pattern was evident among the seven turtles tagged in 2018 (Table 3-1 and Table 3-2).

Given the satellite coverage at Guyana's low latitude, data reception from all seven transmitters deployed in 2018 exceeded expectations. Variability in data acquisition from green turtles appeared to be related to movement behavior, producing similar numbers of locations (Table 3-1), sensor data messages (Table 3-2), and tag durations (163 +/- 19 days [mean +/- 1 standard deviation (SD)]; Table 3-1 and Table 3-3). Leatherback turtle data were more variable among individuals (Table 3-1 and Table 3-2); this variation is likely to be directly related to the wider range in total tracking days (60 +/- 44 days [mean +/- 1 SD]; Table 3-1 and Table 3-3).

Green turtle transmissions produced an average of 14.1 +/- 0.7 (mean +/- 1 SD) Argos location estimates and 6.1 +/- 0.7 (mean +/- 1 SD) Fastloc GPS locations per day per turtle over the tracking period (Table 3-1). Only 9 percent of green turtle Argos positions were classified as high quality (i.e., location classes 1, 2, or 3); however, most Argos locations were retained after the filtering process due to a less-conservative hybrid algorithm (95.3 +/- 0.5 percent [mean +/- 1 SD]). For leatherback turtles, there were an average of 11.5 +/- 2.6 (mean +/- 1 SD) Argos location estimates and 4.7 +/- 0.1 (mean +/- 1 SD) Fastloc GPS locations received per day per turtle over the tracking period (Table 3-1). Leatherback Argos positions had a greater proportion of high-quality locations (16 percent), but fewer Argos locations were retained after the filtering process (62.3 +/- 31 percent [mean +/- 1 SD]). The difference between the Argos locations received and retained by the filtering between species is likely due to the animals' movement behaviors and the number of satellites available by latitude (more at higher latitudes, fewer at lower latitudes). The number of Fastloc GPS locations retained after filtering was similar between green and leatherback turtles (76 +/- 4.2 percent and 73.5 +/- 9.2 percent [mean +/- 1 SD], respectively), reflecting the static availability of GPS satellites across the globe. Ultimately, movement metrics based on the filtered Argos locations were only slightly greater than those based on Fastloc GPS locations (Table 3-1).

Table 3-1: 2018-tagged Turtle Location Data and Movement Summary Statistics for Comparison among Individuals and between Location Estimation Methodologies

Turtle ID	Days of Tracking Data	Location Estimation Method	Total # of Locations Received	% of Locations Filtered Out	Convex Hull of Retained Locations (km^2)	Total Distance Traveled (km) [a]	Maximum Displacement (km)	Maximum Offshore Distance (km)
Green Turtles								
173290 Sibille	137	Argos Fast-GPS	2,043 898	5 27	196,774.4 176,853.8	2,211.2 1,794.2	1,536.0 1,416.7	149.6 120.1
173293 Violet	164	Argos	2,250	4	533,866.6	3,487.6	2,597.6	77.3
173291 Becky	180	Argos Fast-GPS	2,454 1,011	5 21	456,993.2 446,367.4	3,248.7 3,130.1	2,579.6 2,576.2	152.7 149.6
173294 Karin	172	Argos	2,422	5	477,219.0	3,801.3	2,497.0	95.4
Leatherback Turtles								
173284 Julie	24	Argos Fast-GPS	350 111	15 20	6,551.3 2,781.4	622.0 517.7	116.6 79.9	111.6 51.1
173288 Denise	47	Argos	464	25	76,414.9	1,900.7	939.7	515.6
173285 Arleen	110	Argos Fast-GPS	1,120 526	27 33	2,388,788.8 1,836,887.3	5,138.1 4,315.8	3,597.0 3,019.1	1,310.2 1,304.4

km = kilometers; km^2 = square kilometers

[a] indicates a standardized calculation based on a subset of the data (i.e., one location per day)

Table 3-2: 2018-tagged Turtle Dive and Fastloc GPS Data Collected in Predefined Sampling Intervals and Relayed through the Argos System

			Number of Messages Received for Various Data Files						
Turtle ID	**Tag Type**	**Status**	**Time-Series**	**Time-at-Temperature**	**Time at Depth**	**Haul Outs**	**% Dry Time**	**Dive Depth**	**Dive Duration**
Green Turtles									
173290 Sibille	GPS	74	-	122	-	1	-	-	-
173293 Violet	Dive	111	470	143	151	-	142	142	149
173291 Becky	GPS	106	-	169	-	1	-	-	-
173294 Karin	Dive	139	409	145	140	-	131	152	147
Leatherback Turtles									
173284 Julie	GPS	15	-	23	-	1	-	-	-
173288 Denise	Dive	32	129	40	44	-	40	42	39
173285 Arleen	GPS	54	-	103	-	1	-	-	-

Note: Columns represent the reconstructed data files that were generated during the decoding process with respect to tag type (see Figure 2-3). Values indicate the number of messages of each type received.

Table 3-3: Summary of 2018-tagged Turtle Behavioral Intervals Determined from Satellite Tracking Data

Turtle ID	Tracking Dates	Inter-nesting			Migrating		Foraging [a]		Method Used
		Clutches	Days	km Countries	Days	km Countries	Days	km Countries	
Green Turtles									
173290 Sibille	23 Mar–11 Aug 2018	7	72	16.7 GY	69	1,697.9 GY, SR, GF, BR	-	-	Haul-Out, GIS
173293 Violet	24 Mar–4 Sep 2018	3	36	106.5 GY, VE	91	2,746.8 GY, SR, GF, BR	38	29.9 BR	Haul-Out, % Dry, Time Series, GIS
173291 Becky	24 Mar–22 Sep 2018	5	55	17.8 GY	78	2,781.0 GY, SR, GF, BR	50	52.6 BR	Haul-Out, GIS
173294 Karin	25 Mar–14 Sep 2018	6	70	261.7 GY, VE, TT	62	2,719.6 GY, SR, GF, BR	41	15.2 BR	Haul-Out, % Dry, Time Series, GIS
Leatherback Turtles									
173284 Julie	14 Jun–11 Jul 2018	3	26	104.9 GY, VE	1	-	-	-	Haul-Out, GIS
173288 Denise	14 Jun–8 Aug 2018	4	30	120.4 GY, VE	26	-	-	-	Haul-Out, % Dry, Time Series, GIS
173285 Arleen	14 Jun–5 Oct 2018	2	17	204.6 GY, VE	96	-	-	-	Haul-Out, GIS

BR = Brazil; GF = French Guiana; GY = Guyana; km = kilometer; SR = Suriname; TT = Trinidad & Tobago; VE = Venezuela.

Note: Behavioral intervals were characterized by a change in heading and movement rates calculated from tracking data. “Clutches” indicates the total number of nests laid. “Days” indicates the number of days during the respective behavioral period (inter-nesting, migrating, and foraging) within the tracking period. “km Countries” indicates the approximate distance of coastline that was covered during the behavioral period and the countries whose territorial waters were involved.

[a] One of the green turtles and all of the leatherbacks did not reach foraging grounds during their tracking periods. It is generally believed that turtles do not feed during inter-nesting and migration periods.

Dive sensor information was received for a minimum of 76 percent of the data-days possible and included daily histogram summaries for depth and temperature, hourly summaries of percent dry time, and time series of dive and temperature profiles (Table 3-2). Haul-out information was received for each of the four green turtles and the three leatherback turtles via either haul-out or status messages[8]; this was a critical parameter for determining re-nesting events.

Tracking durations for the tags deployed in 2018 were shorter than what was projected by battery life and programming alone for both tag models. This could be due to a variety of factors, not limited to animal behavior, biofouling, predation, incidental capture of the animal, antenna damage, discharged battery, or attachment failure. It is impossible to positively identify the root cause of tag failure in each case; however, the data provided were examined in the status messages over the lives of the tags and the manufacturer was consulted to try to identify indications or rule out potential causes of the shorter-than-anticipated tracking durations. Examination of the data revealed no degradation in battery voltage, power of signal strength, or number of GPS satellite fixes in any of the tags, and all tags had made fewer than half of the total transmissions possible, allowing those issues to be ruled out.

There was some evidence from the wet/dry sensors that biofouling might have occurred, especially for Arleen, but perhaps also for Becky and Karin. Tags and epoxy affixed to green turtles were coated with antifouling paint during the attachment process. Leatherback tags were not painted because they typically swim faster and range farther offshore than green turtles, which tends to result in less biofouling in leatherbacks compared to green turtles. Sometimes, in cases of biofouling, a tag will stop transmitting for a period of time but then start up again when the fouling organism falls off or is scraped off on reefs, pilings, etc. However, none of the tags in this study started transmitting again once going offline.

All of the green turtle tags showed an increase over time in the minimum wet/dry sensor values, which has never been seen before by the tag manufacturer; they are currently consulting with the engineers for possible explanations. This did not occur with the leatherback tags.

Incidental capture of the animal can probably be ruled out as a cause, as there was no sudden increase in a series of high-quality locations that are typically associated with an animal being on land or in a boat. There was an indication given by a PAC ranger that one of the leatherback tags was having attachment issues (R. DeFreitas, personal communication). Only one of the two lanyards was still attached when the turtle came ashore to nest again, and an attempt was made to re-secure the tag at that time; however, we cannot be sure which animal it was since the leatherbacks were not flipper tagged. The first leatherback to stop transmitting was Julie, so it is reasonably likely that Julie was the animal with the attachment issues. More potential explanations associated with individual behavior are discussed in Sections 3.2 through 3.4.

[8] Wildlife Computers' tags send encoded information through the Argos System that indicate the health and overall condition of the tag based on a set of diagnostic data (e.g., battery voltage, thermistor status, timekeeping errors). These are called "status messages". Status messages are transmitted separately from the tracking data transmissions that occur on a pre-defined schedule. Both types of messages can indicate haul outs.

3.1.2. 2019 Expedition

Similar to the 2018 Expedition, data reception from all seven transmitters deployed in 2019 exceeded expectations given the satellite coverage at Guyana's low latitude. Variability in data acquisition appeared to be related to movement behavior among green turtles, producing similar numbers of Argos locations (2,378 ± 362; mean ± 1 SD; Table 3-4), sensor data messages (Table 3-5), and tag durations (173 ± 5 days; mean ± 1 SD; Table 3-4 and Table 3-6). Leatherback data were more variable among individuals for Argos locations (2,915 ± 1,578; mean ± 1 SD; Table 3-4) and sensor data (Table 3-5) and were likely to be directly related to the wider range in total tracking days in leatherbacks (218 ± 120 days; mean ± 1 SD; Table 3-4 and Table 3-6).

Green turtle transmissions produced an average of 13.8 (± 2.5; mean ± 1 SD) Argos location estimates and 5.4 (based on one tracker) Fastloc GPS locations per day per turtle over the tracking period (Table 3-5). Only 9 percent of green turtle Argos positions were classified as high-quality (i.e., location classes 1, 2, or 3); however, most Argos locations were retained after the filtering process due to a less-conservative hybrid algorithm (91 ± 0.0 percent; mean ± 1 SD). For leatherback turtles, there were an average of 13.4 (± 0.8; mean ± 1 SD) Argos location estimates and 4.4 (± 0.0; mean ± 1 SD) Fastloc GPS locations received per day per turtle over the tracking period (Table 3-4). Leatherback Argos positions had a higher number of high-quality locations (32 percent), but fewer Argos locations were retained after the filtering process (86.8 ± 2.9 percent; mean ± 1 SD). The difference between the Argos locations received and retained by the filtering between species is likely due to the animals' movement behaviors and the number of satellites available by latitude (more at higher latitudes, fewer at lower latitudes). The number of Fastloc GPS locations retained after filtering was similar between green and leatherback turtles (64 percent and 65 percent, respectively), reflecting the static availability of GPS satellites across the globe. Ultimately, movement metrics based on the filtered Argos locations were only slightly greater than those based on Fastloc GPS locations (Table 3-4).

Dive sensor information was received for a minimum of 84 percent of the data-days possible and included daily histogram summaries for depth and temperature, hourly summaries of the percent dry time, and time series of dive and temperature profiles (Table 3-5). Haul-out information was received for all green turtles and three out of five leatherback turtles in either haul-out or status messages.

Table 3-4: 2019-tagged Turtle Location Data and Movement Summary Statistics for Comparison among Individuals and between Location Estimation Methodologies

Turtle ID	Days of Tracking Data	Location Estimation Method	Total # of Locations Received	% of Locations Filtered	Convex Hull of Retained Locations (km^2)	Total Distance Traveled (km) [a]	Maximum Displacement (km)	Maximum Offshore Distance (km)
Green Turtles								
173292 Michelle	169	Argos Fast-GPS	2,634 906	9 36	554,275.5 530,280.7	3,559.8 3,253.8	2,923.8 2,891.8	88.1 86.3
173295 Sadie	176	Argos	2,122	9	533,866.6	3,487.6	2,365.7	150.1
Leatherback Turtles								
173286 Teij	311	Argos Fast-GPS	4,036 1,375	13 35	7,970,999.2 7,888,017.1	15,489.5 15,229.6	4,925.8 4,915.9	2,030.7 1,995.5
173287 Kari	207	Argos	3,003	13	3,317,079.1	10,360.0	4,471.2	1,423.8
173289 Christine	84	Argos	1,172	18	1,467,306.6	4,941.2	3,317.5	518.0
180748 Regina	124	Argos	1,521	11	1,250,483.1	6,397.4	4,221.9	917.8
180749 Rhoda	366	Argos	4,843	11	2,764,932.1	12,068.8	3,528.4	779.9

km = kilometer

[a] indicates a standardized calculation based on a subset of the data (i.e., one location per day)

Table 3-5: 2019-tagged Turtle Dive and Fastloc GPS Data Collected in Predefined Sampling Intervals and Relayed through the Argos System

Turtle ID	Tag Type	Status	Time-Series	Time-at-Temperature	Time at Depth	Haul-Out	% Dry Time	Dive Depth	Dive Duration
Green Turtles									
173292 Michelle	GPS	136	-	166	-	1	-	-	-
173295 Sadie	Dive	100	468	150	152	-	148	152	157
Leatherback Turtles									
173286 Teij	GPS	249	-	300	-	1	-	-	-
173287 Kari	Dive	219	599	199	198	-	193	193	199
173289 Christine	Dive	91	244	83	82	-	83	82	83
180748 Regina	Dive	119	350	122	123	-	116	118	122
180749 Rhoda	Dive	435	1,015	344	336	-	327	342	330

Note: Columns represent the reconstructed data files that were generated during the decoding process with respect to tag type (see Figure 2-4). Values indicate the number of messages received for each message type.

Table 3-6: Summary of 2019-tagged Turtle Behavioral Intervals Determined from Satellite Tracking Data

Turtle Id	Tracking	Inter-nesting			Migrating		Foraging		Method Used
	Dates	Clutches	Days	km Countries	Days	km Countries	Days	km Countries	
Green Turtles									
173292 Michelle	10 May–28 Oct 2019	1	1	7.5 GY	70	3,149.8 GY, SR, GF, BR	92	87.2 BR	Haul-Out, GIS
173295 Sadie	10 May–3 Nov 2019	4	36	56.8 GY	80	2,535.6 GY, SR, GF, BR	62	42.6 BR	Haul-Out, % Dry, Time Series, GIS
Leatherback Turtles									
173286 Teij	10 May 2019–16 Mar 2020	5	59	560.0 GY, VE, TT	211	-	44	-	Haul-Out, GIS
173287 Kari	10 May–3 Dec 2019	5	46	310.6 GY, VE	133	-	24	157.5 CA	Haul-Out, % Dry, Time Series, GIS
173289 Christine	11 May–5 Aug 2019	2	11	70.1 GY, VE	64	683.6 GP, BS, US	12	157.6 US	Haul-Out, % Dry, Time Series, GIS
180748 Regina	12 May–12 Sep 2019	5	56	244.0 GY	65	-	3	7.9 CA	% Dry, Time Series, GIS
180749 Rhoda	13 May 2019–18 May 2020	5	40	222.0 GY, VE	234	820.7 US	98	438.7 US	% Dry, Time Series, GIS

BS = Bahamas; BR = Brazil; CA = Canada; GF = French Guiana; GP = Guadeloupe; GY = Guyana; SR = Suriname; TT = Trinidad & Tobago; US = United States; VE = Venezuela

Note: “Clutches” indicates the total number of nests laid. “Days” indicates the number of days during the respective behavior period (inter-nesting, migrating, and foraging) within the tracking period. “km Countries” indicates the approximate distance in kilometers of coastline that was covered during the period and the territorial waters of the countries involved.

Although shorter than projected by battery life and programming alone, transmitter endurance improved for the 2019-tagged turtles over the 2018-tagged turtles for both green turtles (2018: 163.5 ± 15.4 days, 2019: 172.5 ± 5 days; mean ± 1 SD) (χ^2= 0.214, df = 1, p = 0.643)[9] and leatherback turtles (2018: 60.3 ± 44.5 days, 2019: 218.4 ± 119.9 days; mean ± 1 SD) (χ^2= 3.756, df = 1, p = 0.053). For the 2019-tagged turtles, all satellite tags were pretreated (rather than just the green turtle tags, as in the 2018 Expedition) with a high-quality commercial antifouling paint (Interlux® Micron 66), and the leatherback attachment technique was changed to a single wire from a double wire, which resulted in a tighter attachment. Tracking losses could be due to a variety of factors, including animal behavior, biofouling, predation, incidental capture of the animal, antenna damage, discharged battery, or attachment failure. As in the case of the 2018-tagged turtles, the data provided in the status and Argos messages and the number of satellites available over the life of the tags deployed in 2019 were examined to determine or rule out potential causes. In all but one turtle (Teij), there was no degradation in battery voltage and all tags had made fewer than half of the total transmissions possible, so issues related to battery life may be ruled out. Similar to the 2018-tagged turtles, there was evidence of biofouling from the wet/dry sensors on the tags deployed in 2019 on green (Michelle and Sadie) and leatherback (Teij, Kari, and Rhoda) turtles. This was further indicated by decreases in the number of GPS satellites seen over time (Michelle and Teij) and in the power of the Argos signal strength (Rhoda).

Even though all tags were coated with antifouling paint, as was the epoxy during attachment for green turtles, the GPS antenna remains obligatorily exposed and the efficacy of the antifouling paint degrades over time and with ablation. As described above, a tag affected by biofouling will sometimes stop transmitting for a period of time but then start up again; however, none of the 2019-deployed tags came back online after ceasing transmissions (similar to the 2018-deployed tags). The tag information from the two turtles with the shortest tracking durations (Christine and Regina) did not indicate biofouling or any other problems. Although both turtles' final locations occurred in regions of known high fisheries activities in both United States and Canadian waters, respectively, we can also probably rule out incidental capture of these animals, as there was no sudden increase in a series of high-quality locations that are typically associated with an animal on land or on a boat. Christine was last recorded in the western edge of the Gulf Stream, which could have added shear stress on her transmitter.

Despite the fact that the actual transmitting period was shorter for both the 2018- and 2019-deployed tags than predicted by battery life and programming, the actual tracking durations of the turtles in this study are within the range of those published in the scientific literature.

[9] χ^2=Chi-squared value, df = degrees of freedom, p = p value

3.2. Inter-nesting Period

3.2.1. 2018 Expedition

Three types of inter-nesting movement behaviors were identified for the 2018-tagged turtles (Figure 3-1):

1. Remained in the immediate vicinity of Almond Beach, making small near-shore loops (Sibille and Becky);
2. Moved moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops (Violet); and
3. Moved large distances, making small near-shore loops in the vicinity of Almond Beach and larger offshore loops between Venezuela, Trinidad, and Guyana (Karin, Julie, Denise, and Arleen).

Turtles nested between two and seven times each, exclusively on Almond Beach, typically at intervals of approximately 12 days, with the exception of one animal (Violet), who also nested across the Barima-Waini river mouth and nested at longer time intervals than the other turtles (Figure 3-2, Figure 3-3, and Figure 3-4; Table 3-3). Green turtles (13 +/- 1.7 days [mean +/- 1 SD]) demonstrated longer re-nesting intervals than leatherback turtles (9.5 +/- 0.5 days [mean +/- 1 SD]) (χ^2= 12.492, df = 1, $p < 0.001$; Figure 3-4). The distances of green turtle nests from their initial capture locations ranged from 0 to 33.7 kilometers (Figure 3-4) with significant differences among individuals (χ^2= 33.017, df = 3, $p < 0.001$). Most of this variability stemmed from Violet and Karin; if their nests are removed from the data set, the remaining nests were all within 1 kilometer of the respective original capture locations. Leatherback turtle nests were within 1.9 kilometers of their respective original capture locations (Figure 3-4), but also showed individual differences in nest dispersal (χ^2= 7.593, df = 2, $p = 0.022$), driven by Denise's slightly more diffuse nesting, as compared to that of Julie or Arleen. All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements between nesting events (Table 3-1). With respect to the size of the area used by the turtles during the inter-nesting period, there were no significant differences between species or among individuals; however, the leatherback turtles occupied waters at a farther distance from shore during inter-nesting than did the green turtles (χ^2= 4.500, df = 1, $p = 0.034$; Figure 3-4).

Figure 3-1: Spatial Footprints of 2018-tagged Green and Leatherback Turtle Inter-nesting Movements from Almond Beach

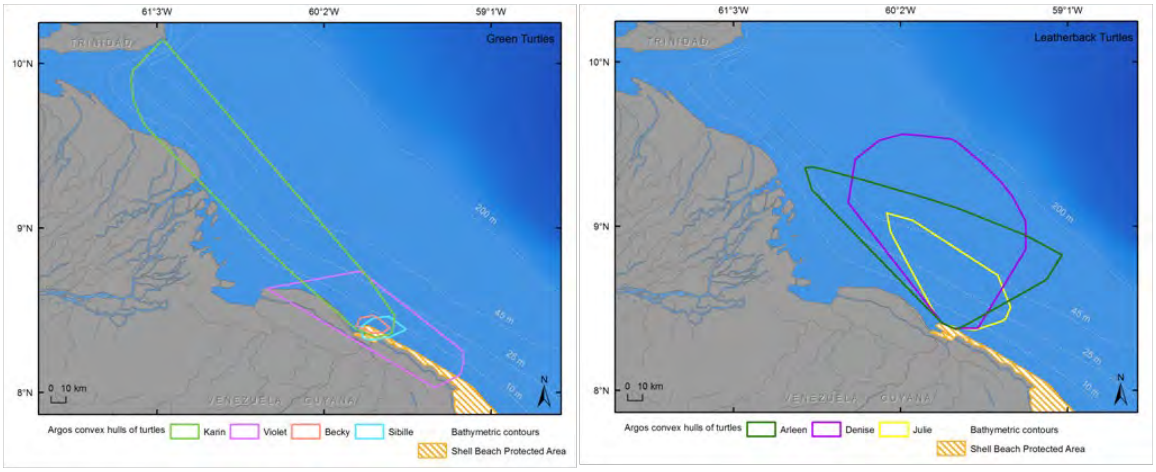


Figure 3-2: Re-nesting Locations and Spatial Footprints of 2018-tagged Green Turtles during Inter-nesting

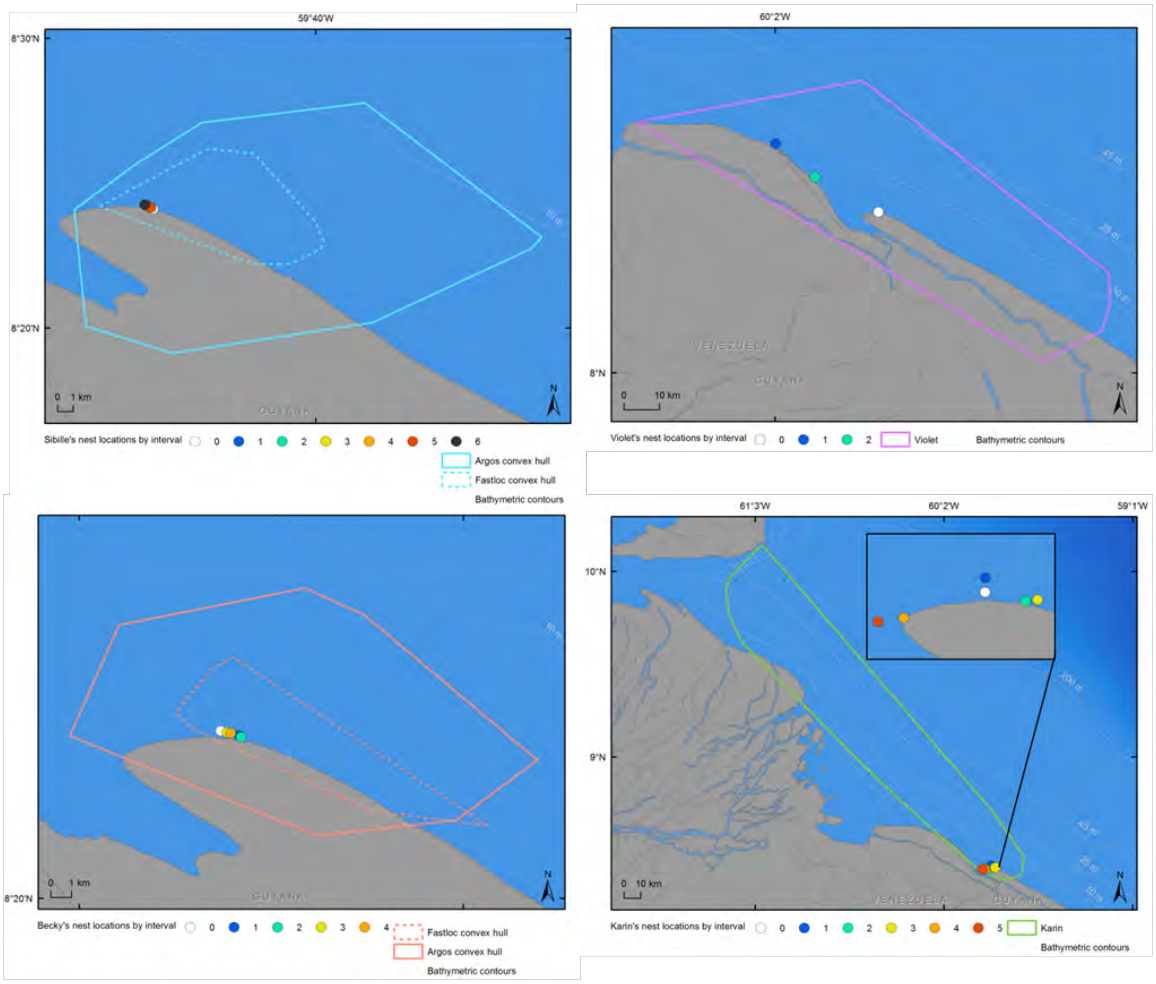
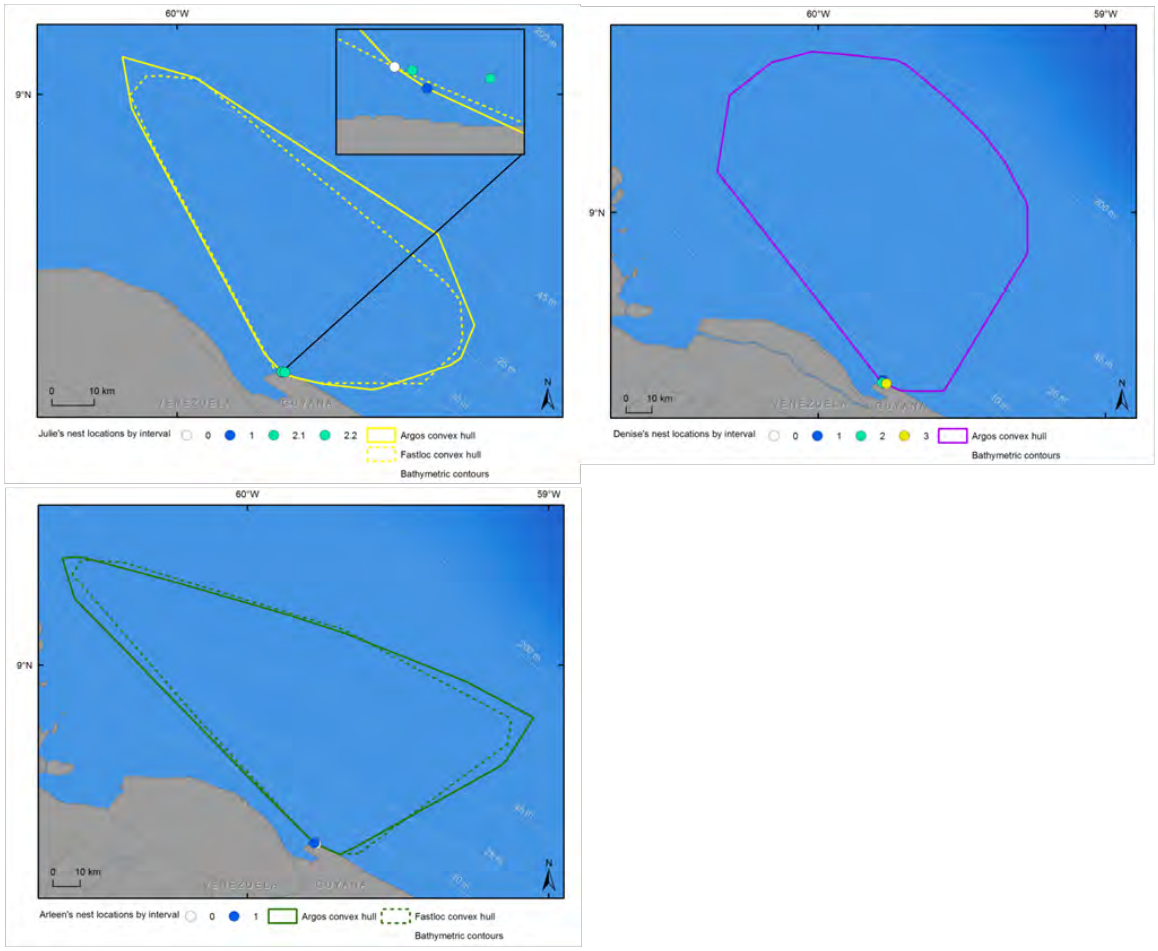
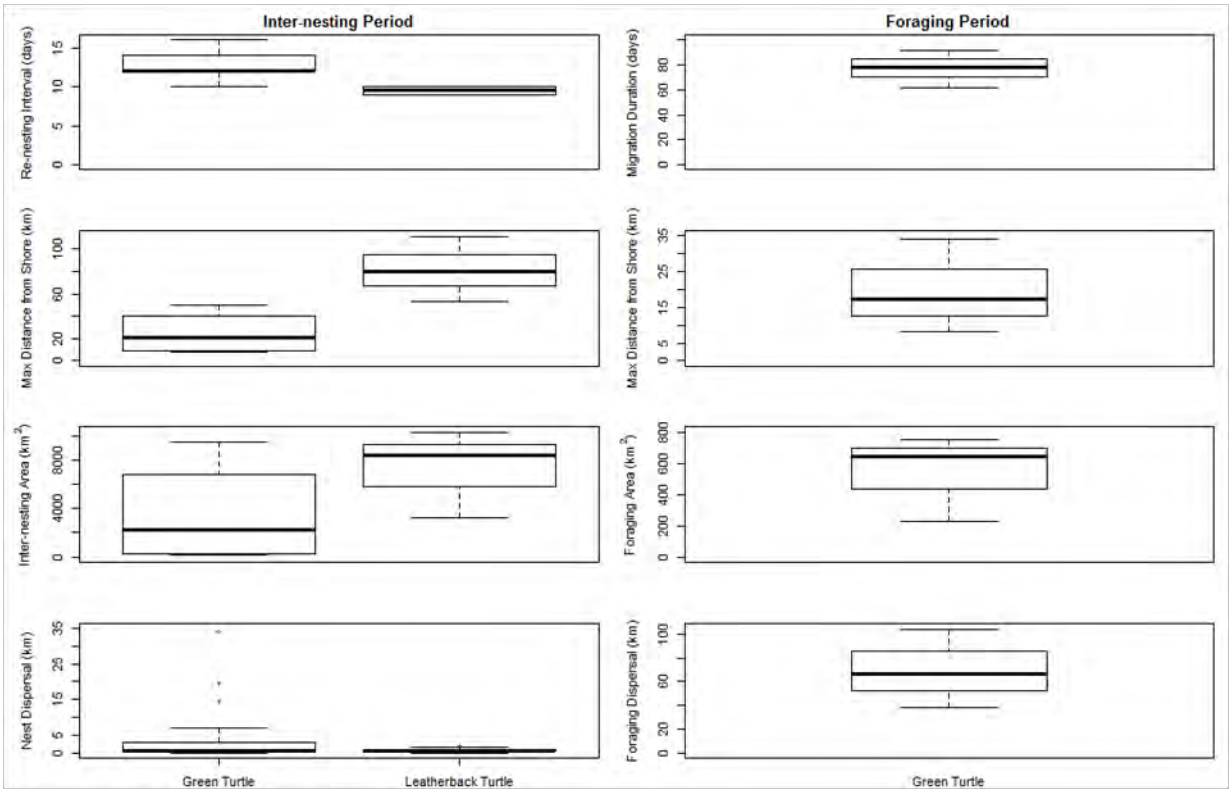


Figure 3-3: Re-nesting Locations and Spatial Footprints of 2018-tagged Leatherback Turtles during Inter-nesting



Note: Re-nesting periods with more than one point with the same color symbol (numbered with decimal labels) represent multiple attempts (i.e., false crawl) as indicated by the haul-out or percent dry time data.

Figure 3-4: Box and Whisker Diagrams Comparing Habitat Use Metrics between Species and between Inter-nesting and Foraging Periods for 2018-tagged Turtles



Note: The thick line represents the median value, the box shows the values between the upper and lower quartiles, the whiskers indicate the range, and the points show outliers.

Leatherback turtles occupied deeper water (34.9 +/- 35.8 meters [mean +/- 1 SD]) than green turtles (6.8 +/- 7.2 meters [mean +/- 1 SD]) during the inter-nesting period (Figure 3-5). The greatest density of green turtle locations occurred in less than 5 meters of water depth (Figure 3-6); the greatest density of leatherback turtle locations occurred in less than 10 meters of water depth (Figure 3-7). There were individual differences in depth use during this period for both green turtles and leatherback turtles. The two green turtles with depth sensors recorded maximum dives of 16.7 meters during this period, but data indicated that the majority of their dives were within the upper 5 meters of the water column (Figure 3-8A and Figure 3-9A). The one leatherback turtle with a depth sensor tag recorded a maximum dive of 134.5 meters during the inter-nesting period, but data indicated that most dives were within the upper 10 meters of the water column (Figure 3-10A). Details on the vertical habitat use of turtles during their entire tracking period are summarized in Table 3-7 and Figure 3-11, Figure 3-12, and Figure 3-13.

Table 3-7: 2018-tagged Turtle Daily Vertical Habitat Use

Turtle ID	Water Depth (m)		Turtle Depth (m) [a]		Maximum Dive Depth (m) [b]	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Green Turtles						
173290 Sibille	10.5 (9.1)	1.0–42.0	-	-	-	-
173293 Violet	9.9 (6.9)	1.0–42.0	6.9 (5.4)	0.0–34.0	12.5 (6.1)	1.8–33.8
173291 Becky	12.2 (11.1)	1.0–69.0	-	-	-	-
173294 Karin	9.1 (9.1)	1.0–48.0	6.0 (5.1)	0.5–37.0	10.3 (6.8)	2.8–37.0
Leatherback Turtles						
173284 Julie	58.9 (198.4)	1.0–1,065.0	-	-	-	-
173288 Denise	1,400.9 (1,961.8)	1.0–5,437.0	22.7 (33.5)	0.5–560.5	108.3 (100.0)	7.3–560.5
173285 Arleen	3,909.9 (1,932.3)	1.0–5,963.0	-	-	-	-

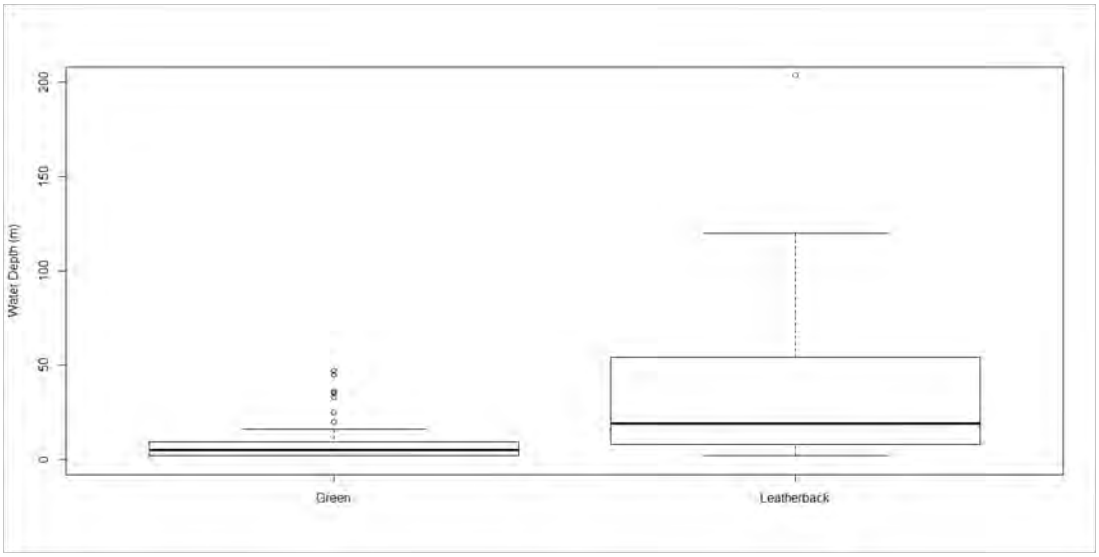
m = meter

Note: Turtle daily vertical habitat use (i.e., depth) was inferred from sampling bathymetric maps (see Figure 3-5 and Figure 3-6) and from dive data collected by the turtle tags. Sibille, Becky, Julie, and Arleen were not equipped with dive recorders.

[a] Turtle Depth values are calculated from separate data files than Maximum Dive Depth, so in some cases the deeper limit of the Turtle Depth range does not coincide with the Maximum Dive Depth. In most cases, the difference in these numbers is small, but for each individual turtle, the actual maximum depth that turtle was documented to have reached is the largest of these two numbers.

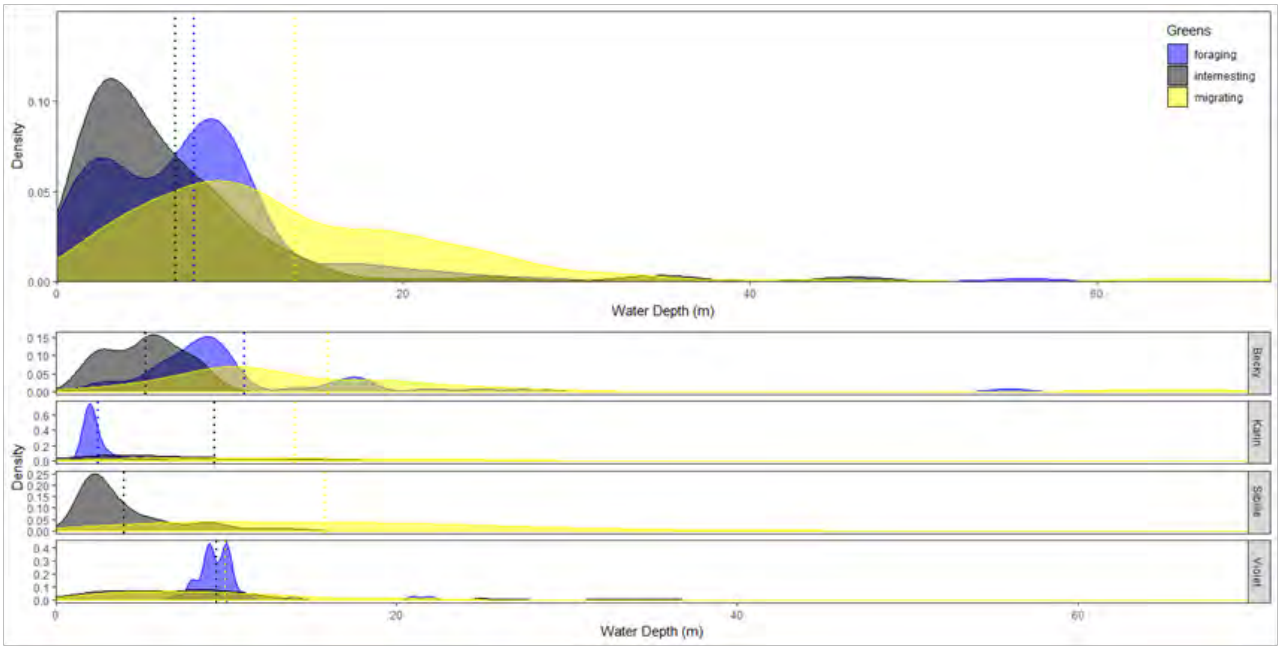
[b] This table shows the mean and standard deviation as well as the range. For example, the maximum depth of a given dive was on average 10 to 13 meters for green turtles. Maximum dives of 30 to 40 meters were rare but are captured in the range column of the table. The same logic applies to leatherbacks.

Figure 3-5: Box and Whisker Diagram Showing Water Depth Use for 2018-tagged Green and Leatherback Turtles during the Inter-nesting Period



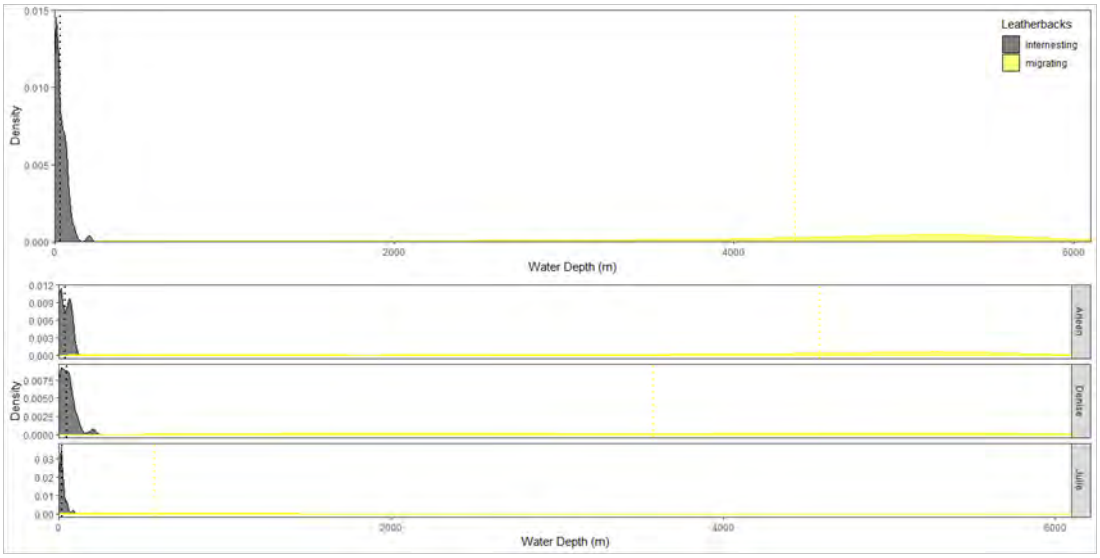
Note: The thick line represents the median value, the box shows the values between the upper and lower quartiles, the whiskers indicate the range, and the points show outliers.

Figure 3-6: Density Distribution of Water Depths Occupied by 2018-tagged Green Turtles Combined Together (Top Panel) and Individually (Bottom Panels) during Different Tracking Periods (Indicated by Color)



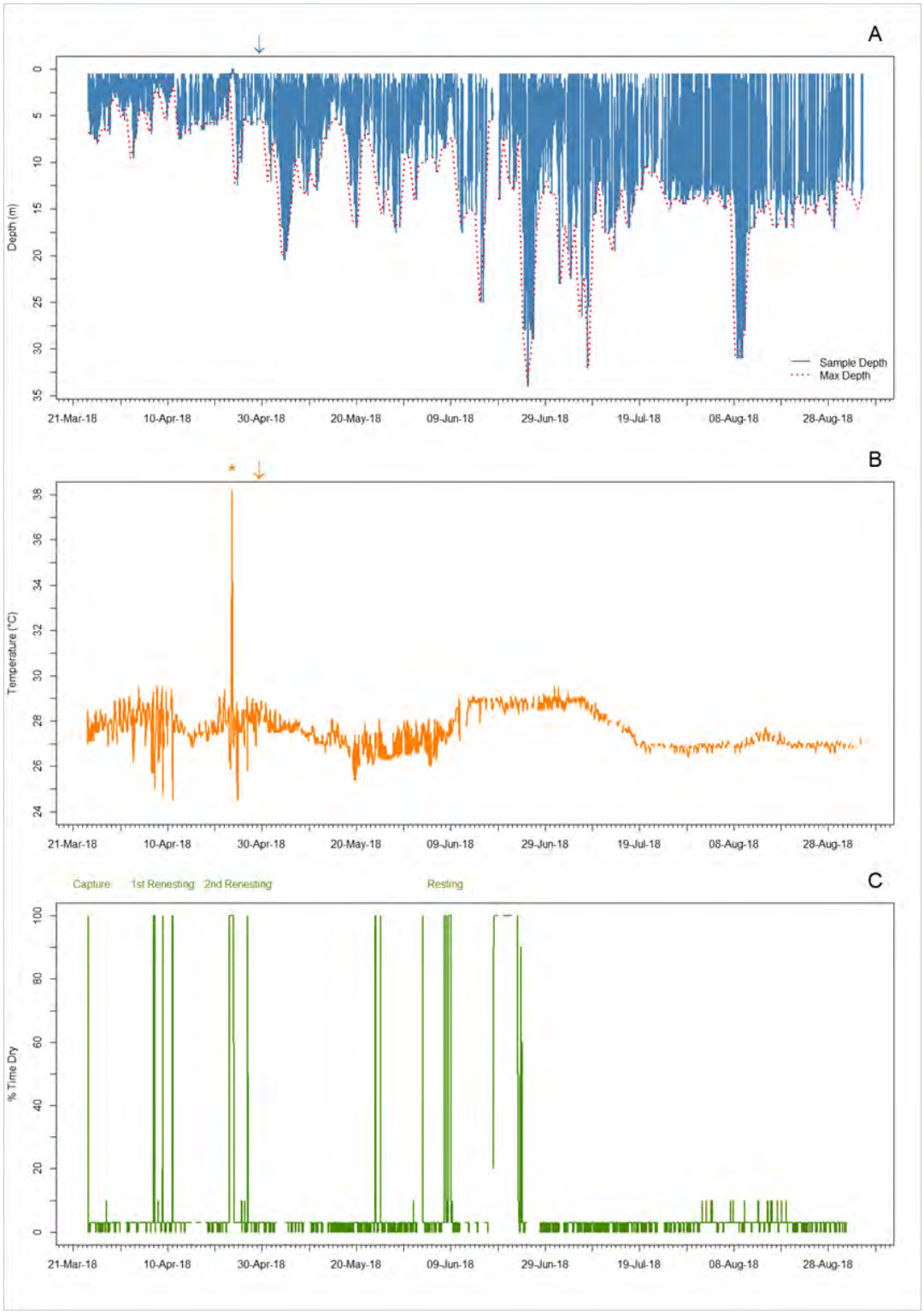
Note: Mean values for the sampling period are indicated by a vertical dotted line. Water depth values were extracted from a GEBCO-14 global bathymetry raster at the single best Argos location per day in a GIS to facilitate comparisons among animals. Points falling on land were excluded from this analysis.

Figure 3-7: Density Distribution of Water Depths Occupied by 2018-tagged Leatherback Turtles Combined Together (Top Panel) and Individually (Bottom Panels) during Different Tracking Periods (Indicated by Color)



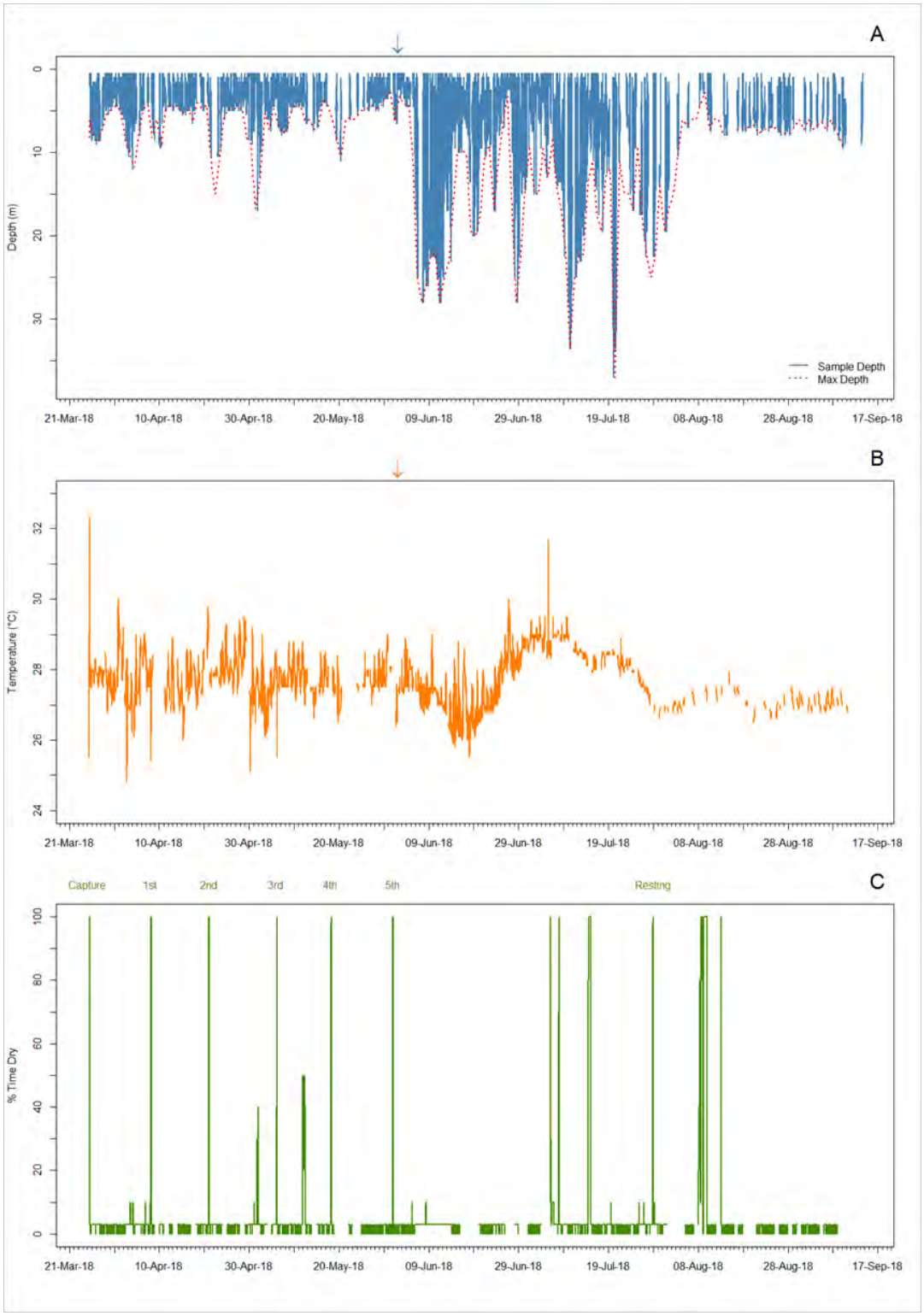
Note: Mean values for the sampling period are indicated by a vertical dotted line. Water depth values were extracted from a GEBCO-14 global bathymetry raster at the single best Argos location per day in a GIS to facilitate comparisons among animals. Points falling on land were excluded from this analysis.

Figure 3-8: Time-Series Plots of (Green Turtle) Violet's Dive Data



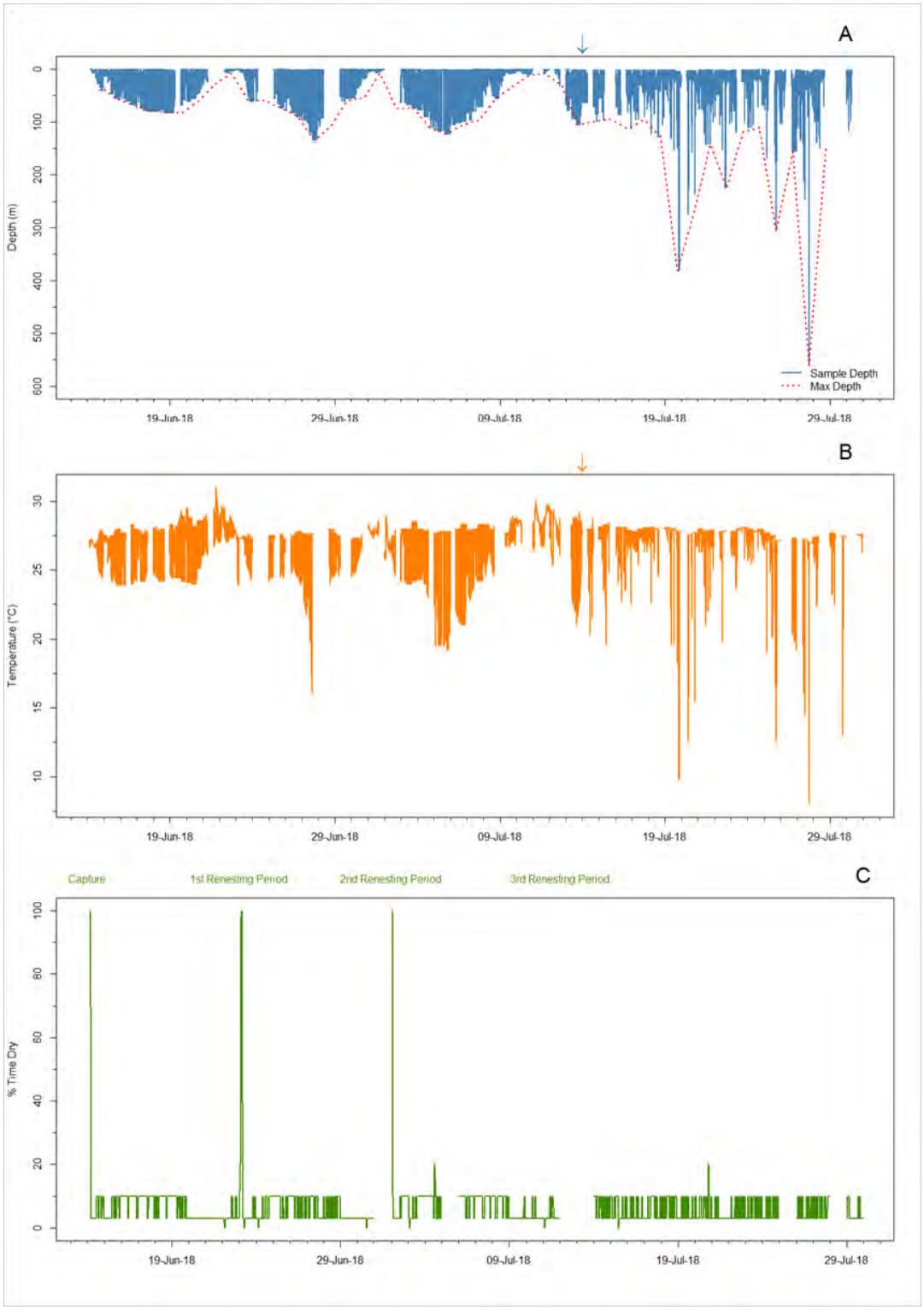
A. depth; B. temperature; C. percent dry time. Arrows indicate the start of Violet's migration period. The orange asterisk indicates a "stranding" event from 23 to 24 April 2018. Note the asynchronous 100 percent dry times (i.e., dry times that are not concurrent with a nesting event) over a period of 5 days within individual re-nesting periods and again during the migration period; these are probable resting periods at the surface.

Figure 3-9: Time-Series Plot of (Green Turtle) Karin's Dive Data



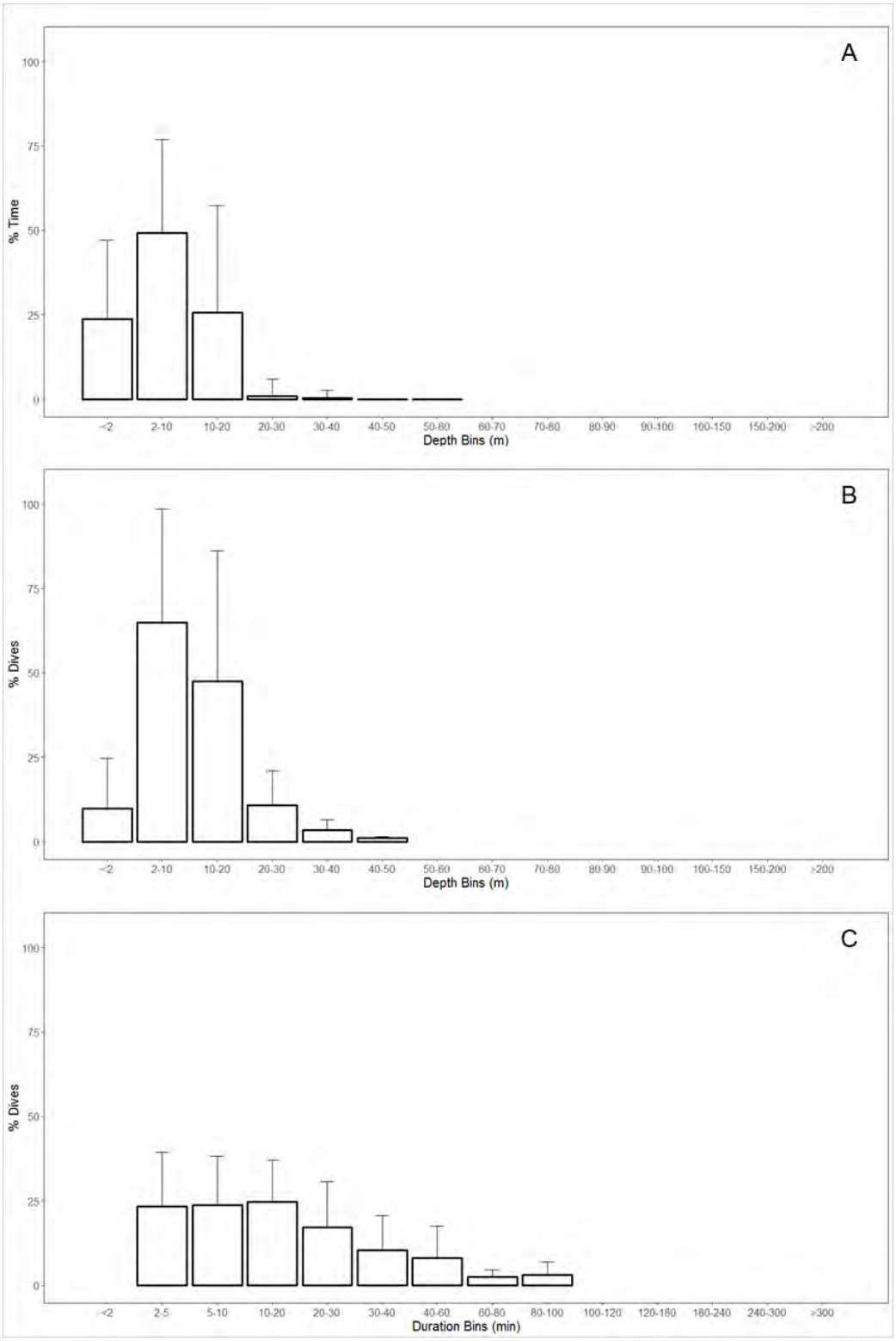
A. depth; B. temperature; C. percent dry time. Arrows indicate the start of Karin's migration period. Note the synchronous 100 percent dry times marking individual re-nesting periods and the asynchronous 100 percent dry times (i.e., dry times that are not concurrent with a nesting event), during the migration period; the latter are probable resting periods at the surface.

Figure 3-10: Time-Series Plot of (Leatherback Turtle) Denise's Dive Data



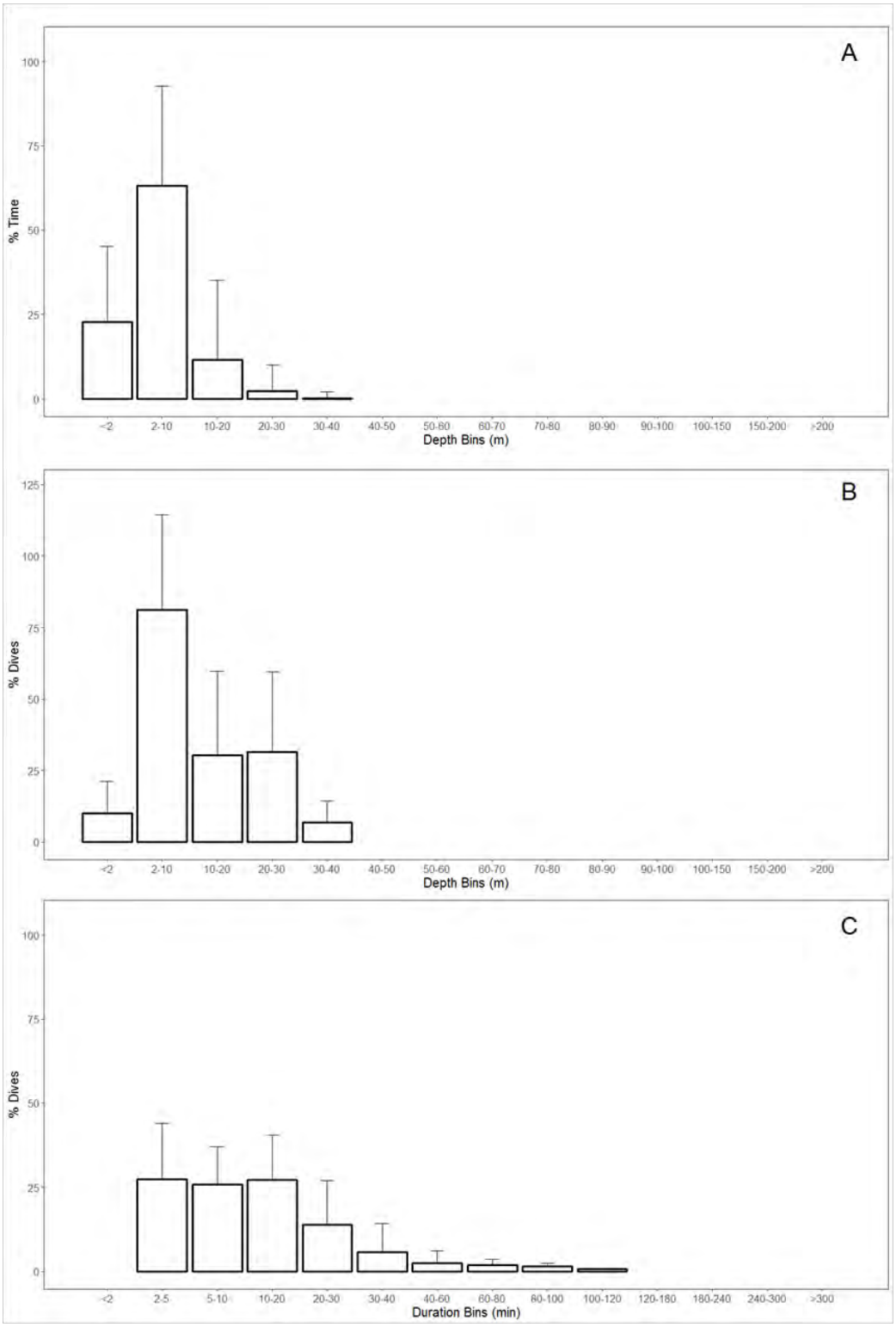
A. depth; B. temperature; C. percent dry time. Arrows indicate the start of Denise's migration. Note the synchronous 100 percent dry times marking two individual re-nesting periods, but a gap in the data that misses the third re-nesting event, which was determined by location data.

Figure 3-11: Frequency Histograms of (Green Turtle) Violet's Dive Data during the Entire Tracking Period



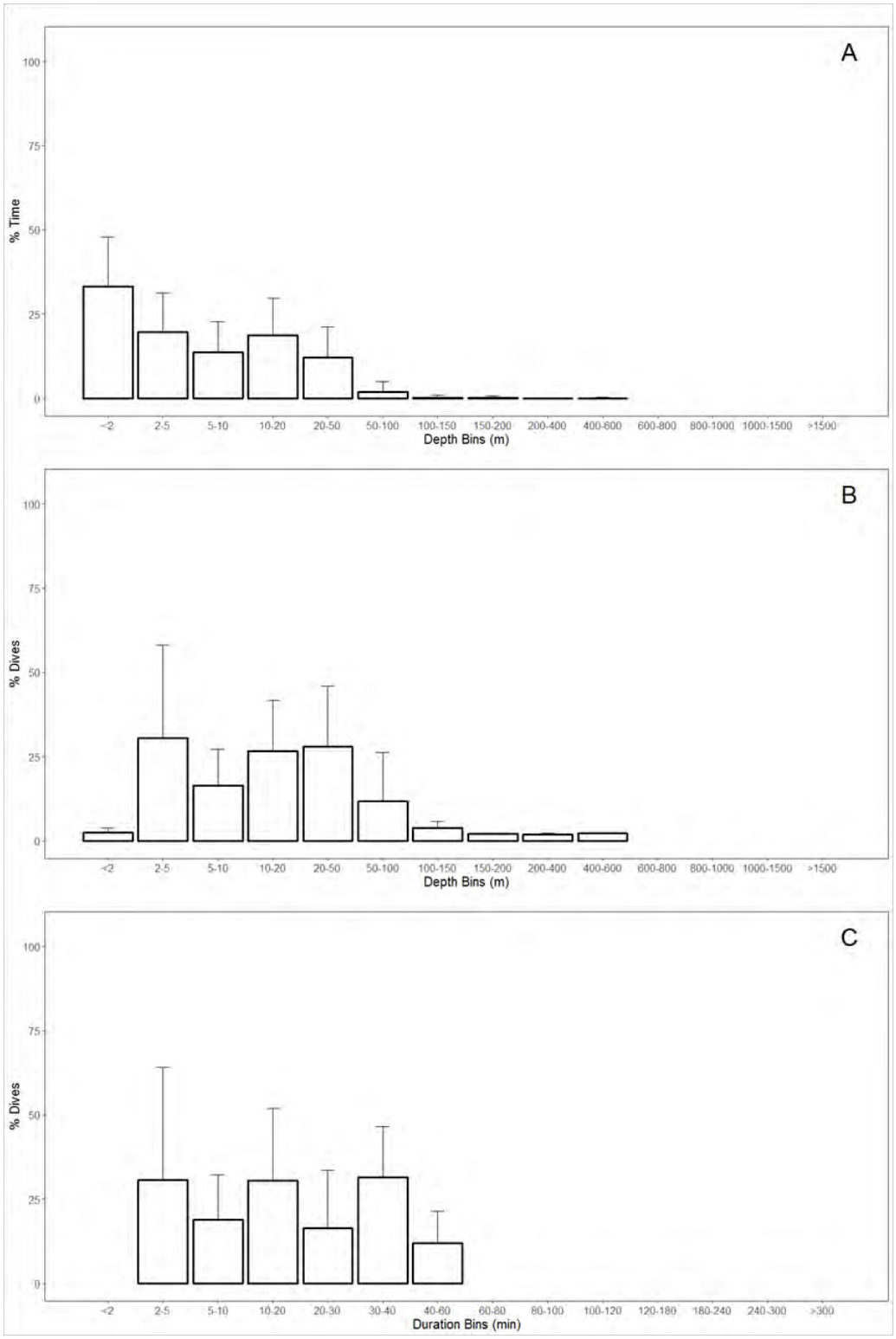
A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals. Boxes represent mean daily values and whiskers represent standard deviations.

Figure 3-12: Frequency Histograms of (Green Turtle) Karin's Dive Data during the Entire Tracking Period



A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals. Boxes represent mean daily values and whiskers represent standard deviations.

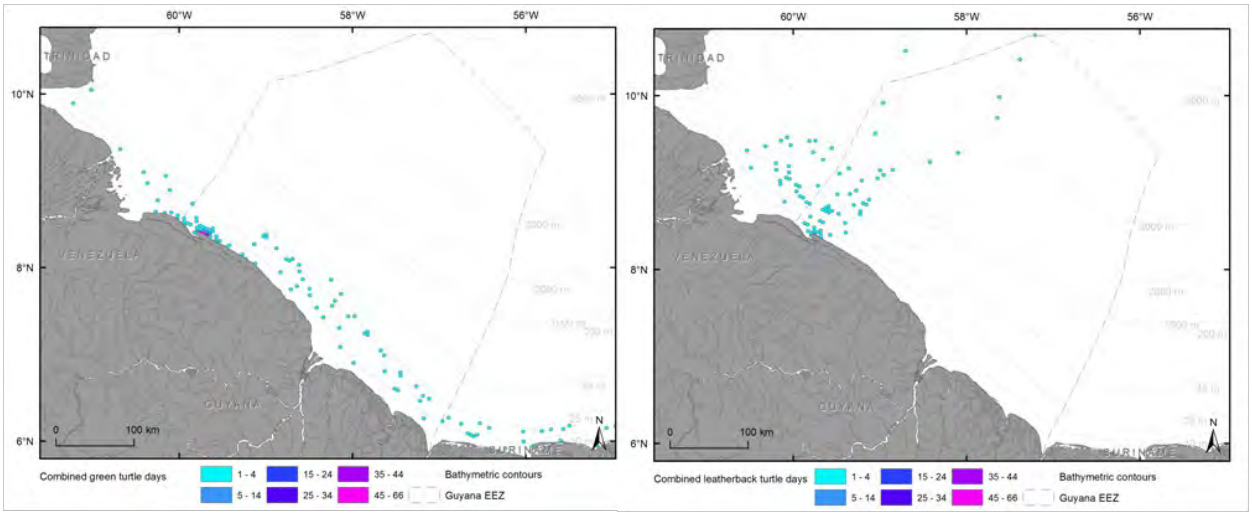
Figure 3-13: Frequency Histograms of (Leatherback Turtle) Denise's Dive Data during the Entire Tracking Period



A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals. Boxes represent mean daily values and whiskers represent standard deviations.

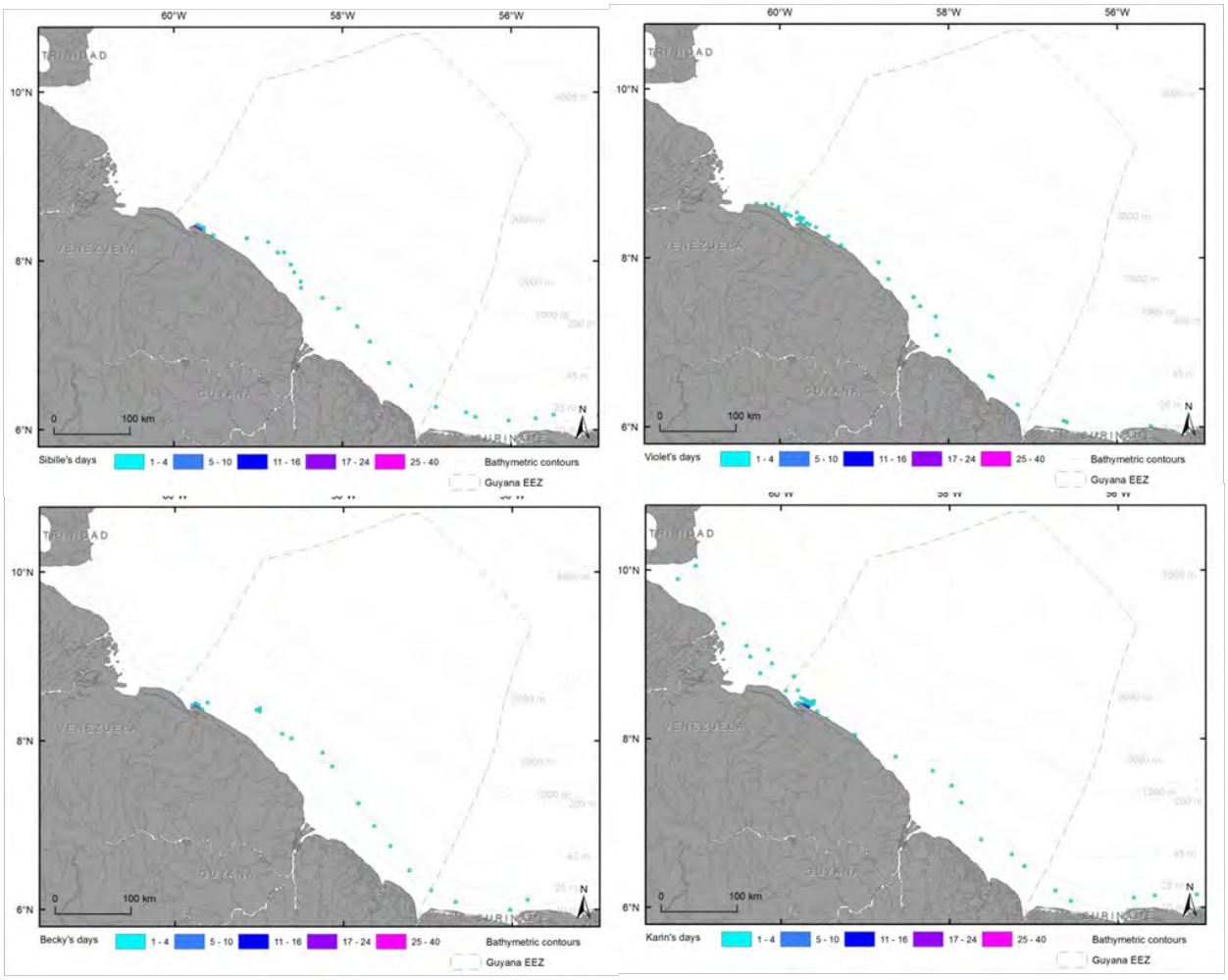
As highlighted above, three types of inter-nesting movement behaviors were characterized among the tagged turtles; despite these differences, the center of inter-nesting activity for all turtles was immediately adjacent to the nesting beach (Figure 3-1). Generally, the turtles' inter-nesting habitat use was concentrated within the territorial seas of Guyana—within the direct vicinity of Almond Beach (Figure 3-1, Figure 3-14), but also included the territorial seas of Venezuela and Trinidad & Tobago (Table 3-3). Sibille and Becky (Figure 3-2, Figure 3-15) remained near their capture locations, spanning 16.7 kilometers and 17.8 kilometers of coastline, respectively, circling within the 10-meter bathymetric contour, and never traveling more than 11 kilometers from shore. Both of these animals' tags were equipped with Fastloc GPS capability. While there is some variability in the tracks generated from their Argos and Fastloc GPS data, both demonstrated similar patterns, with Fastloc data falling within the Argos convex hulls (Figure 3-2).

Figure 3-14: Synopsis of Habitat Use of 2018-tagged Turtles, Centered within Guyana's Exclusive Economic Zone



Note: A synopsis of habitat use of turtles centered within Guyana's Exclusive Economic Zone, presented as the number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers. This encompassed the turtles' inter-nesting periods and part of their migration period.

Figure 3-15: Synopsis of Habitat Use of Individual 2018-tagged Green Turtles, Centered within Guyana's Exclusive Economic Zone

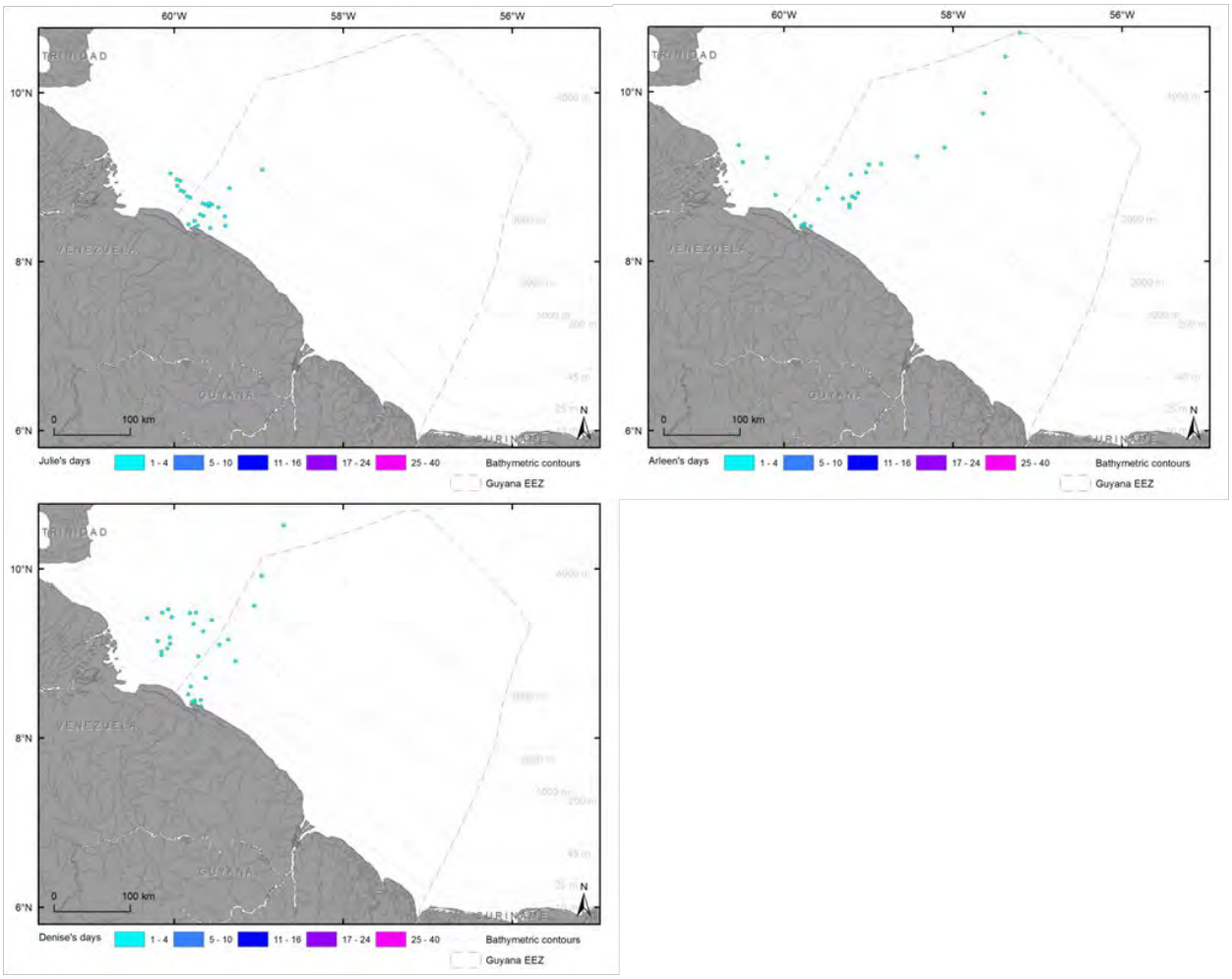


Note: A synopsis of habitat use of individual green turtles centered within Guyana's Exclusive Economic Zone, presented as number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers. This encompassed the turtles' inter-nesting periods and part of their migration period.

Violet and Karin (Figure 3-15) and the three leatherbacks (Julie, Denise, and Arleen [Figure 3-16]), demonstrated more itinerant movement behaviors as compared to Sibille and Becky (Figure 3-15). Violet's movements extended 106.5 kilometers laterally northwest and southeast along the coastline, where she made similar but more extensive loops offshore, primarily within the 10-meter bathymetric contour (Figure 3-2 and Figure 3-15) and within 30 kilometers of Guyana and Venezuela (Figure 3-2 and Figure 3-15; Table 3-3). This turtle was identified as a new nester at the SBPA (not already having flipper tags at capture). Her elaborate forays, disparate nesting attempts, and extended inter-nesting intervals may reflect her inexperience in selecting a nest site. Violet presented an interesting example of unusual inter-nesting behavior (Figure 3-8C). During her second re-nesting period, she was apparently stranded on the Venezuela shoreline for a nearly 22-hour period. This area is characterized entirely by mud banks (R. DeFreitas, personal communication), so when the turtle came up to nest, she apparently got stuck in the mud and was unable to return until the tide came in and released

her. This stranding event is visible in the data by looking at the combined characteristics of the time-series graphs, specifically: (a) a positive depth (i.e., higher than sea level), (b) a maximum temperature peak of 38°C, and (c) a wide peak in the 100 percent dry time (Figure 3-8). The event occurred across the channel from the SBPA, where the turtle would not have been visible to PAC rangers conducting nightly patrols (Figure 3-1), but the turtle was eventually able to re-enter the water and successfully started her migration southward just days later. She was the first to leave the SBPA (Table 3-3).

Figure 3-16: Synopsis of Habitat Use of Individual 2018-tagged Leatherback Turtles Centered within Guyana's Exclusive Economic Zone



Note: A synopsis of habitat use of individual leatherback turtles centered within Guyana's Exclusive Economic Zone, presented as number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers.

Karin exhibited the farthest movements during her inter-nesting period of all the green turtles, extending along 261.7 kilometers of coastline, venturing 50 kilometers offshore of the Orinoco River Delta, Venezuela on one of her loops, and reaching the Port of Galeota on the Trinidad coastline on another (Figure 3-2 and Figure 3-15; Table 3-3). She also made five shorter loops within the 10-meter bathymetric contour. This turtle had previously nested at the SBPA (already possessing flipper tags) and the precision of her returns after forays may demonstrate her

previous experience nesting at this area. Karin also presented an interesting example of what first appeared to be an unusually high number of erroneous points on land on the east end of Almond Beach between 8 and 29 May 2018 (Figure 3-17). Upon close inspection in Google Earth for more recent shoreline profiles, the points still seemed unlikely, albeit some are in swampland and several have high-quality location classes. More recent photos from the air (see Figure 3-17) illustrate clearly that extreme coastal erosion had facilitated seawater intrusions across the beach and into the large swampland behind the beach. Increased erosion was observed in June, making parts of Almond Beach inaccessible at high tides. Evidently, Karin swam into the swamp area and either had difficulties finding her way out, or was content to go back and forth between the ocean and swamp during the 10-day period. Karin and Sibille were the last to leave the SBPA, only 1 day apart (Table 3-3).

Figure 3-17: Satellite View of Karin's Locations between 8 and 29 May 2018

Photos by R. DeFreitas

Note: A satellite view of Karin's locations between 8 and 29 May 2018 showing an unusual concentration of high-quality positions falling in series on what appeared to be land. Low-quality positions are shown in black and high-quality positions are in red. Photos of the area from the air in March 2018 show that due to large amounts of coastal erosion, the sea had breached the shore in several places, making the swamp in the background accessible. The turtle was therefore determined to indeed be inhabiting these "inland" regions for a 10-day period.

Julie was the only leatherback with a flipper tag scar, and so was not a neophyte nester. She displayed the most moderate offshore movements (54 kilometers from shore) among the leatherback turtles during the nesting season, traveling 104.9 kilometers of coastline between Guyana and Venezuela and staying within the 50-meter bathymetric contour (Figure 3-3 and Figure 3-16; Table 3-3). This turtle most likely made a false crawl on her second re-nesting

attempt. There were several false crawls associated with the 2018-tagged turtles, presumably due to the large amount of debris covering the nesting beach at that time (Figure 3-18).

Figure 3-18: Extensive Debris Present on Almond Beach in June 2018

Photo by C. McClellan

Denise moved the farthest distance from shore (111 kilometers), crossing the 100-meter bathymetric contour during three inter-nesting loops (Figure 3-3 and Figure 3-16) that spanned 120.4 kilometers of shoreline including both Guyana and Venezuela (Table 3-3). It was these highly visible and equally timed loops that indicated Denise's third re-nesting event, which was not captured in the time-series or haul-out records (Figure 3-10C).

Arleen made only one offshore inter-nesting loop into 50 meters of water before being the first of the tagged leatherback turtles to leave the SBPA (Figure 3-3 and Figure 3-16; Table 3-3). This movement stretched across the Orinoco River Delta approximately 80 kilometers from land, comprising a total span of 204.6 kilometers along the coast.

Time-series information was useful for visualizing vertical movements and identifying re-nesting events for animals that generally displayed complicated horizontal movements. Lower temperatures occurred during deeper dives, while the highest temperatures typically occurred during periods when the animals were hauled-out on land to nest (Figure 3-8B, Figure 3-9B, and Figure 3-10B), but occasionally also when they encountered warm water masses (see Figure 3-8B and below). Similarly, the 100 percent dry times coincided with zero-depths and changes in temperature (Figure 3-8, Figure 3-9, and Figure 3-10). Karin's discrete re-nesting periods were readily visible when looking at these time-series graphs together (Figure 3-9), for example, even though they were less obvious in the horizontal movement data.

3.2.2. 2019 Expedition

While all individuals tagged in 2019 showed strong nesting-site fidelity to their capture locations throughout the inter-nesting period, three inter-nesting movement behaviors were identified:

1. Immediately departing from the nesting region (Michelle);
2. Remaining in the immediate vicinity of Almond Beach making small near-shore loops (Sadie);
3. Moving large distances, making offshore loops between Venezuela, Trinidad and Tobago, and Guyana (Teij, Kari, Christine, Regina, and Rhoda) (Figure 3-19, Table 3-4).

Turtles returned to nest between zero and four times exclusively on Almond Beach at approximately 12-day intervals (Figure 3-20, Figure 3-21, and Figure 3-22; Table 3-6). Green turtles (11.7 ± 0.5 days; mean ± 1 SD) demonstrated similar re-nesting intervals to leatherback turtles this season (11.8 ± 3.6 days; mean ± 1 SD) (χ^2= 0.950, df = 1, p = 0.331; Figure 3-22). The distance of subsequent green turtle nests from the initial capture location (Sadie only) ranged from 0.5 to 1.5 kilometers (Figure 3-22). Leatherback turtle nests were within 8.3 kilometers of the original capture locations (Figure 3-22) and did not show individual differences in nest dispersal (χ^2= 6.418, df = 4, p = 0.170). All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements from Almond Beach (Table 3-4). With respect to the sizes of the areas used by the turtles during the inter-nesting period, there were no significant differences between species or among individuals; however, leatherback turtles occupied waters at a farther distance from shore than green turtles (χ^2= 2.143, df = 1, p = 0.143; Figure 3-22).

Figure 3-19: Spatial Footprints of 2019-tagged Green and Leatherback Turtle Inter-nesting Movements from Almond Beach

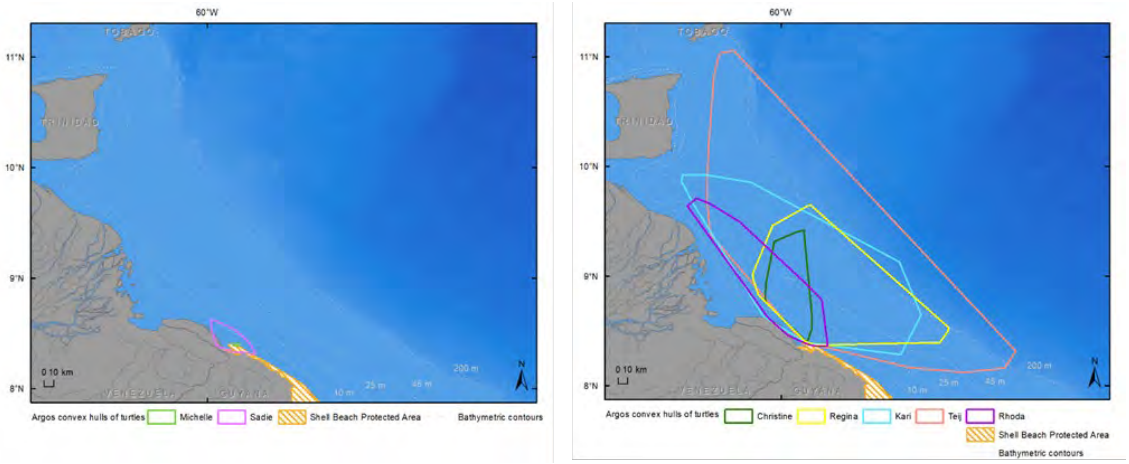


Figure 3-20: Re-nesting Locations of 2019-tagged Green Turtles and Spatial Footprints Generated from Argos and Fastloc Satellite Tracking Data, Respectively

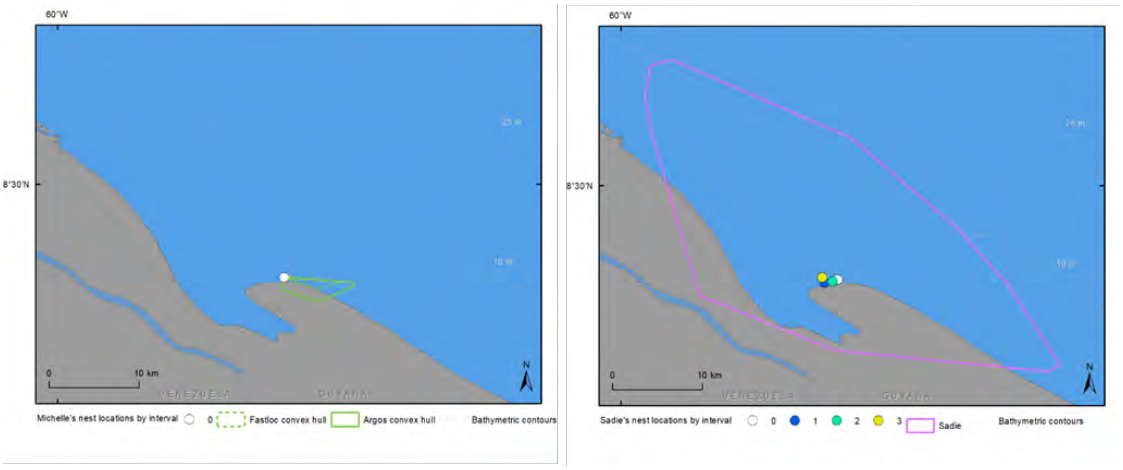
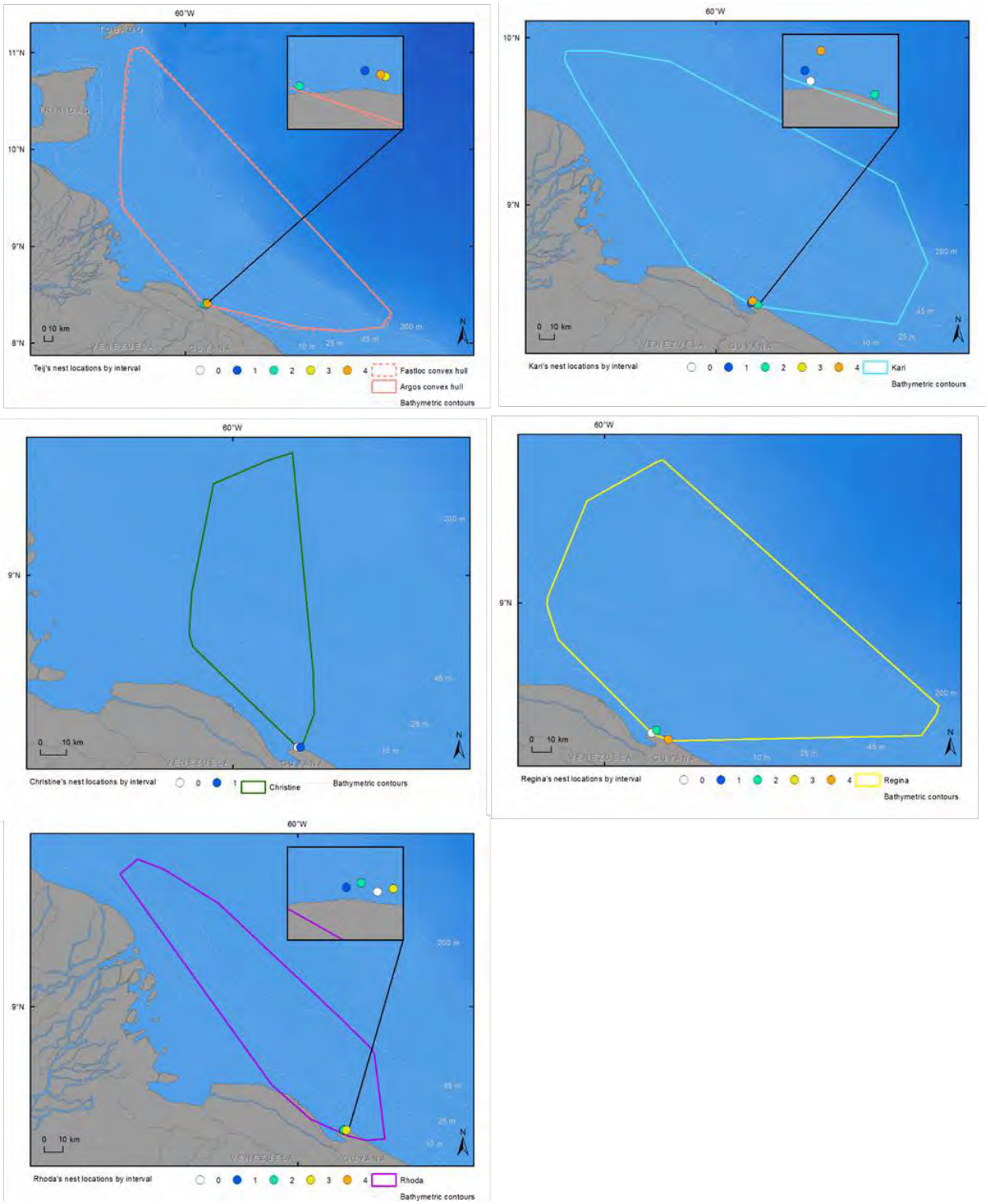
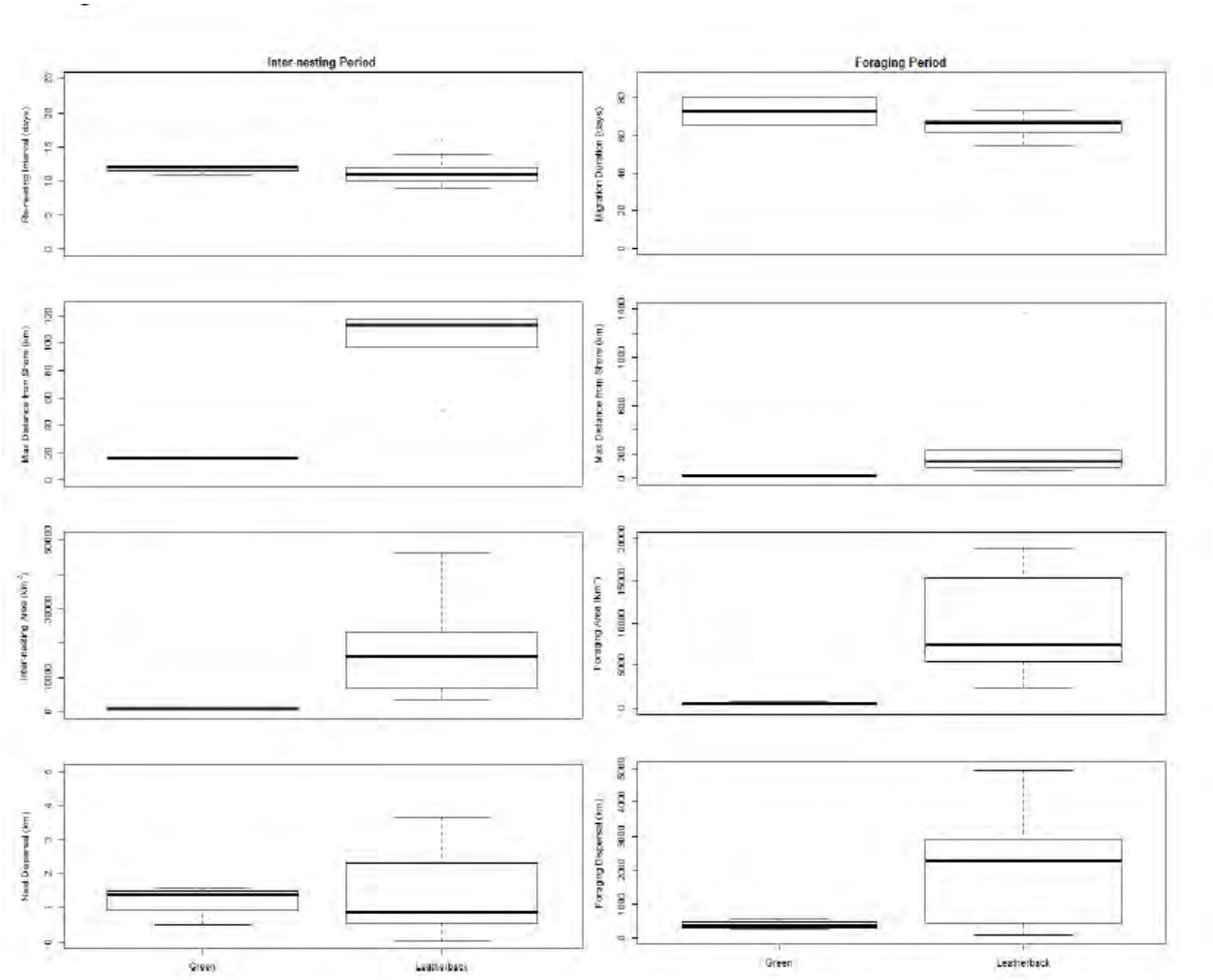


Figure 3-21: Re-nesting Locations of 2019-tagged Leatherback Turtles and Spatial Footprints Generated from Argos and Fastloc Satellite Tracking Data, Respectively



Note: Kari, Regina, and Rhoda had missing locations for some re-nesting intervals.

Figure 3-22: Box and Whisker Diagrams Comparing 2019-tagged Turtle Habitat Use Metrics between Species and between Inter-nesting and Foraging Periods

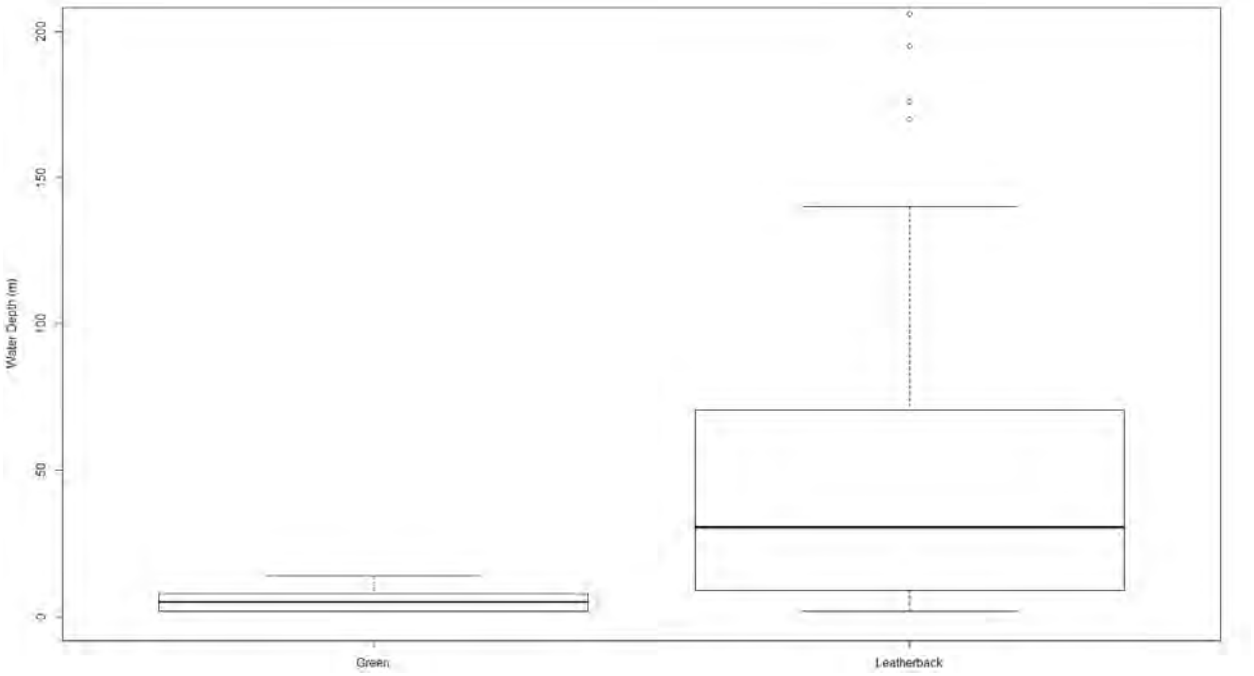


Note: The thick line represents the median value, the box shows the upper and lower quartiles, the whiskers indicate the range, and the points show outliers.

Leatherback turtles occupied deeper water than green turtles in the inter-nesting period (Figure 3-23). The greatest density of green turtle locations occurred in less than 5 meters of water (Figure 3-24) and less than 10 meters for leatherback turtles (Figure 3-25). There were individual differences in depth use during this period as well for leatherback turtles. The one green turtle with a depth sensor (Sadie) recorded maximum dives of 8 meters during this period, but data indicated that most of her dives were within the upper 5 meters of the water column (Figure 3-26A). The four leatherback turtles with depth sensor tags recorded maximum dives of 202 meters during the inter-nesting period, but data indicated that most dives were within the upper 20 meters of the water column (Figure 3-27A, Figure 3-28A, Figure 3-29A, and Figure 3-30A). Details on the vertical habitat use of turtles during their entire tracking period are summarized in Table 3-8 and Figure 3-31, Figure 3-32, Figure 3-33, Figure 3-34, and Figure 3-35. As highlighted above, three general types of movement behaviors were characterized, but despite these differences the center of activity for all turtles was immediately adjacent to the

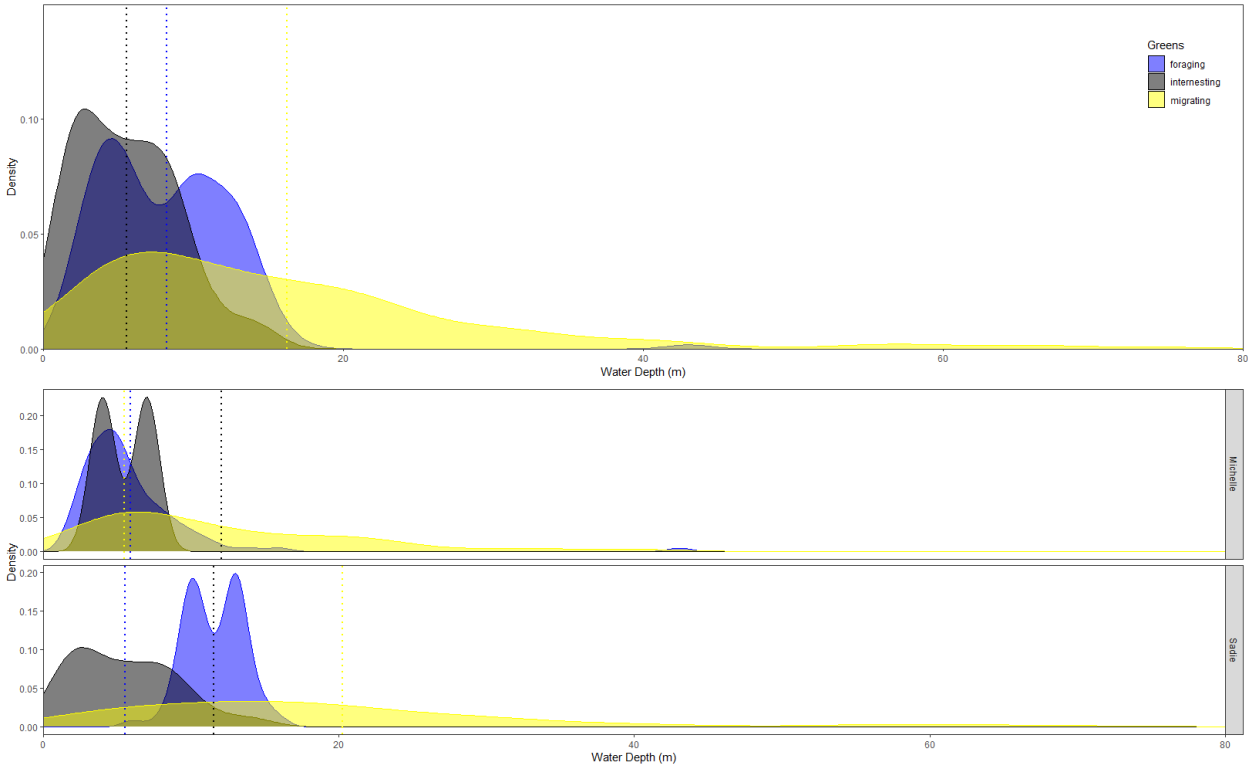
nesting beach (Figure 3-36). Generally, the turtles' inter-nesting habitat use was split between the territorial seas of Guyana and Venezuela (Figure 3-36), but also included the territorial seas of Trinidad and Tobago (Table 3-8). While Michelle left the nesting region right away after nesting, Sadie remained near her capture location, spanning 56.8 kilometers of Guyana's coastline (Figure 3-37) and circling within the 10 meter bathymetric contour, and was never more than 16 kilometers from shore (Figure 3-37, Table 3-6).

Figure 3-23: Box and Whisker Diagram Showing Differential Depth Use between 2019-tagged Green and Leatherback Turtles during the Inter-nesting Period



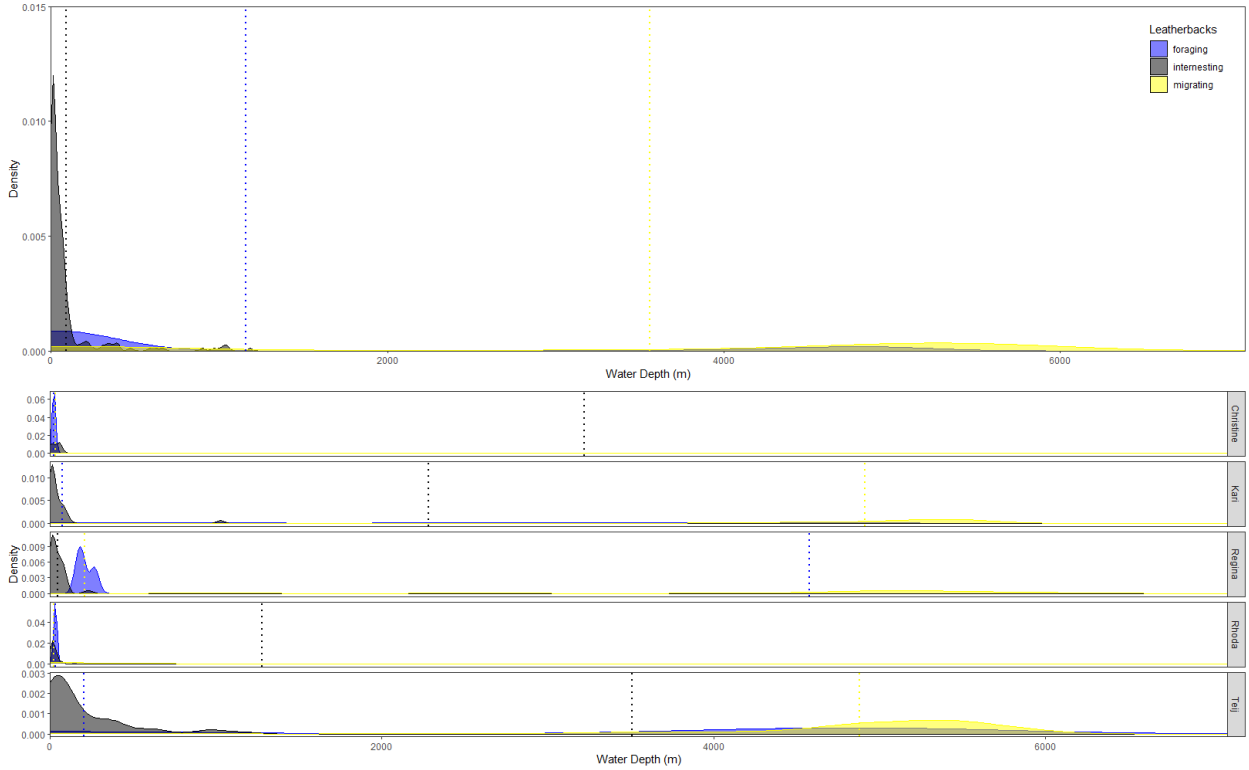
Note: The thick line represents the median value, the box shows the upper and lower quartiles, the whiskers indicate the range, and the points show outliers.

Figure 3-24: Density Distribution of Water Depths Occupied by 2019-tagged Green Turtles Combined (Top Panel) and Individually (Bottom Panels) during Different Tracking Periods (Indicated by Color)



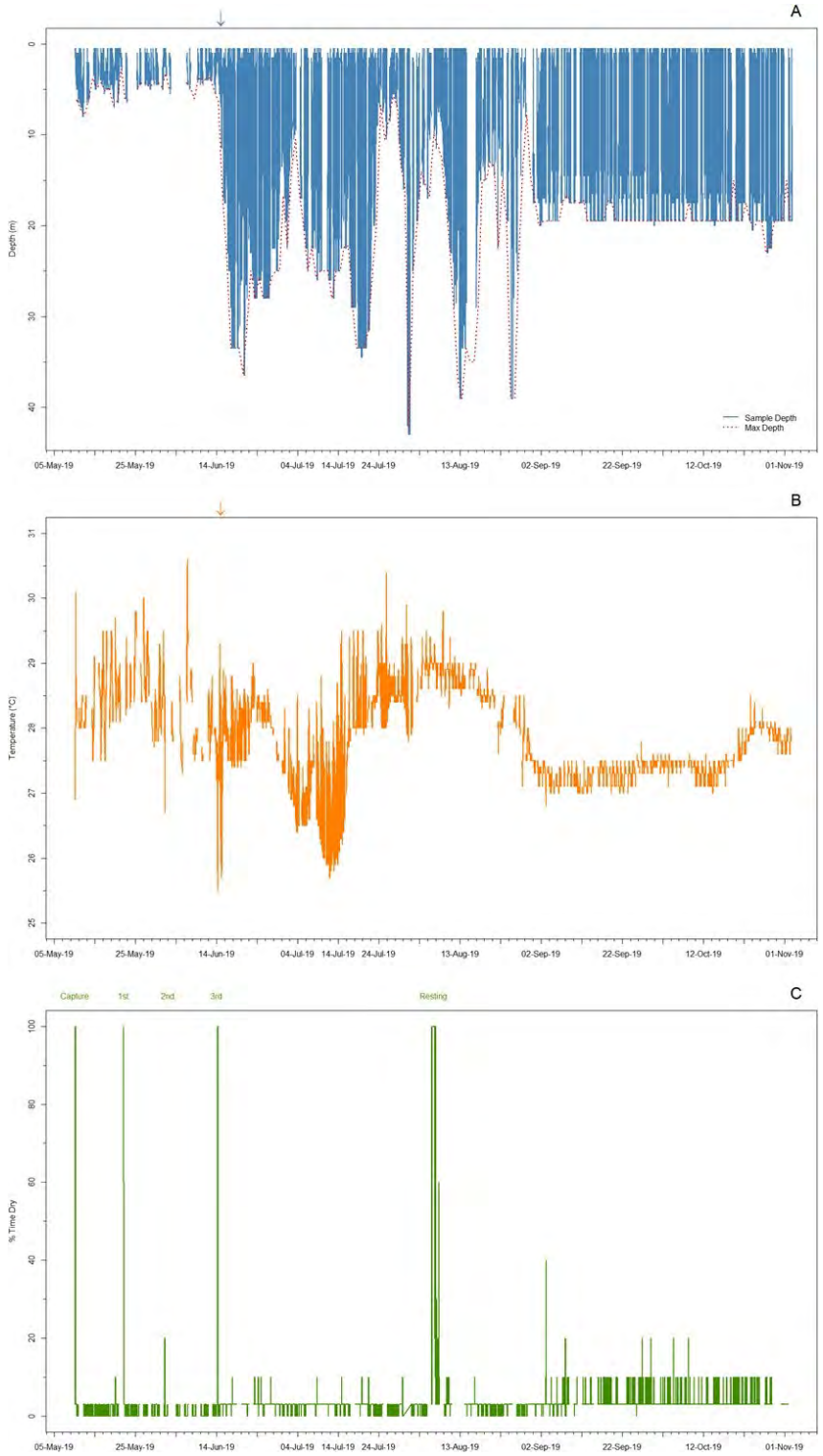
Note: Mean values for the sampling period are indicated by a vertical dotted line. Water depth values were extracted from a GEBCO-14 global bathymetry raster at the single best Argos location per day in a GIS to facilitate comparisons among animals. Points falling on land were excluded from this analysis.

Figure 3-25: Density Distribution of Water Depths Occupied by 2019-tagged Leatherback Turtles Combined Together (Top Panel) and Individually (Bottom Panels) during Different Tracking Periods (Indicated by Color)



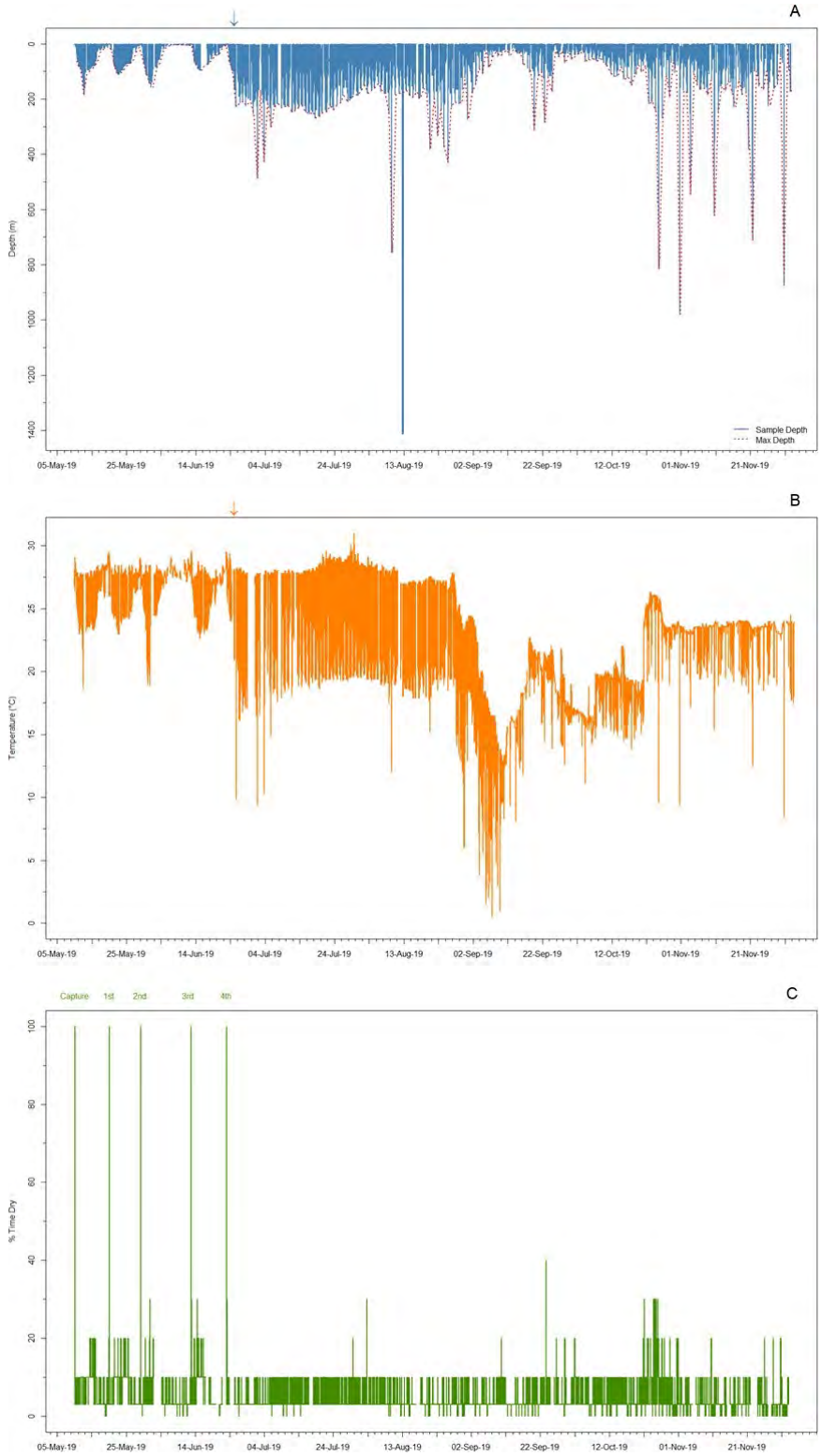
Note: Mean values for the sampling period are indicated by a vertical dotted line. Water depth values were extracted from a GEBCO-14 global bathymetry raster at the single best Argos location per day in a GIS to facilitate comparisons among animals. Points falling on land were excluded from this analysis.

Figure 3-26: Time-Series Plots of Sadie's Dive Data



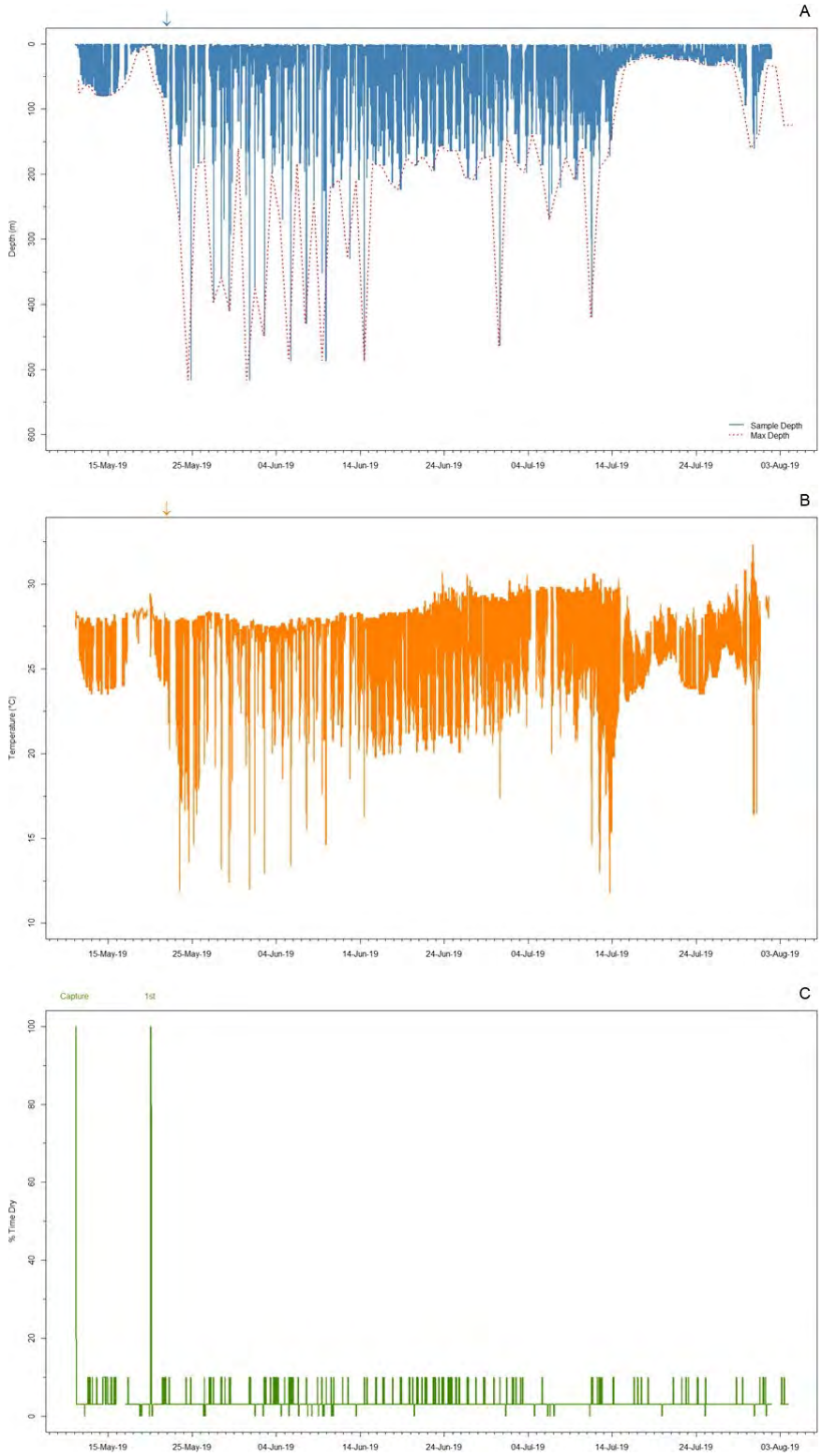
A. Depth; B. Temperature; C. % Dry Time. Arrows indicate the start of Sadie's migration period. Note the synchronous 100 percent dry times marking individual re-nesting events, while the asynchronous 100 percent dry time in early August is a probable resting period at the surface as she crossed the Amazon River. The flattening off of dives in September indicates the onset of her foraging period.

Figure 3-27: Time-Series Plots of Kari's Dive Data



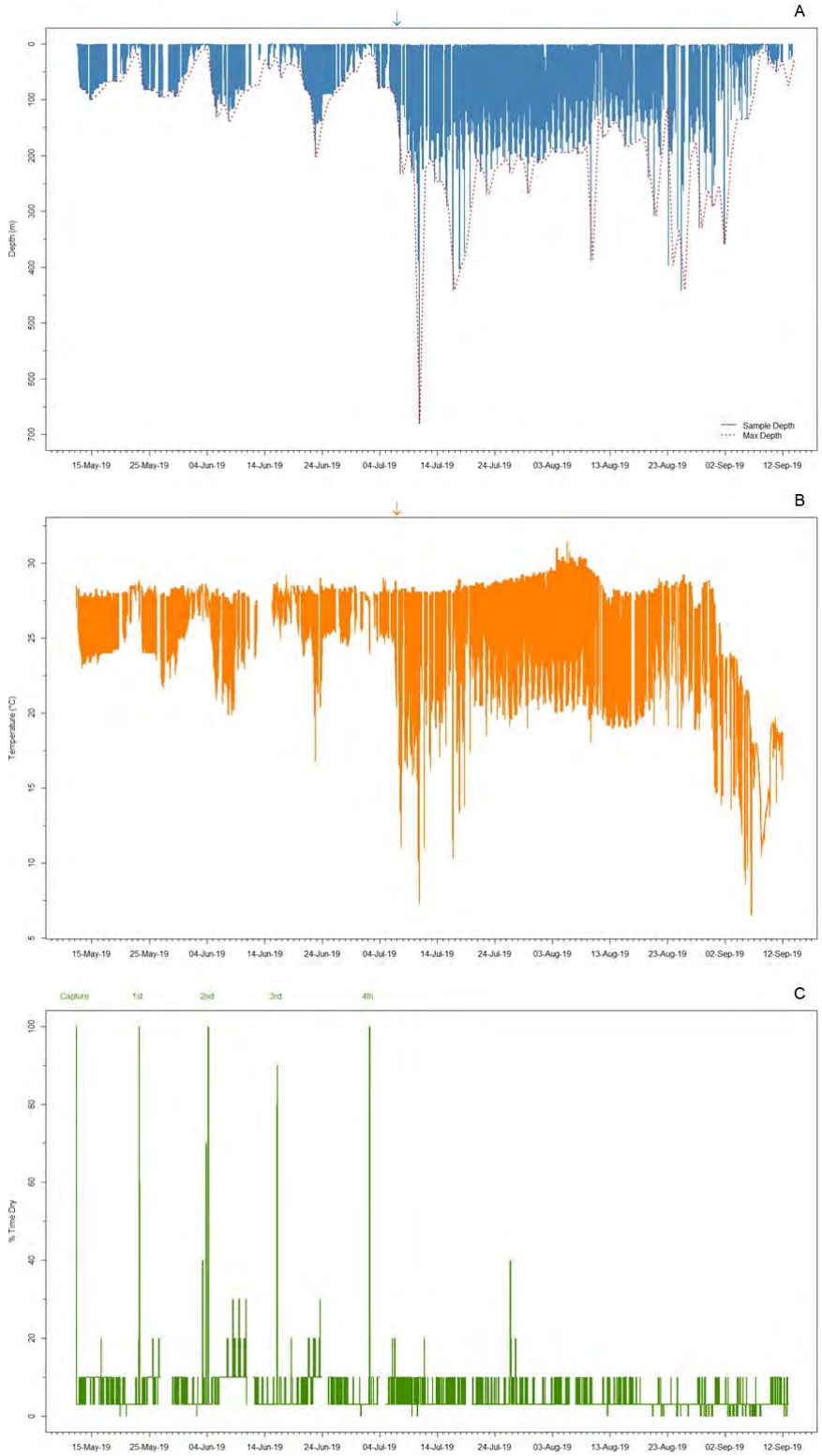
A. Depth; B. Temperature; C. % Dry Time. Arrows indicate the start of Kari's migration period. Note the synchronous 100 percent dry times marking individual re-nesting events. The large drop in temperature coincides with her arrival in cold Canadian waters in September.

Figure 3-28: Time-Series Plots of Christine's Dive Data



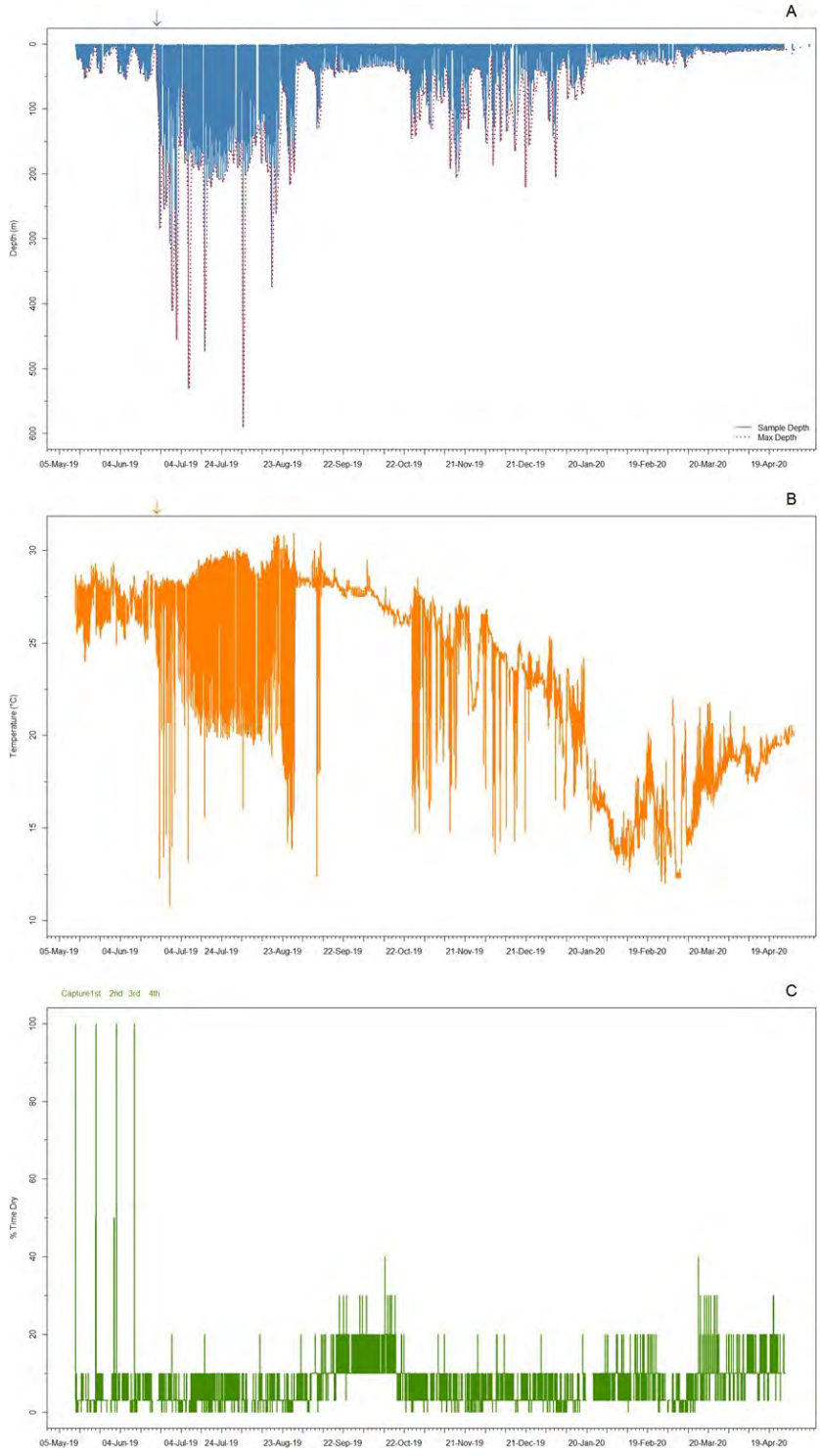
A. Depth; B. Temperature; C. % Dry Time. Arrows indicate the start of Christine's migration. Note the synchronous 100 percent dry times marking a single re- nesting event. The shallowing of dives in mid-July indicates she began foraging in northern Florida.

Figure 3-29: Time-Series Plots of Regina's Dive Data



A. Depth; B. Temperature; C. % Dry Time. Arrows indicate the start of Regina's migration period. Note the synchronous 100 percent dry times marking individual re-nesting events. The large drop in temperature coincides with her arrival in cold Canadian waters in September.

Figure 3-30: Time-Series Plots of Rhoda's Dive Data



A. Depth; B. Temperature; C. % Dry Time. Arrows indicate the start of Rhoda's migration period. Note the synchronous 100 percent dry times marking individual re-nesting events, and the gap in the data that misses the fourth event in mid-June. The decline in temperature marks seasonal changes in her environment, while foraging behavior is evident in the shallowing of dives in late September/October and again in January/February.

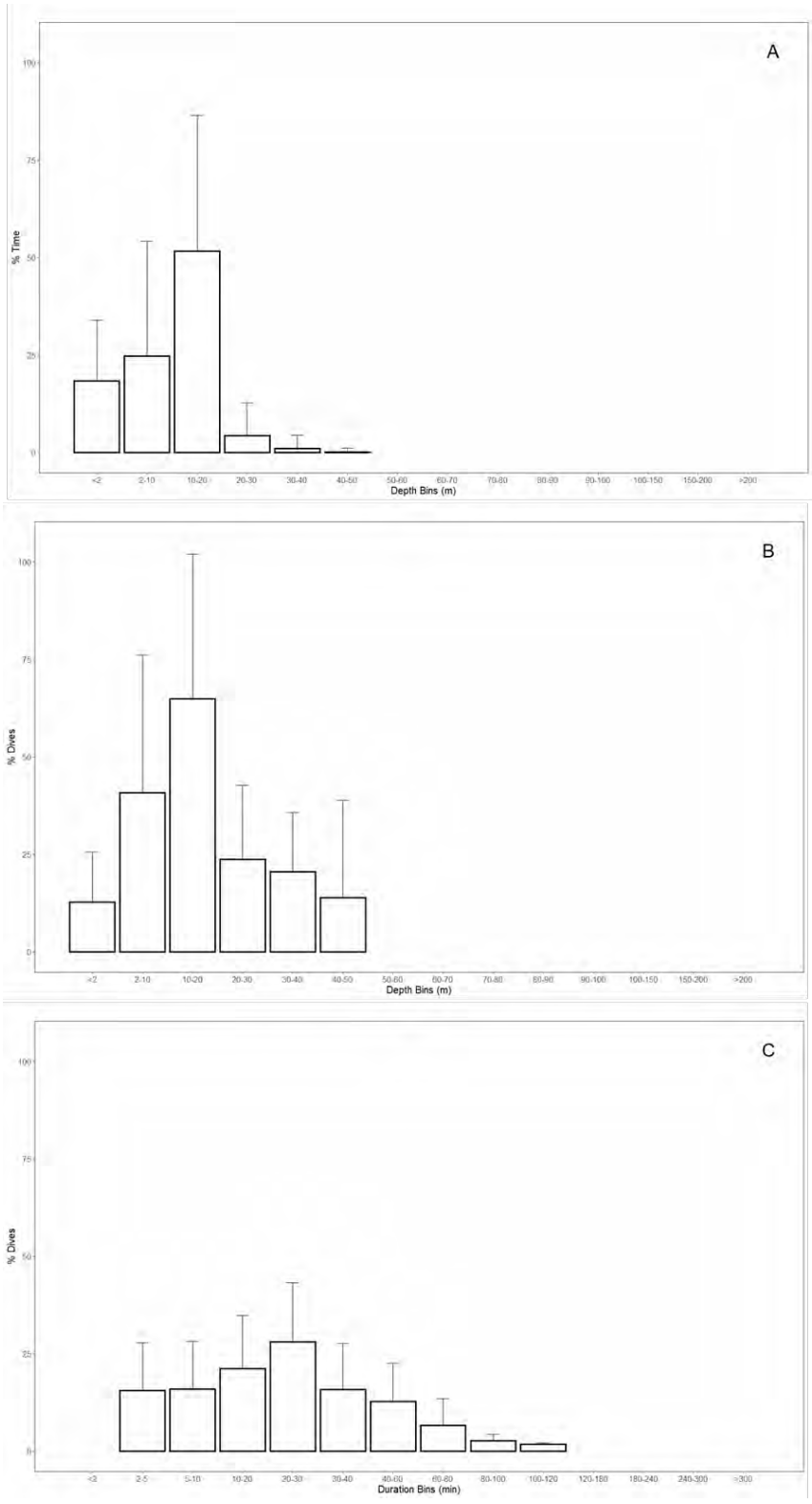
Table 3-8: 2019-tagged Turtle Daily Vertical Habitat Use (i.e., Depth)

Turtle ID	Water Depth (m)		Turtle Depth (m)		Maximum Dive Depth (m)	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Green Turtles						
173292 Michelle	8.7 (7.5)	2.0–43.0	-	-	-	-
173295 Sadie	14.9 (12.4)	2.0–75.0	11.4 (7.5)	0.5–43.0	18.0 (8.9)	2.8–42.0
Leatherback Turtles						
173286 Teij	3,823.2 (2,131.9)	2.0–6,286.0	-	-	-	-
173287 Kari	3,535.7 (2,236.8)	2.0–5,814.0	33.3 (59.8)	0.5–1413.5	161.1 (146.1)	3.8–1413.5
173289 Christine	2,349.2 (2,486.0)	2.0–7,093.0	32.5 (46.7)	0.5–516.0	179.0 (135.8)	4.8–515.8
180748 Regina	2,445.0 (2,512.0)	2.0–6,455.0	44.1 (53.0)	0.5–680.0	151.4 (111.9)	7.8–680.0
180749 Rhoda	800.9 (1,758.4)	1.0–5,971.0	15.4 (30.9)	0.5–590.5	75.8 (84.3)	4.3–590.3

m = meter

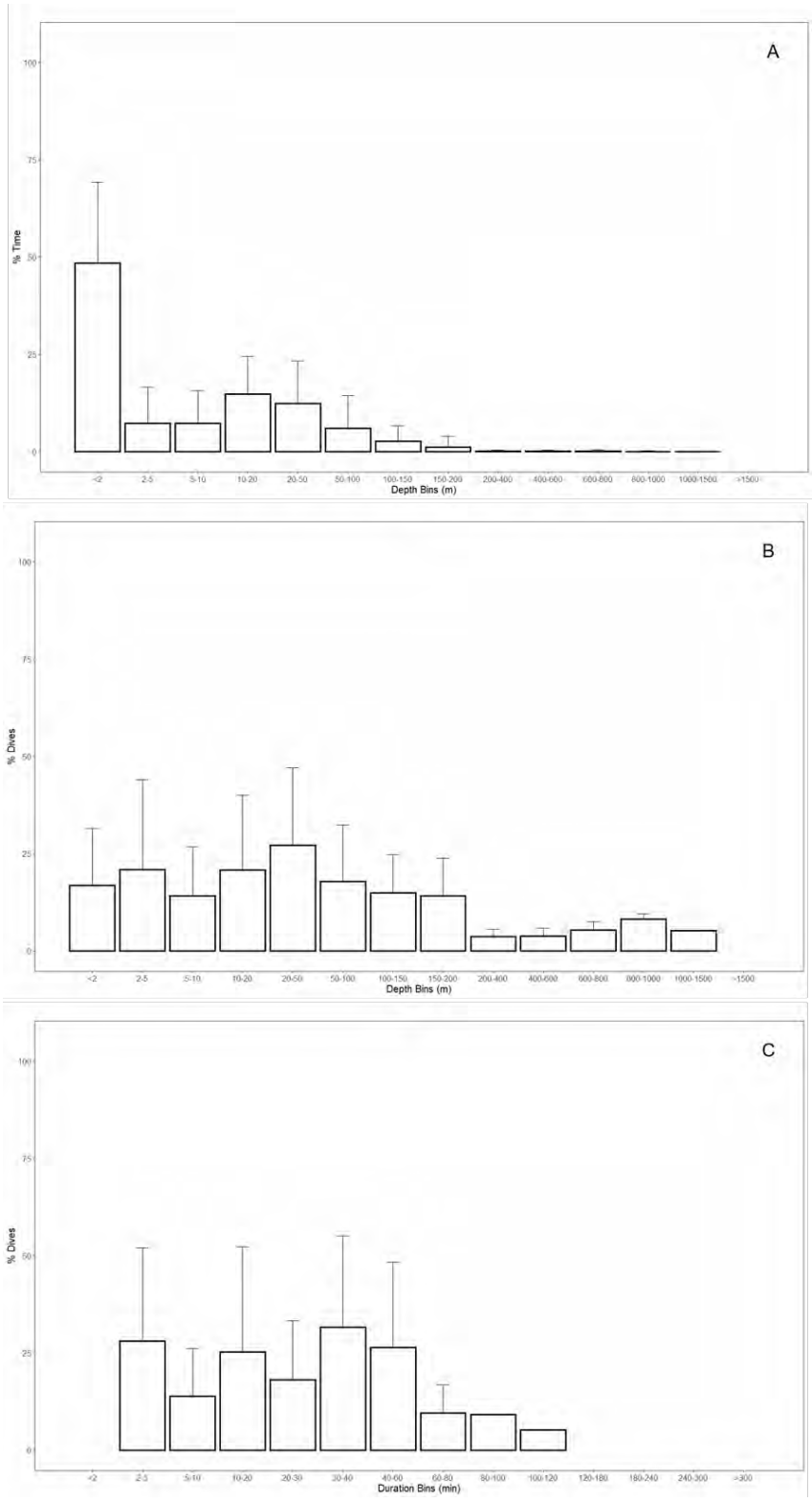
Note: Inferred from sampling bathymetric maps (see Figure 3-5 and Figure 3-6) and from dive data collected by the turtle tags. Michelle and Teij were not equipped with dive recorders.

Figure 3-31: Frequency Histograms of Sadie's Dive Data during the Entire Tracking Period



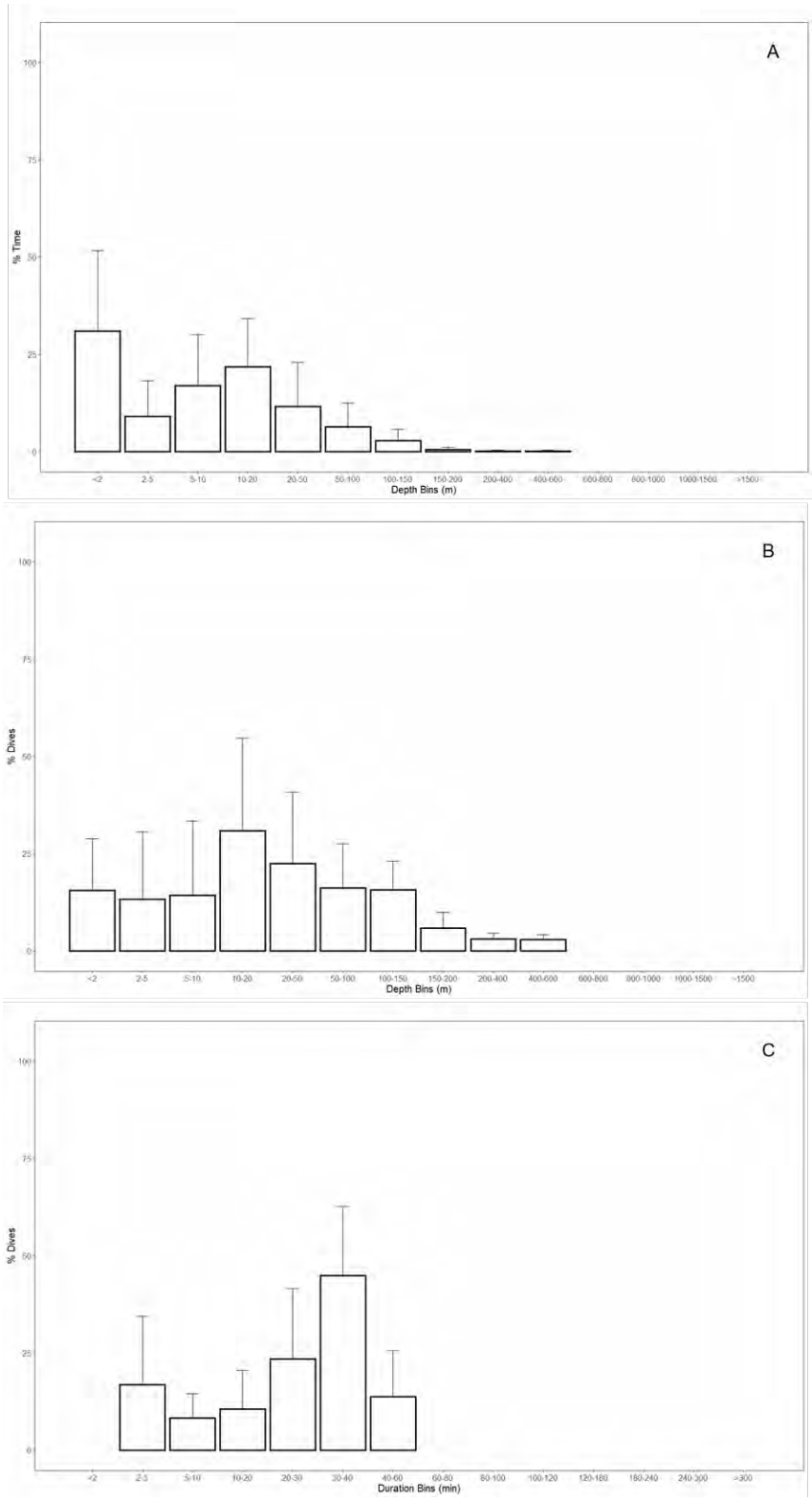
A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals

Figure 3-32: Frequency Histograms of Kari's Dive Data during the Entire Tracking Period



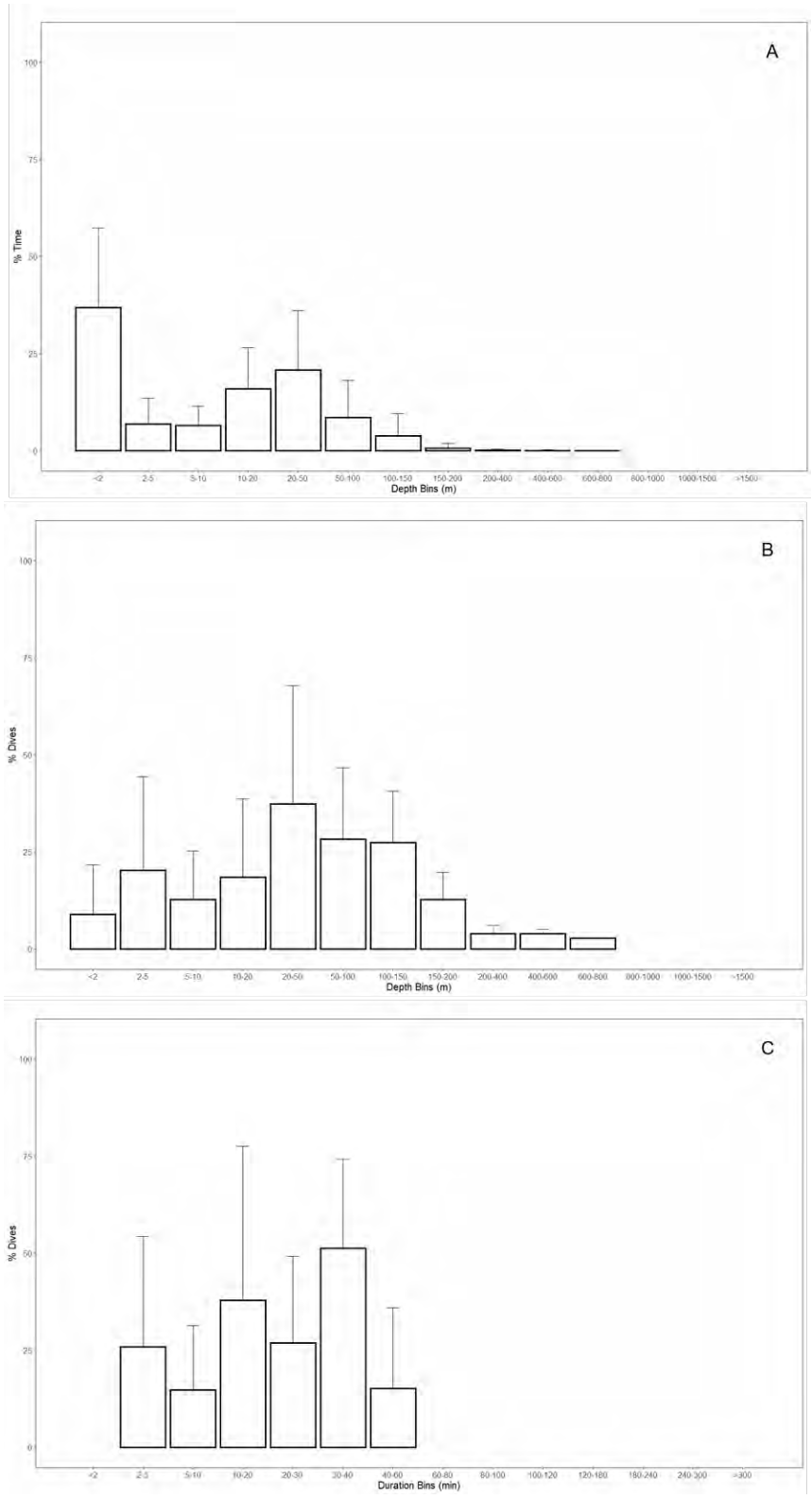
A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals

Figure 3-33: Frequency Histograms of Christine's Dive Data during the Entire Tracking Period



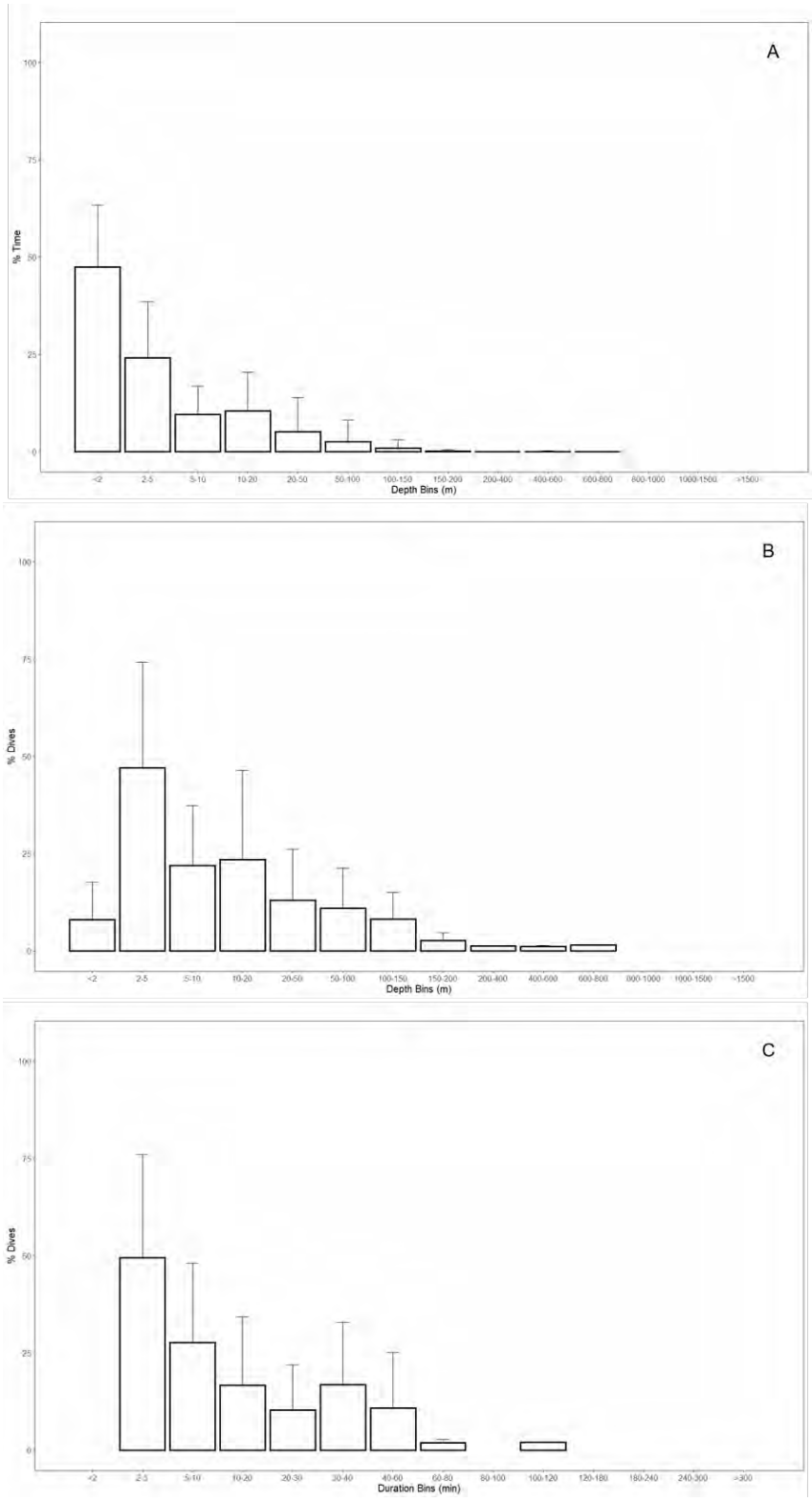
A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals

Figure 3-34: Frequency Histograms of Regina's Dive Data during the Entire Tracking Period



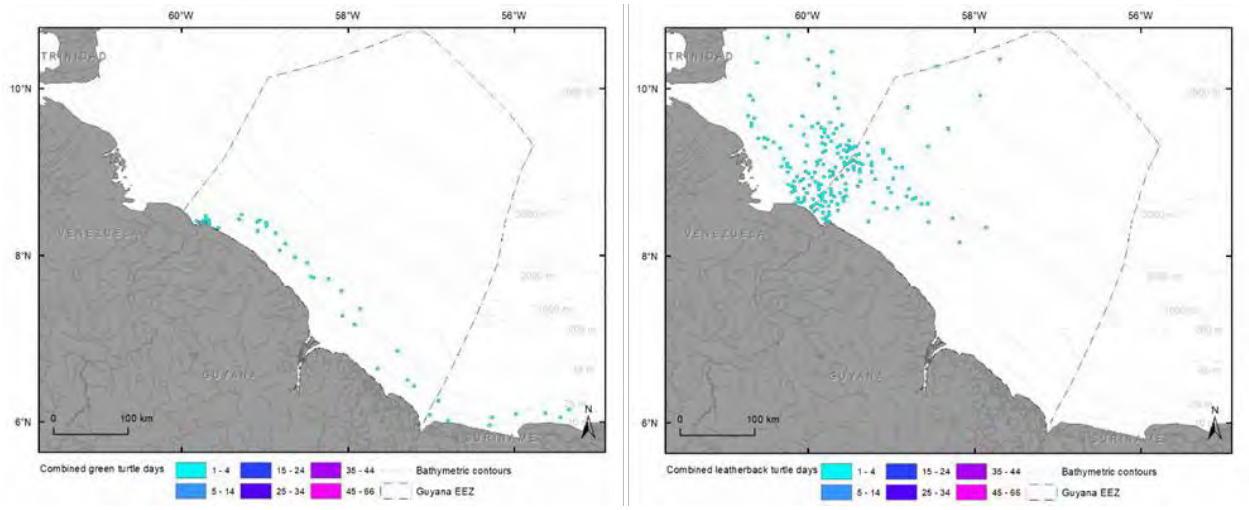
A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals

Figure 3-35: Frequency Histograms of Rhoda's Dive Data during the Entire Tracking Period



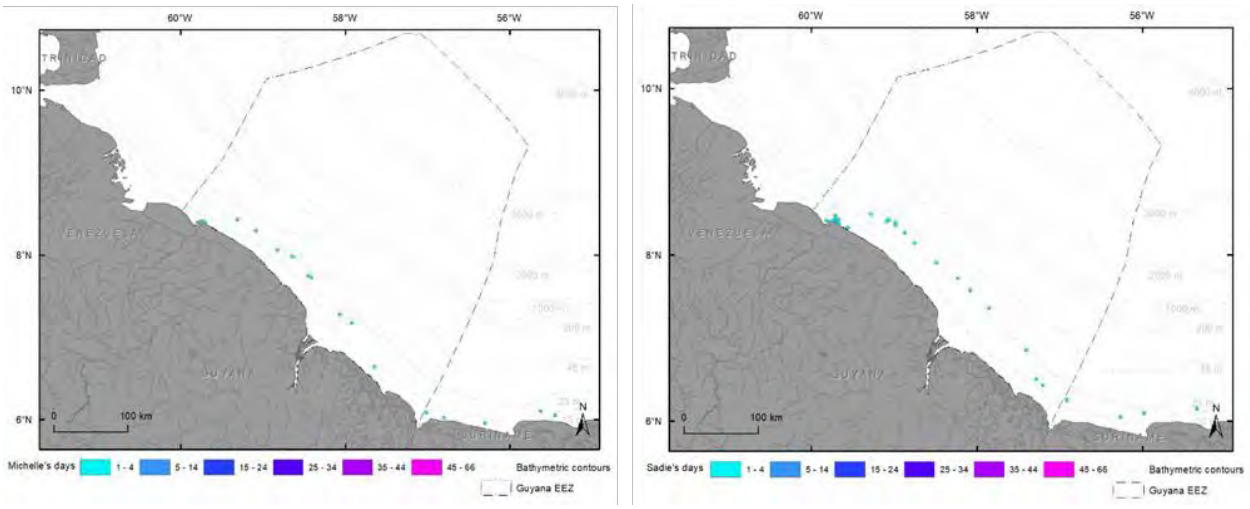
A. time at depth intervals; B. percent of dives at depth intervals; C. percent of dives at duration intervals

Figure 3-36: Synopsis of Habitat Use by 2019-tagged Turtles, Centered within Guyana's Exclusive Economic Zone—2019



Note: Presented as the number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers in area. This encompassed the turtles' inter-nesting periods and part of their migration period.

Figure 3-37: Synopsis of Habitat Use of Individual 2019-tagged Green Turtles Centered within Guyana's Exclusive Economic Zone



Note: Presented as number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers in area. This encompassed the turtles' inter-nesting periods and part of their migration period.

All of the leatherback turtles (Teij, Kari, Christine, Regina, and Rhoda) (Figure 3-38), demonstrated itinerant movement behaviors. Teij's inter-nesting movements were the most extensive, spreading 560 kilometers between Guyana and Tobago, where she made a large loop offshore, taking her almost 150 kilometers from the coastline and just off the continental shelf break (i.e., 200 meters depth) (Figure 3-22 and Figure 3-38; Table 3-6). During this 24-day loop, she missed one of her expected nesting intervals (i.e., her second to last)[10]. The rest of

[10] Leatherbacks tend to develop an inter-nesting routine and return to the beach to re-nest after a set number of days. Their re-nesting intervals vary from turtle to turtle, but tend to be predictable for each individual.

the time, she made three smaller offshore loops out to the edge of the continental shelf between nesting events, making one false crawl the day before her second nest, as observed through haul-out records. This animal's tag was equipped with Fastloc GPS capability. While there is some variability in the appearance in her tracks generated from Argos and Fastloc GPS data, both demonstrate similar patterns, with Fastloc data falling within the Argos convex hulls (Figure 3-21).

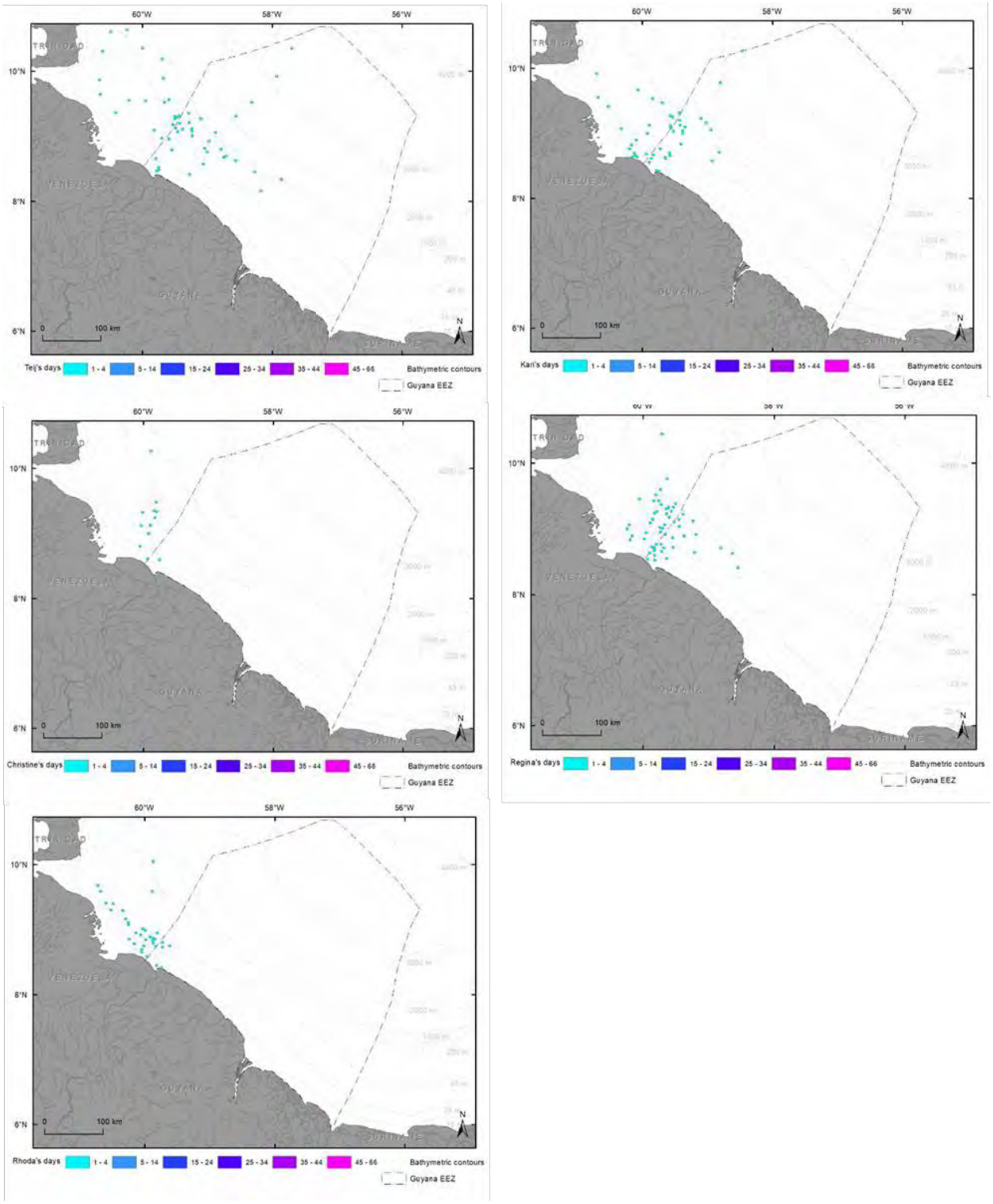
Christine made a single loop offshore (97 kilometers from land from the Venezuelan coast) spanning a lateral shoreline distance of 70.1 kilometers between her two nests (Figure 3-22 and Figure 3-38; Table 3-6). She made an 80-meter-deep dive (Figure 3-28A) at the furthest extent of this loop and another just before leaving on her migration from the nesting region.

Regina's inter-nesting movements included four offshore loops (at most 117 kilometers from shore) split between Guyana and Venezuela (covering 244 kilometers coastline distance) (Figure 3-22 and Figure 3-38; Table 3-6). She also made some deep dives while along the edge of the continental shelf break (100 to 200 meters; Figure 3-29A).

Rhoda's inter-nesting movements were the closest to shore among the leatherback turtles, staying within 51 kilometers of the coastline (Figure 3-22) and primarily within the 50-meter bathymetric contour. She made two elongated loops offshore of the Orinoco River Delta, Venezuela and two offshore loops closer to Almond Beach, but still in Venezuelan waters, covering a shoreline distance of 222 kilometers (Figure 3-22 and Figure 3-38; Table 3-6). Her deepest dives were also at the outer reaches of these inter-nesting forays, but were much shallower than the other turtles (54 to 55 meters; Figure 3-30A).

As in the case of the 2018-tagged turtles, the 2019-tagged turtles displayed complex horizontal movements and time-series information was useful for visualizing vertical movements and identifying re-nesting events. Lower temperatures occurred during deeper dives, while the highest temperatures typically occurred during periods when the animals were hauled-out on land to nest (Figure 3-26B, Figure 3-27B, Figure 3-28B, Figure 3-29B, and Figure 3-30B), but occasionally also when they hit warm water masses. Similarly, the 100 percent dry times coincided with zero-depths and changes in temperature (Figure 3-26, Figure 3-27, Figure 3-28, Figure 3-29, and Figure 3-30). Discrete re-nesting periods were readily visible when looking at these time-series graphs together, even though they were less obvious in the horizontal movement data; see for example Kari and Regina who had missing location data during some nesting events (Figure 3-27C and Figure 3-29C). Rhoda also had missing location data, time-series data, and haul-out data for her last nest, so her last re-nesting event was inferred based on previous nesting intervals and the turtles' consistent behavior of leaving the nesting region within a day or two of their last nests.

Figure 3-38: Synopsis of Habitat Use of Individual 2019-tagged Leatherback Turtles, Centered within Guyana's Exclusive Economic Zone



Note: Presented as number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers in area

3.3. Migration Period

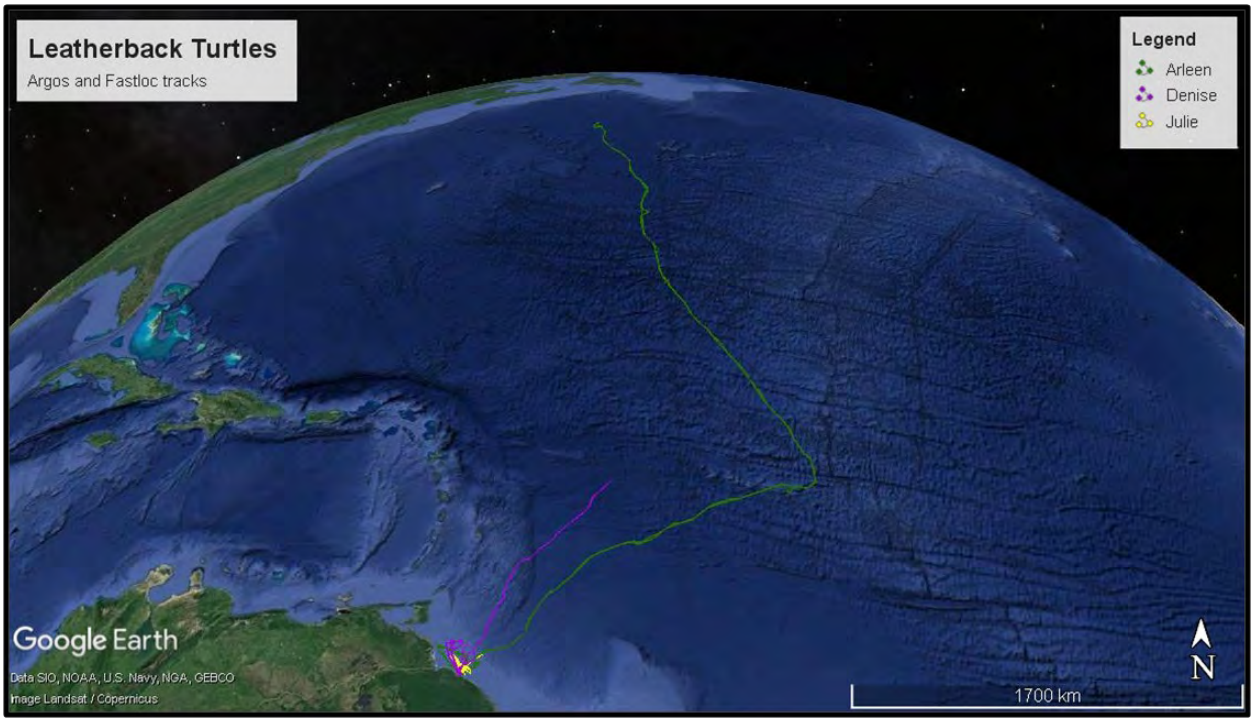
3.3.1. 2018 Expedition

The study was able to capture the onset of one turtle's migration, a partial route for four turtles, and the complete migration route to the foraging grounds for three turtles that were tagged on Almond Beach in 2018. Migratory movements were characterized by a consistent heading and an increase in movement rates. All the green turtles tagged in 2018 headed southeast to Brazil, following a near-shore corridor across an average distance of 2,485 +/- 526 kilometers (mean +/- 1 SD) (Figure 3-39, Table 3-3). All the leatherback turtles initially headed directly out to sea in a northeasterly direction (Figure 3-40, Table 3-3). However, the tracking durations once they left the nesting beach were highly dissimilar and none of the leatherbacks had definitively arrived at their foraging grounds (which would have been indicated by a change in movement parameters) before their transmissions ceased. Both green and leatherback turtles used deeper waters during their migration period as compared to water depths used in other tracking periods, and leatherbacks used significantly deeper waters than green turtles, the latter remaining on the continental shelf (Figure 3-6 and Figure 3-7).

Figure 3-39: Migration Routes of 2018-tagged Green Turtles Tracked from SBPA

Note: Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. In most cases the difference is unapparent.

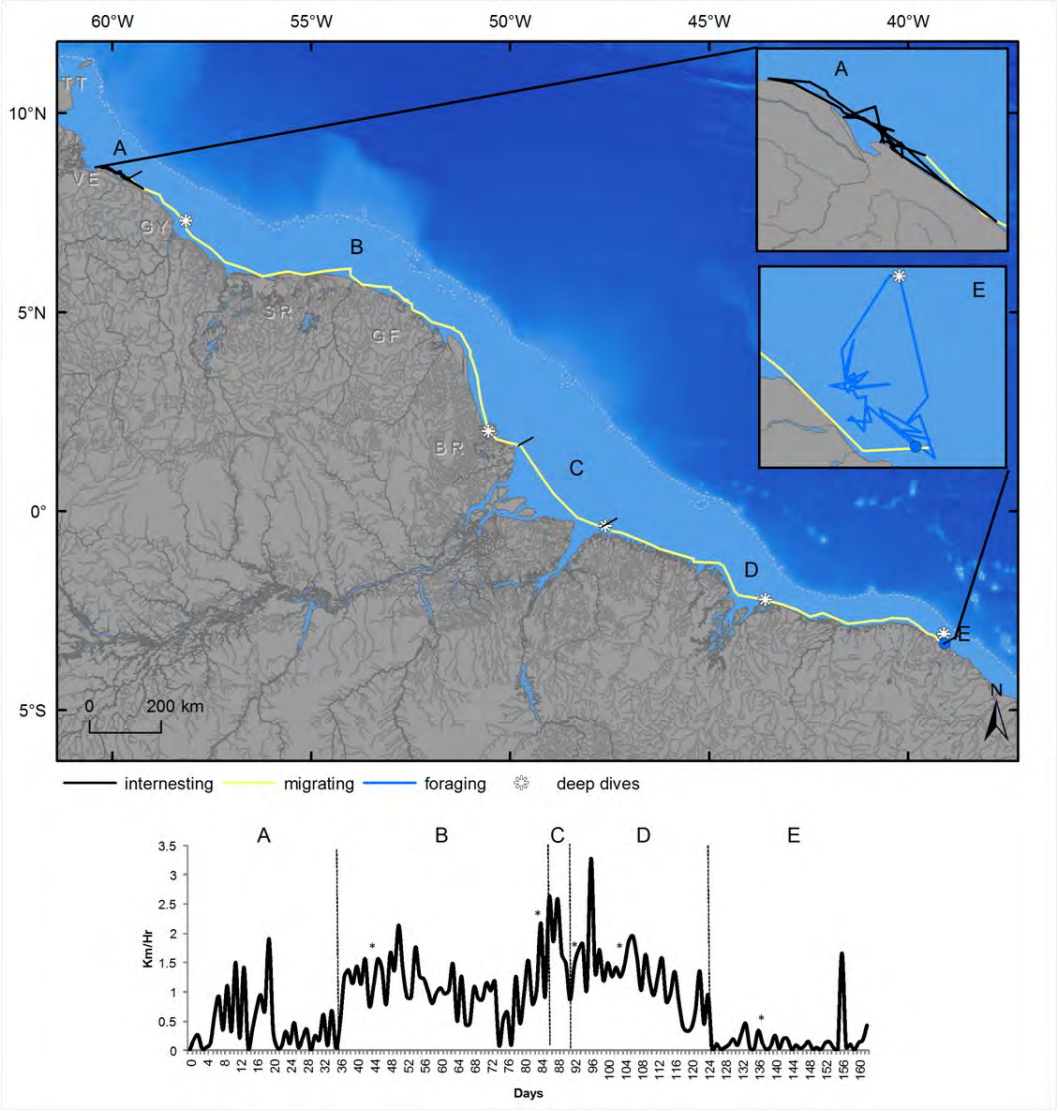
Figure 3-40: Migration Routes of 2018-tagged Leatherback Turtles Tracked from SBPA



Note: Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. In most cases the difference is unapparent.

Violet was the first green turtle to start her migration, on 28 April 2018, and took the longest to complete it (91 days; Table 3-3). Figure 3-41 shows the different behavioral periods of Violet's journey and the associated changes in speed. It appears that Violet's deepest dives occurred in the vicinity of (prior to or after crossing) major river mouths (i.e., the Essequibo River, Guyana; the Amazon and Pará rivers and the Mearima River/Arraial Bay, Brazil) (Figure 3-8A and Figure 3-41), which may be an energetic strategy to avoid turbulence and current flows associated with these rivers. The turtle's speed steadily increased as it crossed into Brazil, passed inshore of Maracá Island, and traversed the mouths of the Amazon and Pará rivers (17 to 25 June 2018), and showed a brief spike at the mouth of the Mearima River, after which it declined. Although there are gaps in the time-series data, it appears that Violet rested at the surface on several occasions during her migration, but particularly during her crossing of the Amazon River between deep dives on either side (Figure 3-8A, Figure 3-8C, and Figure 3-41). The dive data indicated that Violet spent most of her time in the upper 10 meters of the water column and never went deeper than 60 meters (Figure 3-11A). More than 80 percent of her dives were less than 10 meters and all dives lasted under 1.6 hours, with most being less than 20 minutes in duration (Figure 3-11B and Figure 3-11C).

Figure 3-41: Map of the Reconstructed Movement Track for Violet, by Behavioral Intervals

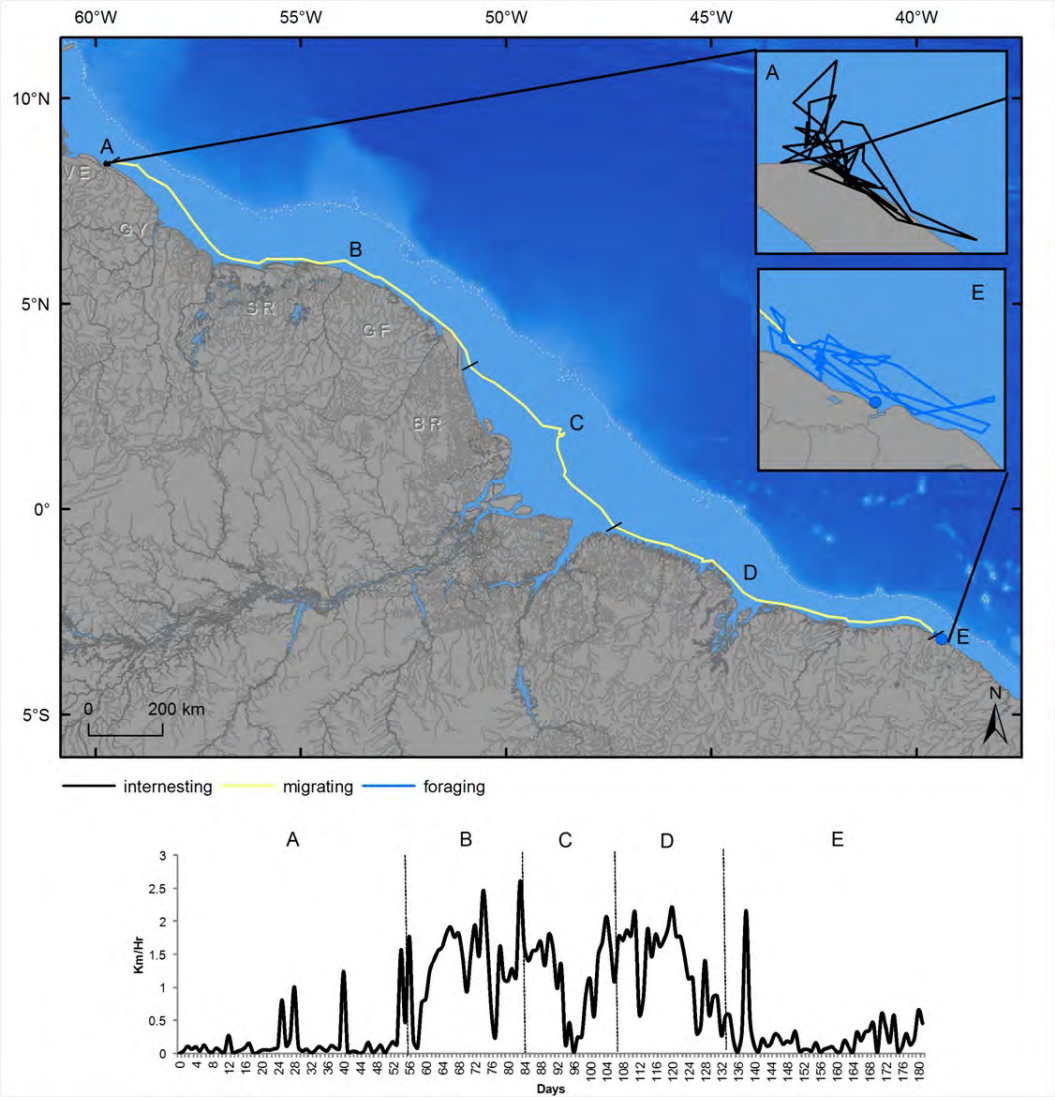


Note: Approximate locations of deep dives are marked with an *. Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Becky was the next green turtle to migrate from the SBPA, beginning on 17 May 2018. She took 78 days to cover the distance between nesting and foraging sites (Table 3-3). As with the other green turtles, her journey was marked by changes in movement speeds, but these were even more marked than those of the other green turtles, with peaks and valleys that were likely related to changing currents encountered during her migration. There was a dip in movement rates just prior to her crossing from French Guiana into Brazil, and again prior to her crossing the Mearima River (Brazil) (Figure 3-42). She started her crossing of the Amazon and Pará river mouths just 1 day after Violet, but differed in that she moved directly across so that she was farther offshore and took longer to transit (18 June to 9 July 2018; Figure 3-39 and Figure 3-42). As a result, she was farther away from the river plume, but closer to the edge of the swift-moving North Brazil western boundary current. Becky's movement rates plummeted mid-

crossing. There were no dive data associated with this tag to determine if she navigated this zone at depth or near the surface.

Figure 3-42: Map of the Reconstructed Movement Track for Becky, by Behavioral Intervals

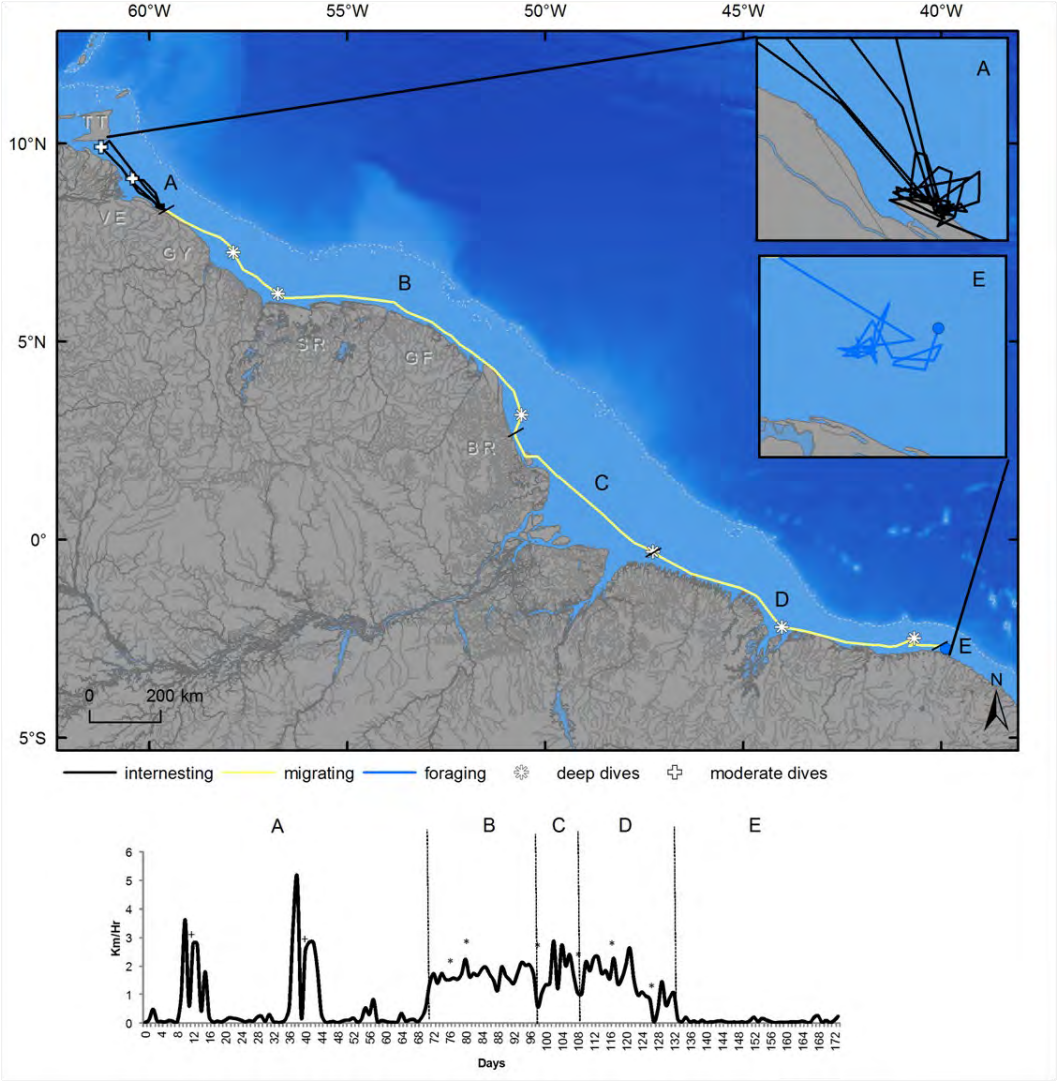


Note: Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Karin was the next green turtle to migrate, leaving the SBPA on 2 June 2018. She migrated the fastest of the green turtles, making the trip in only 62 days (Table 3-3). Her journey and behavior were nearly identical to Violet's: she made deep dives before or after major river mouths (i.e., the Essequibo River, Guyana; the Corentyne River, Suriname; and the Amazon and Pará rivers, the Mearima River/Arraial Bay, and the Parnaíba River, Brazil), and her speed increased as she crossed the Amazon and Pará river mouths, then steadily declined (Figure 3-9A and Figure 3-43). However, she crossed later than the other turtles (30 June to 11 July 2018) and although she took the near-shore route, she traveled offshore of Maracá Island.

Analogous to Violet's dive profiles, Karin demonstrated resting periods at the surface during and after the Amazon River crossing, as well as spikes in temperature of surface waters prior to entering and exiting the crossing, which may delineate the different water masses within the plume (Figure 3-9A, Figure 3-9B, and Figure 3-9C). Karin's dive record indicates that she spent most of her time in the upper 10 meters of the water column, never going deeper than 40 meters, and more than 80 percent of her dives were less than 10 meters (Figure 3-12A and Figure 3-12B). All her dives were less than 2 hours in duration and most were less than 20 minutes (Figure 3-12C).

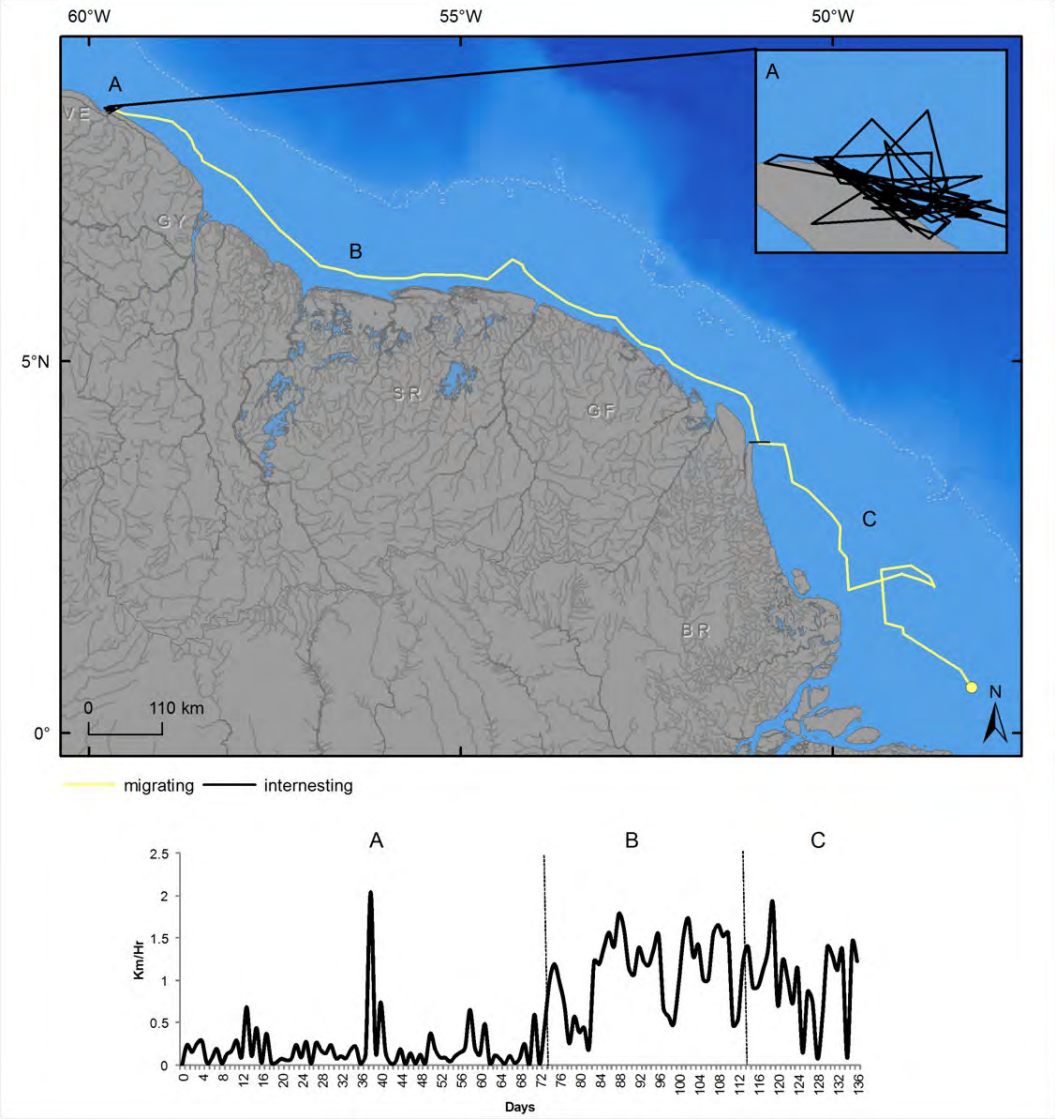
Figure 3-43: Map of the Reconstructed Movement Track for Karin, by Behavioral Intervals



Note: Approximate locations of deep dives are marked with an *. The moderately deep dives occurring during the inter-nesting period are marked with a + and occurred at the outer limits of the two furthest inter-nesting loops and were flanked by peak movement rates. Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Sibille was the last green turtle to leave the nesting beach, on 3 June 2018. She was tracked for 69 days during her migration to the foraging grounds, but her transmissions stopped before arriving (Table 3-3). Her route and movement characteristics were very similar to Becky's, with troughs and peaks in movement rates as she crossed into Brazil (Figure 3-44). On 28 July 2018, Sibille also began crossing the Amazon farther offshore, but she veered inland and then turned back offshore, making a loop that was coincident with dips in the movement speed mid-way through. She continued on a straight course to the other shoreline, but transmissions ceased just as she was approaching the Pará River mouth. There were no dive data associated with this tag.

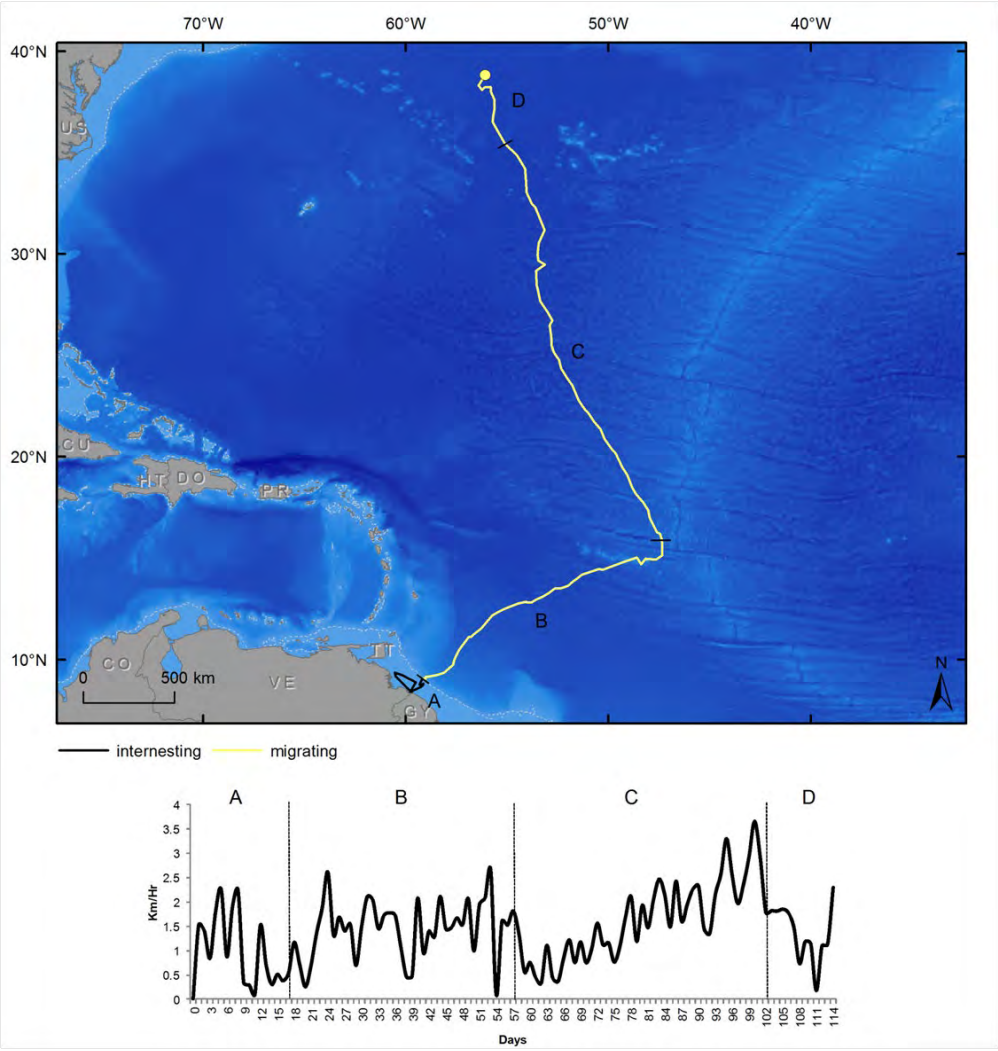
Figure 3-44: Map of the Reconstructed Movement Track for Sibille, by Behavioral Intervals



Note: Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset box is a close-up version of the inter-nesting area.

The first leatherback to start her migration was Arleen. She left the SBPA on 1 July 2018 and traveled for 96 days into the North Atlantic, covering a remarkable distance of 4,634 kilometers before her transmissions ceased (Figure 3-25, Table 3-3). Her migration path was divided into three behavioral intervals (movement rate and directional phases) (Figure 3-45). In interval B, she moved offshore to the northeast until reaching the Mid-Atlantic Ridge, after which she headed north-northwest (interval C), gradually gaining speed within the Sargasso Sea until she passed between the Corner Rise and New England Seamounts, where her progress slowed (interval D). It appeared as though she was heading for the Laurentian Channel when her tag stopped transmitting. Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have been previously described as critical foraging habitat for leatherback turtles (James et al. 2005, 2006) and indeed capture studies in this area have previously confirmed flipper tag recoveries from the Guianas (James et al. 2007).

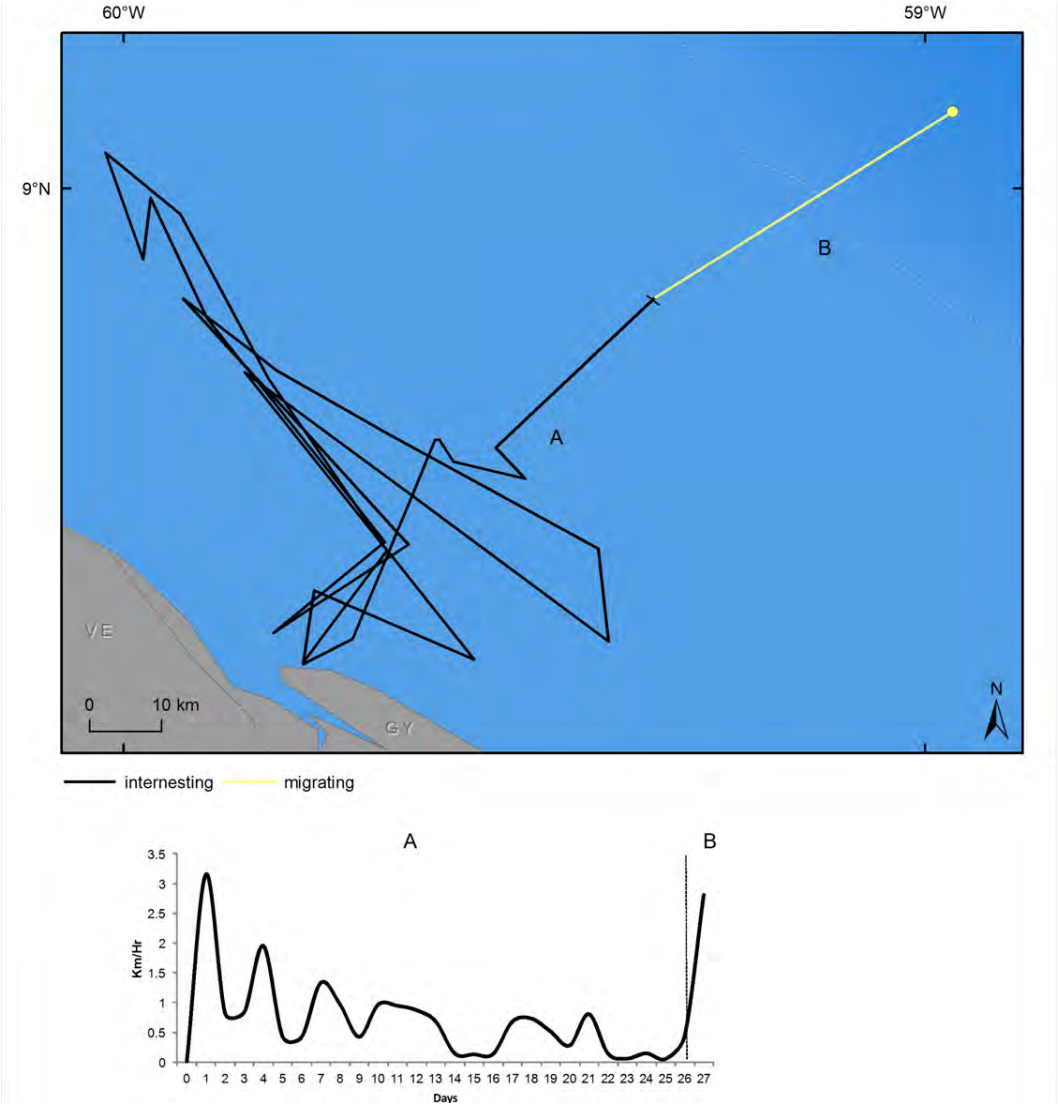
Figure 3-45: Map of the Reconstructed Movement Track for Arleen, by Behavioral Intervals



Note: Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph.

Julie was the second leatherback to leave the nesting beach, on 10 July 2018 (Table 3-3). Unfortunately, she ceased transmitting 1 day later, just as her movement rates increased (Figure 3-46).

Figure 3-46: Map of the Reconstructed Movement Track for Julie, by Behavioral Intervals

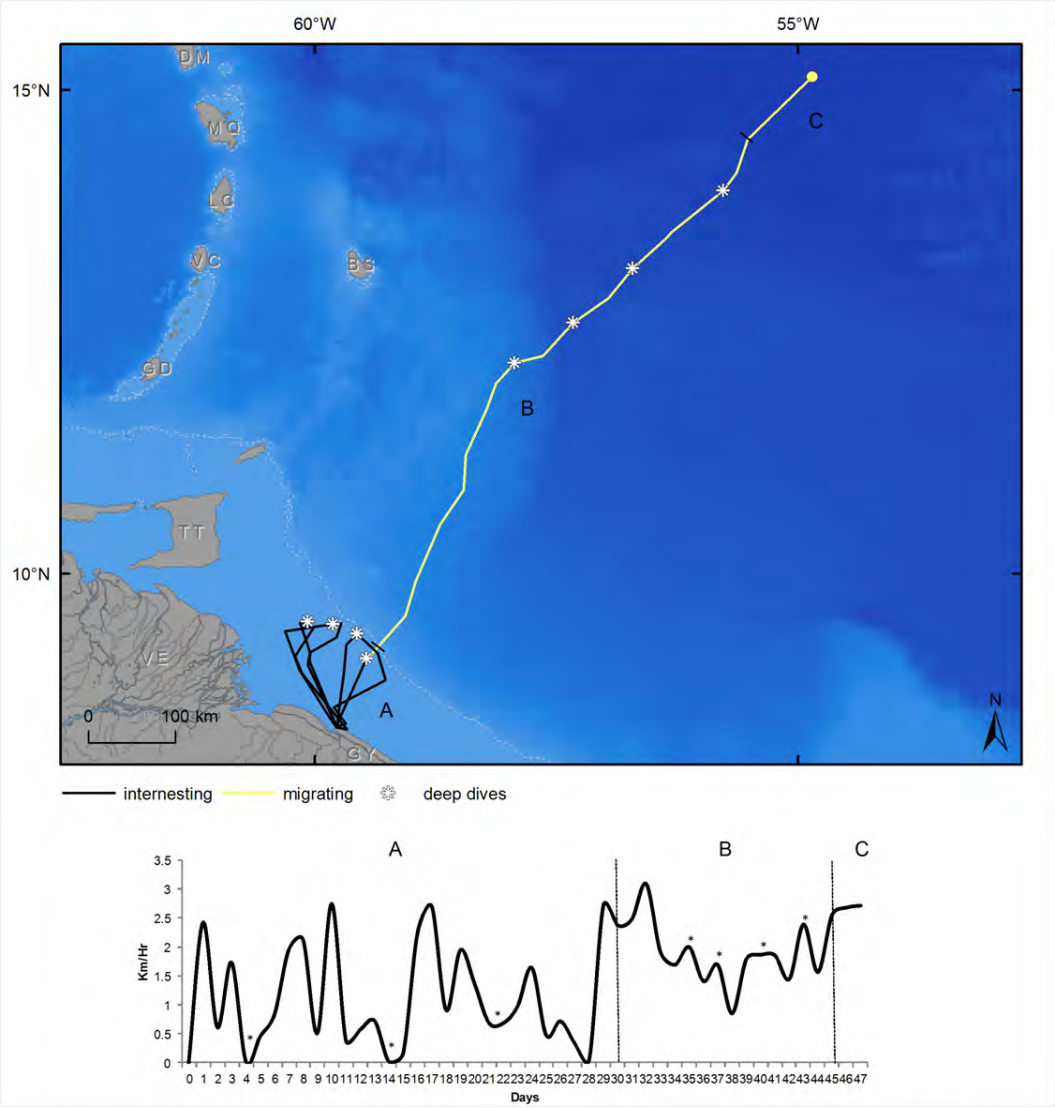


Note: Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph.

Denise was the final turtle to leave the SBPA during this study. She began migrating on 14 July 2018 and continued transmitting for 26 days, maintaining a northeasterly course offshore of Guyana (Figure 3-47, Table 3-3). A week after she began migrating, she started making deep dives every 2 or 3 days (Figure 3-10), the deepest of which (560.5 meters) was the day before her last transmission—where she was in water depths exceeding 5,000 meters (Figure 3-7 and Figure 3-10A). Denise spent most of the time in the upper 20 meters of the water column, making more than 75 percent of her dives within 50 meters, and making few dives more than

100 meters (Figure 3-13A and Figure 3-13B). All of her dives were less than 1 hour in duration and most were less than 30 minutes (Figure 3-13C)

Figure 3-47: Map of the Reconstructed Movement Track for Denise, by Behavioral Intervals



Note: Approximate locations of deep dives are marked with a *. Note that deep dives also occurred during the inter-nesting period at the outer limits of the inter-nesting loops and were flanked in peak movement rates just like the green turtle, Karin. Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph.

A key consideration in the analysis of tracking marine species is the effect that oceanography plays in their movements. Both green and leatherback turtles are strong swimmers, with specific habitat requirements related to physiology and foraging behaviors. Adult green turtles are neritic[11] and typically remain within the continental shelf (i.e., 200 meters) of the tropics and Equator unless they are migrating from oceanic islands to the mainland, as is the case for Ascension Island turtles (Hays et al. 2003). Leatherback turtles are generally oceanic and may

[11] Relating to the shallow part of the sea near the coast and overlying the continental shelf.

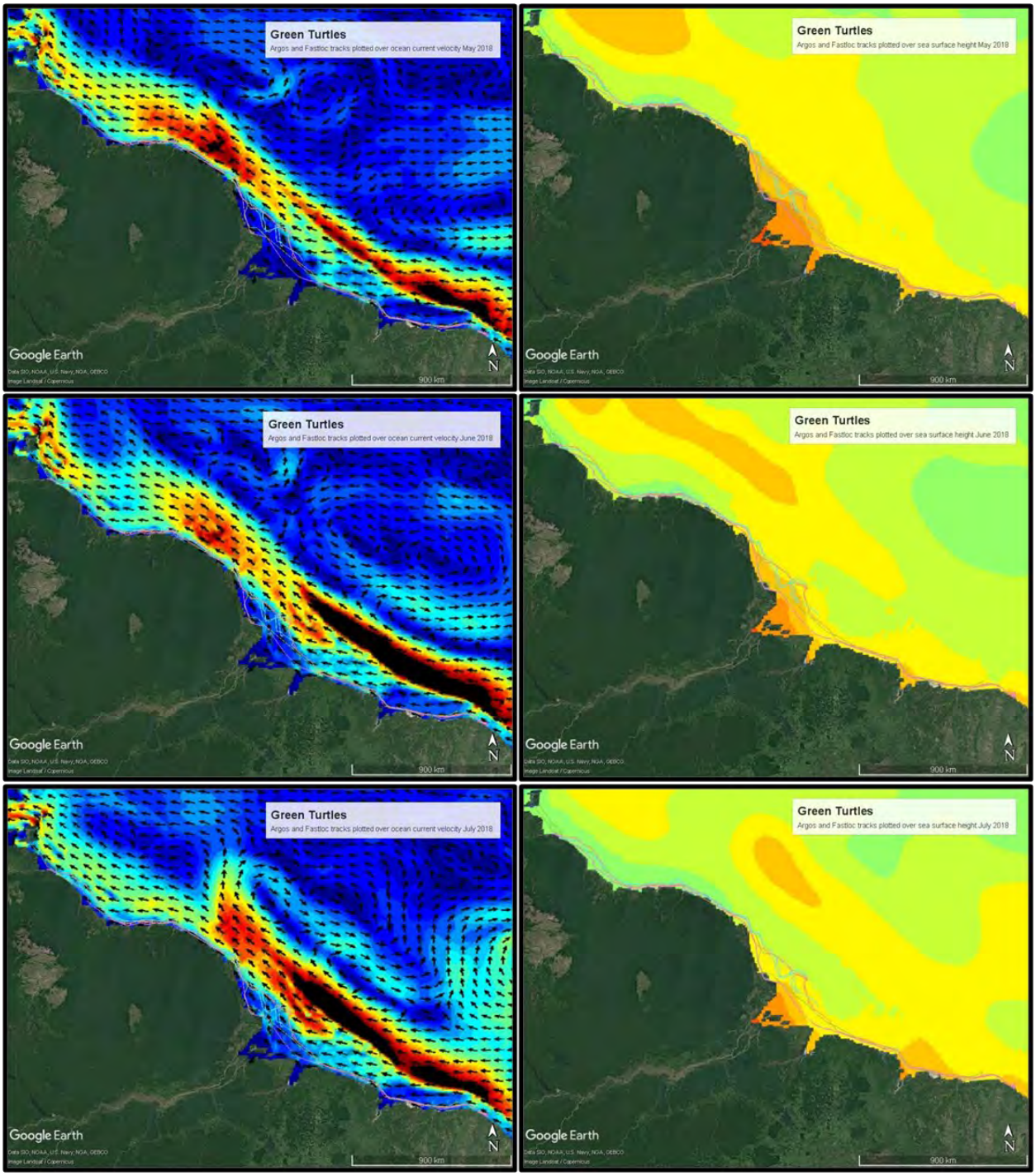
cross entire ocean basins between nesting grounds in tropical waters and their foraging grounds in the temperate and subarctic waters. They are also deep-diving specialists that can behaviorally—and physiologically—regulate environmental conditions.

To examine the influence of ocean currents on their movements, the turtles' tracks were overlaid on monthly-averaged geostrophic current imagery, which included sea surface height (SSH) and velocity. The North Brazil Current and the Guiana Current are regional components of the South Equatorial Current near shore, forming strong northward flow along the South America coastline that can be seen in satellite altimetry data. This is counter-directional to the movements of the green turtle migrations. Similarly, the North Atlantic gyre is readily visible as a mound in the SSH data and Northern Equatorial and Gulf Stream Currents in the velocity data, which leatherback turtles would have to cross to migrate to northern foraging zones. In each case, there is the potential for large energetic costs during migration.

Superimposing the green turtle migrations on the altimetry data suggests that the turtles remain in a very narrow band close to the shore where current magnitudes are relatively low and where SSHs are lowest, except around the major river mouths in Brazil where SSH is elevated (Figure 3-48). This effect was strongest and most extensive in May and weakened in June and July when the turtles crossed these zones. Baudouin et al. (2015) illustrated this narrow migratory corridor for post-nesting green turtles traveling from Suriname and French Guiana to Brazil. Similarly, Chambault et al. (2015) described the Amazon River plume as most turbulent in the upper surface layers and suggested that a strategy of short, deep dives would help green turtles migrating south to avoid the energetic costs of navigating those forces. Their study found the same two spatial patterns used by green turtles crossing the Amazon River that this study has, either close to shore or farther offshore, and suggested that animals that crossed farther offshore would initiate foraging sooner than those that crossed near to shore. These scenarios, with respect to depth or distance to foraging site, were not found to be the case within the small sample size of this study.

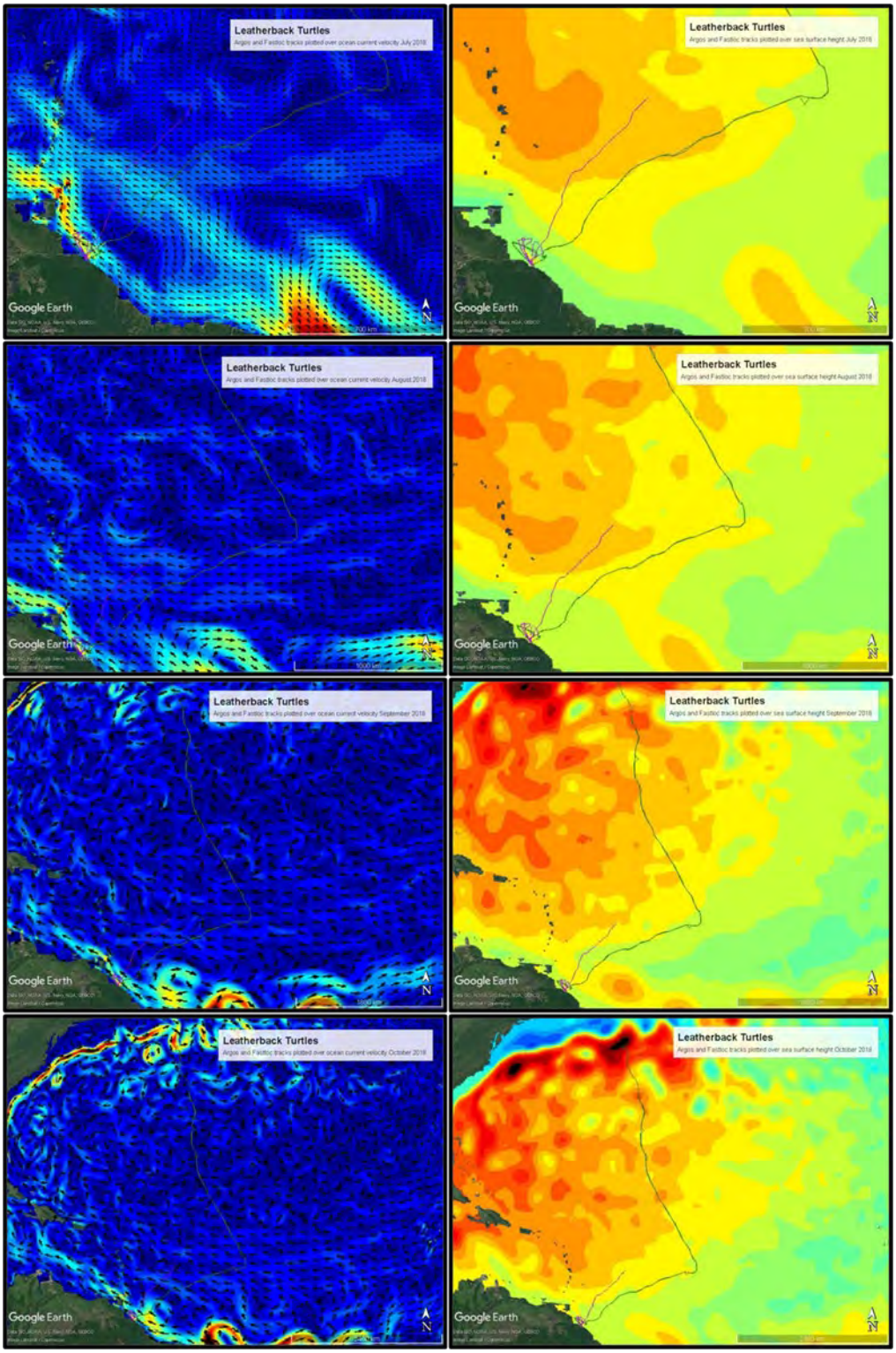
Leatherback turtles initiated migrations in early to mid-July, when altimetry indicated onshore movement of the Guiana Current near the SBPA and a large divergent zone forming approximately 200 kilometers offshore (Figure 3-49). The slightly spatially and temporally offset, but nearly identical, tracks of Arleen and Denise indicated that they may have been traveling along the edge of a convergent zone. Leatherbacks have been documented to maintain remarkably consistent headings traveling through the North Atlantic subtropical gyre, with negligible drift associated with ocean currents (Dodge et al. 2015). Arleen showed similar consistency and essentially swam "uphill" into the North Atlantic toward Canada. It is interesting to note that she stopped transmitting just as she headed into the meandering Gulf Stream current at a point of strong convergence. It is possible that the forces created by strong western boundary currents and pressure forces experienced in leatherback deep dives were too great for the lanyard attachments of the satellite transmitters.

Figure 3-48: Overlay of 2018-tagged Green Turtle Migration Tracks and Altimetry Data



Note: Combined green turtle migration tracks, superimposed over mean-monthly ocean altimetry data, where geostrophic current vectors are displayed in the left hand panels and SSH is displayed in the right hand panels for May through July 2018 (top to bottom). Warmer colors indicate higher magnitude or height, respectively.

Figure 3-49: Overlay of 2018-tagged Leatherback Turtle Migration Tracks and Altimetry Data



Note: Combined leatherback turtle migration tracks, superimposed over mean-monthly ocean altimetry data, where geostrophic current vectors are displayed in the left hand panels and SSH is displayed in the right hand panels for July through October 2018 (top to bottom). Warmer colors indicate higher magnitude or height, respectively.

3.3.2. 2019 Expedition

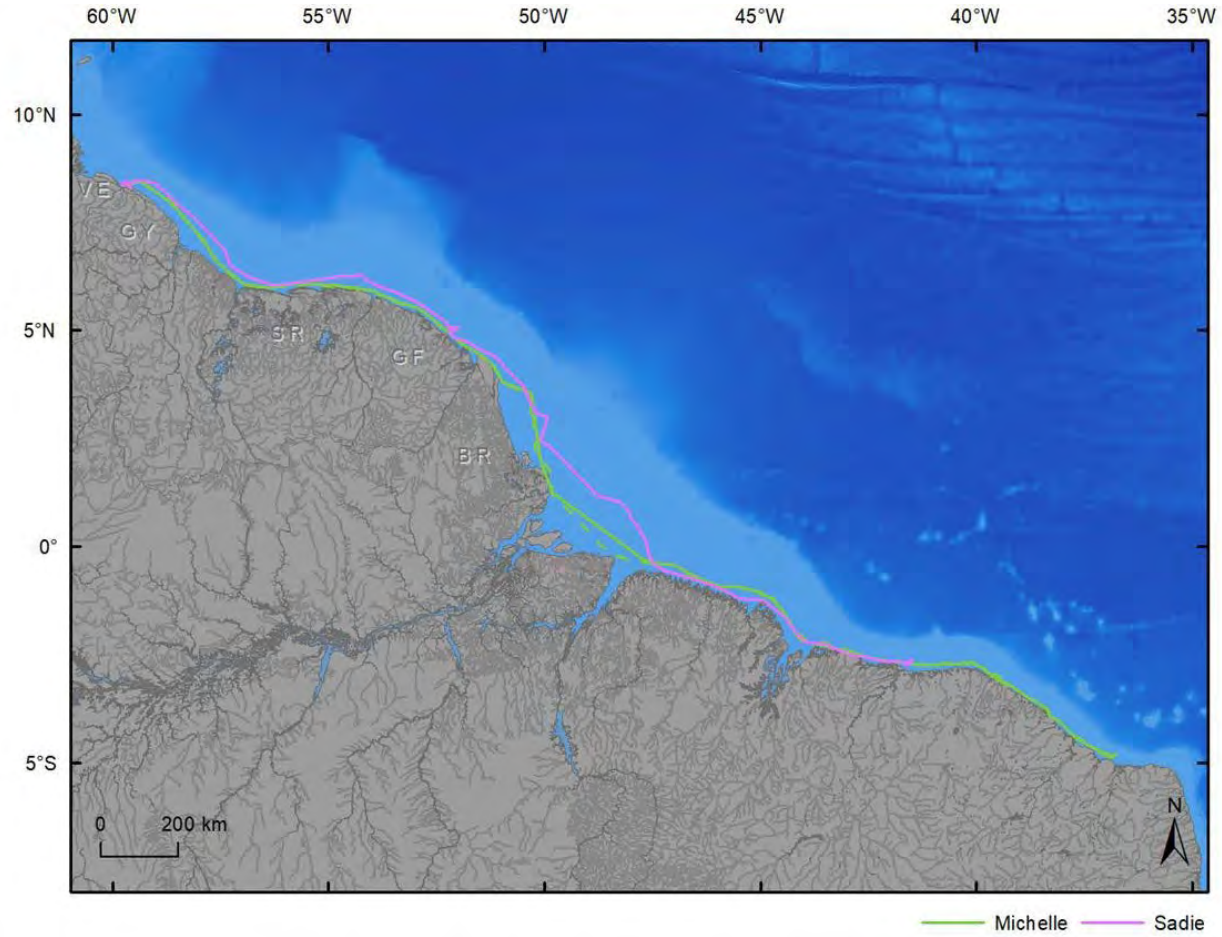
The 2019 Expedition was able to capture the migration of all seven turtles from their nesting sites on Almond Beach to their foraging grounds. The onset of migration was characterized in both species by a consistent heading and an increase in movement rates. Both green turtles tagged in 2019 headed southeast to Brazil by following a near-shore corridor across an average distance of 2,696.5 kilometers (± 125.1; mean ± 1 SD) (Figure 3-50, Table 3-6), while two leatherback turtles initially headed directly out to sea in a northeasterly direction and the three others headed due north (Figure 3-51, Table 3-6). Two of the leatherbacks (Christine and Rhoda) migrated to the southeastern United States (4,184.8 ± 688.8 kilometers; mean ± 1 SD) and remained in near-shore waters moving up and down the coast. The rest of the leatherbacks (Teij, Kari, and Regina) migrated to the continental shelf waters of Canada (4,500.3 ± 183.7 kilometers; mean ± 1 SD) before turning and heading south again into the open ocean. Both green and leatherback turtles used deeper waters during their migration period than in other tracking periods, and leatherbacks used significantly deeper waters of the open ocean than green turtles, which remained exclusively on the continental shelf (Figure 3-24 and Figure 3-25).

Michelle was the first turtle to start her migration, on 11 May 2019, taking 66 days (Table 3-6) to reach the same foraging grounds used by the green turtles tagged in 2018, where she remained for 3 weeks before migrating further south for another 13 days. Figure 3-52 shows the different behavioral periods of Michelle's journey and the associated changes in speed. The largest spikes in her movement rates coincided with major river mouths (i.e., the Essequibo River, Guyana; the Maroni River, Suriname/French Guiana; and the confluence of the Cayenne and Mahury rivers, the Amazon and Pará rivers, the Acarau River, and in the bay off Baleia, Brazil) (Figure 3-52). She traversed the Amazon and Pará rivers from 15 to 19 June 2019, passing offshore of Maracá Island, but then moving nearer to shore and the river's mouth. There were several days during the crossing without location fixes, suggesting she spent little time at the surface enabling satellite transmissions. The same issue was observed in both Argos and Fastloc GPS records. There were no dive data associated with this tag.

The other green turtle, Sadie, left the nesting beach a month later, on 15 June 2019. She took 80 days to cover the distance between nesting and foraging sites (Table 3-6). As with the other turtles, her journey was marked by changes in movement speeds that were likely related to adjustments to the flow of water. Increased movement rates occurred as she passed by the Corentyne River, Suriname; the Maroni River, Suriname/French Guiana; the Sinnamary River, French Guiana; and the Mahury River, the Amazon and Pará rivers, the Turiacu River, and the Mearima River/Arraial Bay, Brazil (Figure 3-53). She followed a similar route as Michelle to cross the Amazon and Pará river mouths, but differed in that she moved farther offshore and took longer to transit (5 to 15 August 2019; Figure 3-50 and Figure 3-53). As a result, she was farther away from the river plume, but in closer proximity to edge of the swift moving North Brazil western boundary current (Figure 3-48). There were a few days at the start of the crossing lacking location data, as in the case of Michelle. Sadie's movement rates were initially elevated upon crossing, then dipped mid-way through, increased again, and then remained lower until reaching the other side. Dive data revealed that she was in the near surface waters (less than 8 meters) in the initial part of this crossing, but then began diving deeper (to a

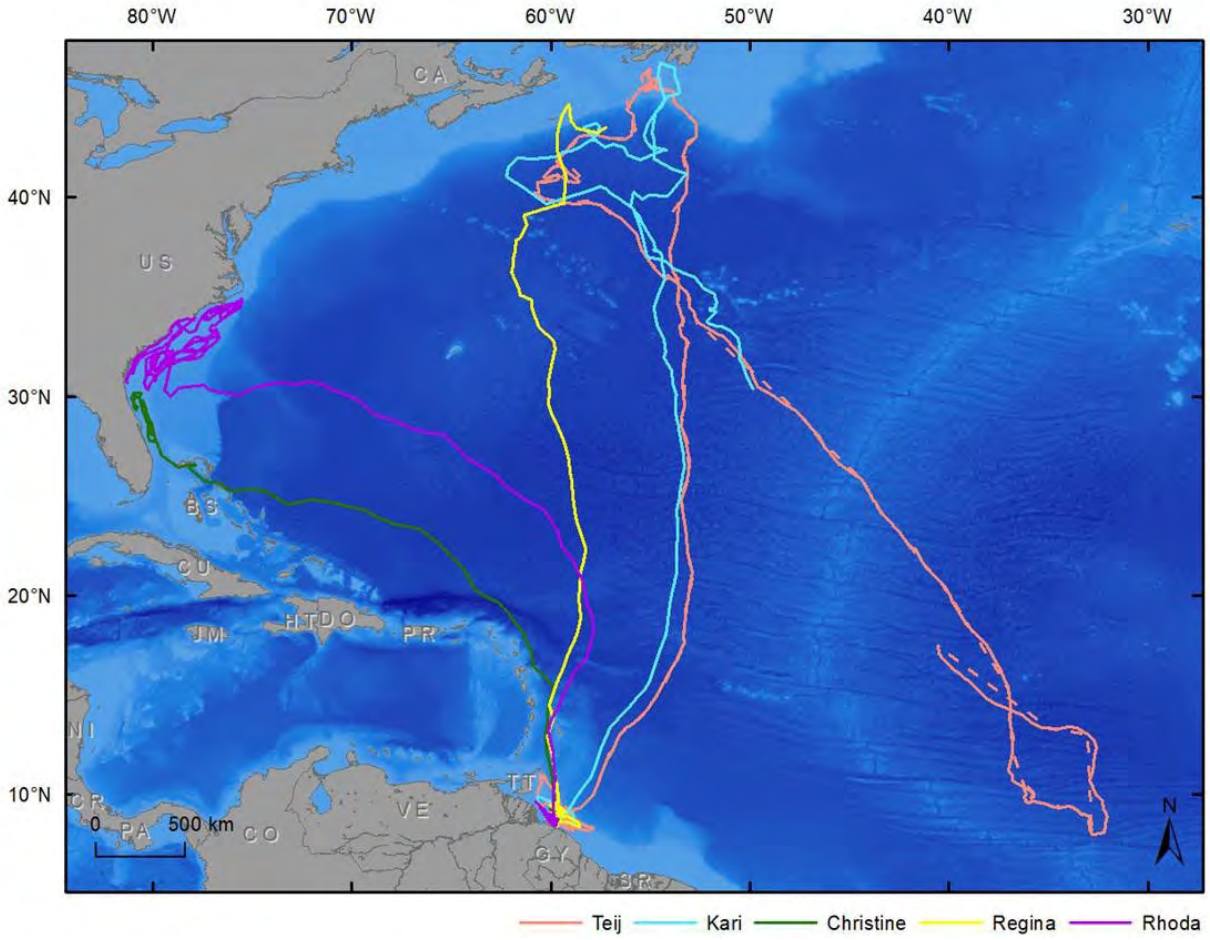
maximum depth of 39 meters) at the point where her forward movements slowed (mid-crossing) (Figure 3-26A). She also made deep dives like this at other points along her migration, at the onset and particularly at some large river mouths (i.e., the Corentyne River, Suriname; the Sinnamary River, French Guiana; and the Amazon and Pará rivers, the Turiacu River, and the Mearima River/Arraial Bay, Brazil) (Figure 3-26A and Figure 3-53). The remainder of her dives were typically within 20 meters of the surface and most frequently between 10 and 20 meters (Figure 3-31A and Figure 3-31B). Her dives were always less than 2 hours in duration, but most were less than 30 minutes (Figure 3-31C). Data from the temperature records documented some of these water masses as well. Specifically dips in temperature were noticeable as she passed the Maroni River that divides Suriname and French Guiana and then the largest dip as she passed the Sinnamary River in French Guiana, after which the temperatures increased again past Brazil's Amazon and Pará rivers and then gradually declined and leveled off when she settled into her foraging ground (Figure 3-26B).

Figure 3-50: Migration Routes of 2019-tagged Green Turtles Tracked from SBPA



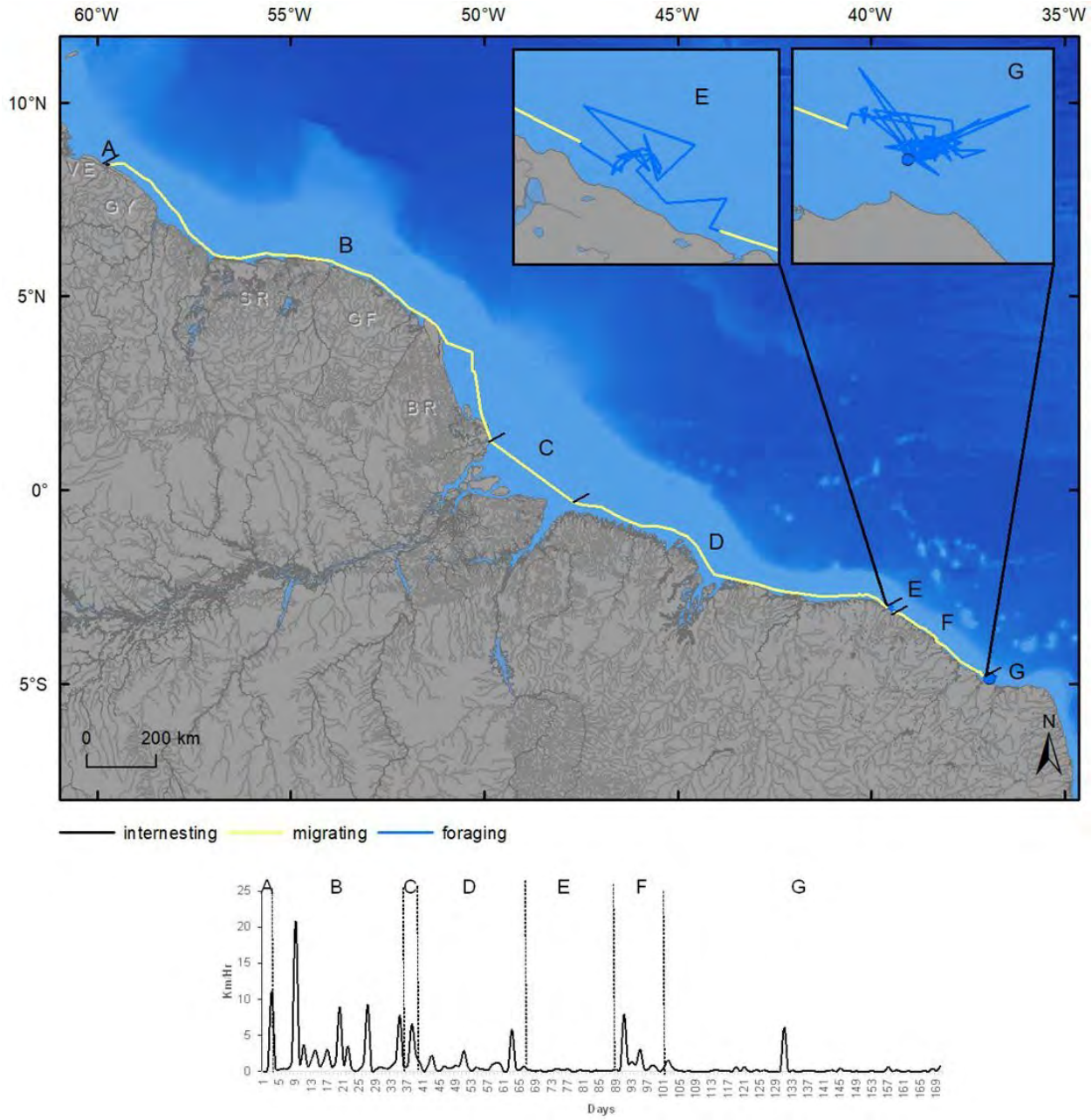
Note: Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. For the most part, the difference is unapparent.

Figure 3-51: Migration Routes of 2019-tagged Leatherback Turtles Tracked from SBPA



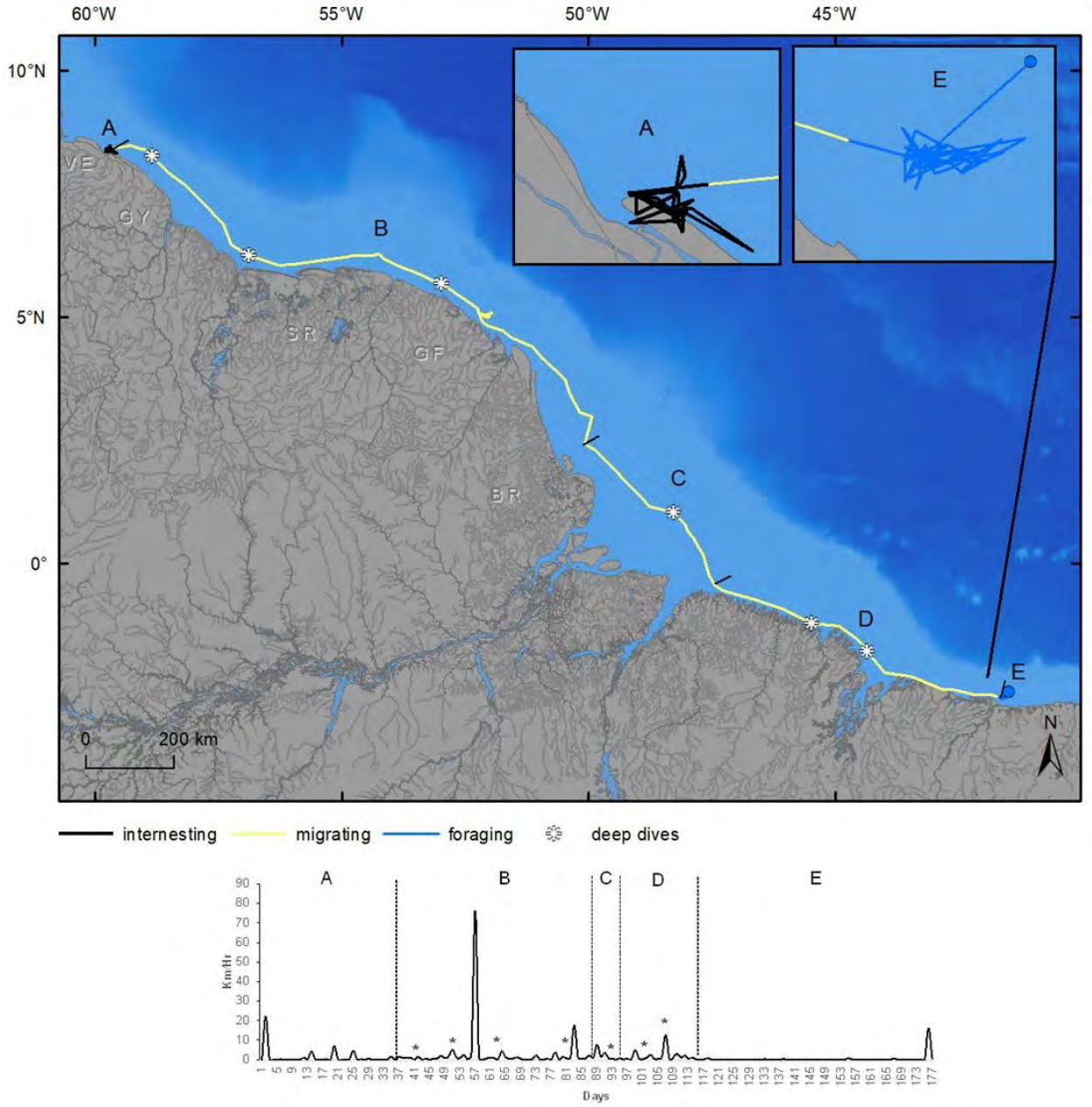
Note: Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. For the most part, the difference is unapparent.

Figure 3-52: Map of the Reconstructed Movement Track for Michelle Colored by Behavioral Intervals



Note: Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the foraging areas.

Figure 3-53: Map of the Reconstructed Movement Track for Sadie Colored by Behavioral Intervals



Note: Approximate locations of deep dives are marked with a *. Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

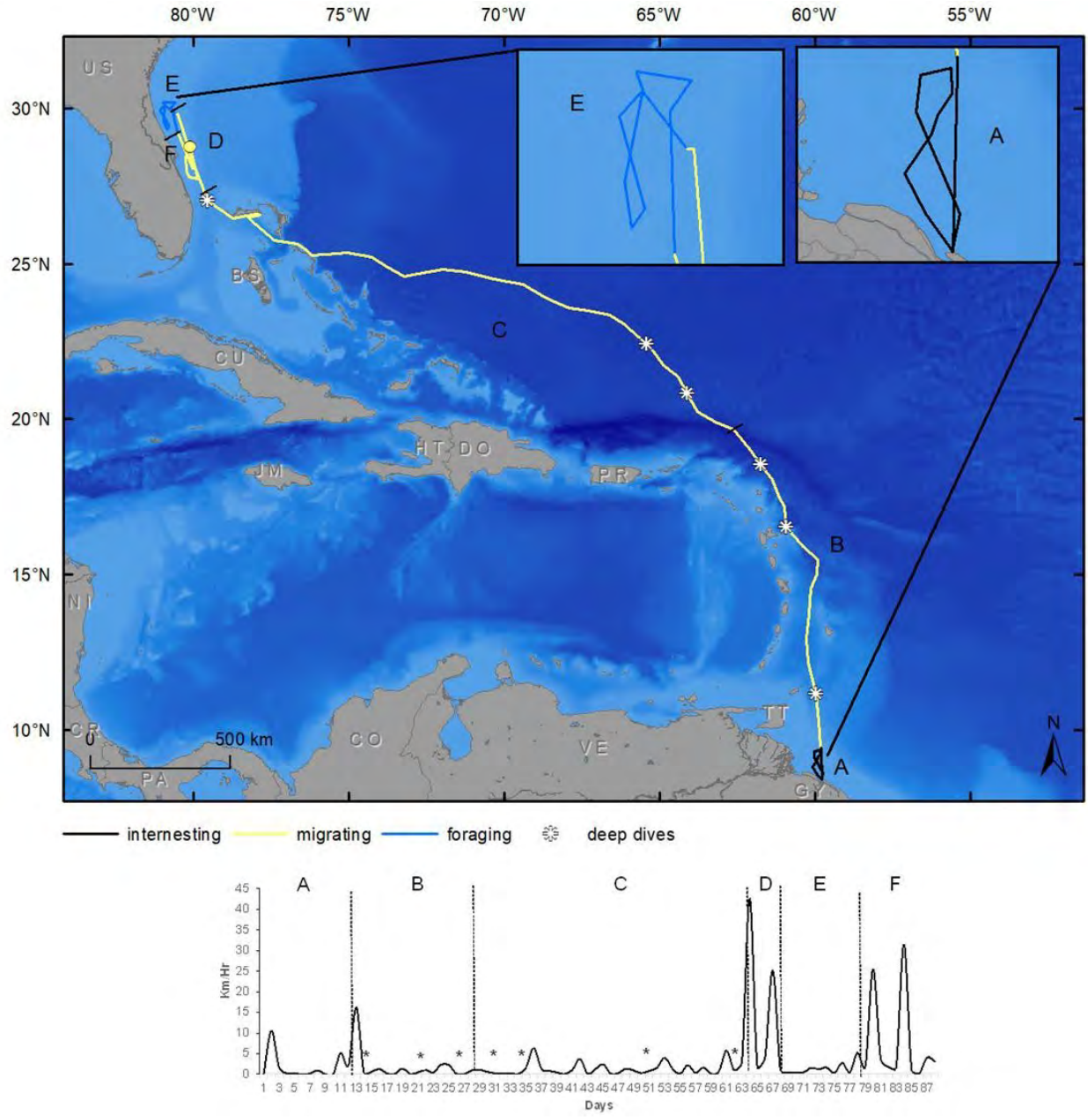
The first leatherback to start her migration was Christine. She left Almond Beach on 22 May 2019 and traveled for 55 days to the coast of Florida, in the southeastern United States (Figure 3-54, Table 3-6). Her migration path was divided into three movement rate and directional phases (Figure 3-54). She began by heading north, passing between Barbados and Saint Vincent and the Grenadines. Then she turned northwest, skirting the lower Caribbean archipelago until approximately 19° 01″ N latitude, where she moved farther out to sea and turned west-northwest until passing through the Grand Bahamas islands and crossing the Gulf

Stream current onto the continental shelf of the United States, upon which she moved north and south between central and northern Florida. The largest peaks in her movement rates were associated with her locations in the Gulf Stream (Figure 3-54). Christine made deep dives (200 to 516 meters) during this journey up through her passage of the Gulf Stream (Figure 3-28A); these dives had lower documented temperatures relative to her shallower dives (Figure 3-28B). The deepest dives (more than 400 meters) occurred east of Tobago, east of Guadeloupe, east of Anguilla, north of the British Virgin Islands, north of Puerto Rico, north of the Bahamas, and west of the Grand Bahamas (Figure 3-24). Other dives occurred at a range of depths but she spent the most time swimming near the surface (Figure 3-34A) and most dive depth records occurred at less than 20 meters (Figure 3-34B). All her dives were less than an hour in duration (Figure 3-34C). Again, it is interesting to note the change in water masses in the temperature data. Once Christine cleared the influence of the Caribbean, the temperature records began to rise as she moved through the warm North Atlantic waters (Figure 3-28B). Other noticeable changes occurred as she approached and moved through the Bahamas (increased), crossed the Gulf Stream current (increased), and moved close to shore off Jacksonville (decreased) and Cape Canaveral (increase), Florida, the latter of which was concurrent with westerly movement of the Gulf Stream toward shore (Figure 3-28B, Figure 3-54, and Figure 3-60).

Rhoda, the second leatherback to depart the nesting beach (22 June 2019), made a nearly identical migration path to the southeastern coast of the United States, only shifted farther north and taking 68 days (Figure 3-55, Table 3-6). She too swam north, passing between Barbados and Saint Vincent and the Grenadines, but arced away from the Caribbean island chain and continued heading north until she turned west-northwest at approximately the same latitude of 19° 01″ N where Christine had made her turn. Rhoda made her way through the Blake Canyon, onto the continental rise, where she entered the Gulf Stream and traveled north, crossing it to the other side, and exiting off of Charleston, South Carolina. In between foraging periods (see Section 3.4.2 for details), she moved between the coastal waters of Jacksonville, Florida, and Cape Hatteras, North Carolina, staying near the continental shelf break during the autumn months and hugging the shoreline during the winter and spring months. Her highest movement rates were seen out in the open ocean traveling in frontal convergence zones and while in the Gulf Stream (Figure 3-55 and Figure 3-60). Rhoda consistently made dives in the upper 150 meters of the water column during this migration, with a few deep dives at points along her journey to a maximum depth of 590 meters (Figure 3-30A). Her deepest dives (more than 400 meters) occurred east of Saint Lucia, east of Guadeloupe, north Barbados, north of Antigua, and north of the Dominican Republic (Figure 3-54). While on the continental shelf, her deepest dives occurred east of Charleston and Myrtle Beach, South Carolina, and east of Ocracoke Island, North Carolina (Figure 3-55). Although she did make a few very deep dives, Rhoda's dive profile consisted primarily of shallow dives (less than 20 meters) with most time spent swimming in depths less than 2 meters (Figure 3-35A and Figure 3-35B). All of her dives were less than 2 hours in duration, but most were less than 5 minutes (Figure 3-35C). Her entrance into the warm North Atlantic gyre was visible in the temperature data, as was her crossing the Gulf Stream. There was a latitudinal dip in temperature along her migration track around 30°0″ N and declines and elevations associated with seasonal changes in temperature while she was

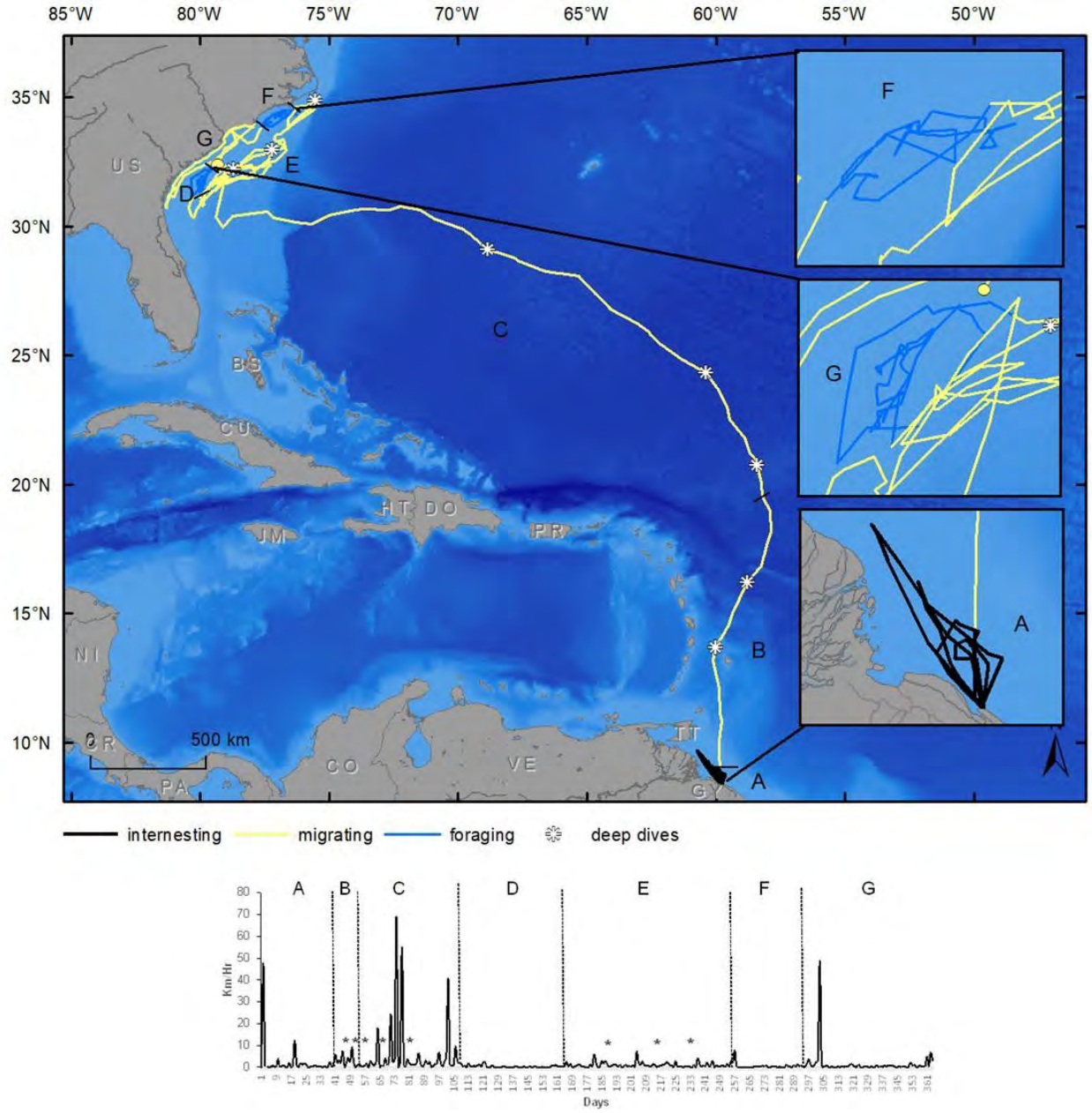
on the continental shelf; the lowest non-dive-related temperatures (12°C) occurred in Onslow Bay, North Carolina, during February 2020 (Figure 3-30B and Figure 3-55).

Figure 3-54: Map of the Reconstructed Movement Track for Christine Colored by Behavioral Intervals



Note: Approximate locations of deep dives are marked with a *. Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Figure 3-55: Map of the Reconstructed Movement Track for Rhoda Colored by Behavioral Intervals



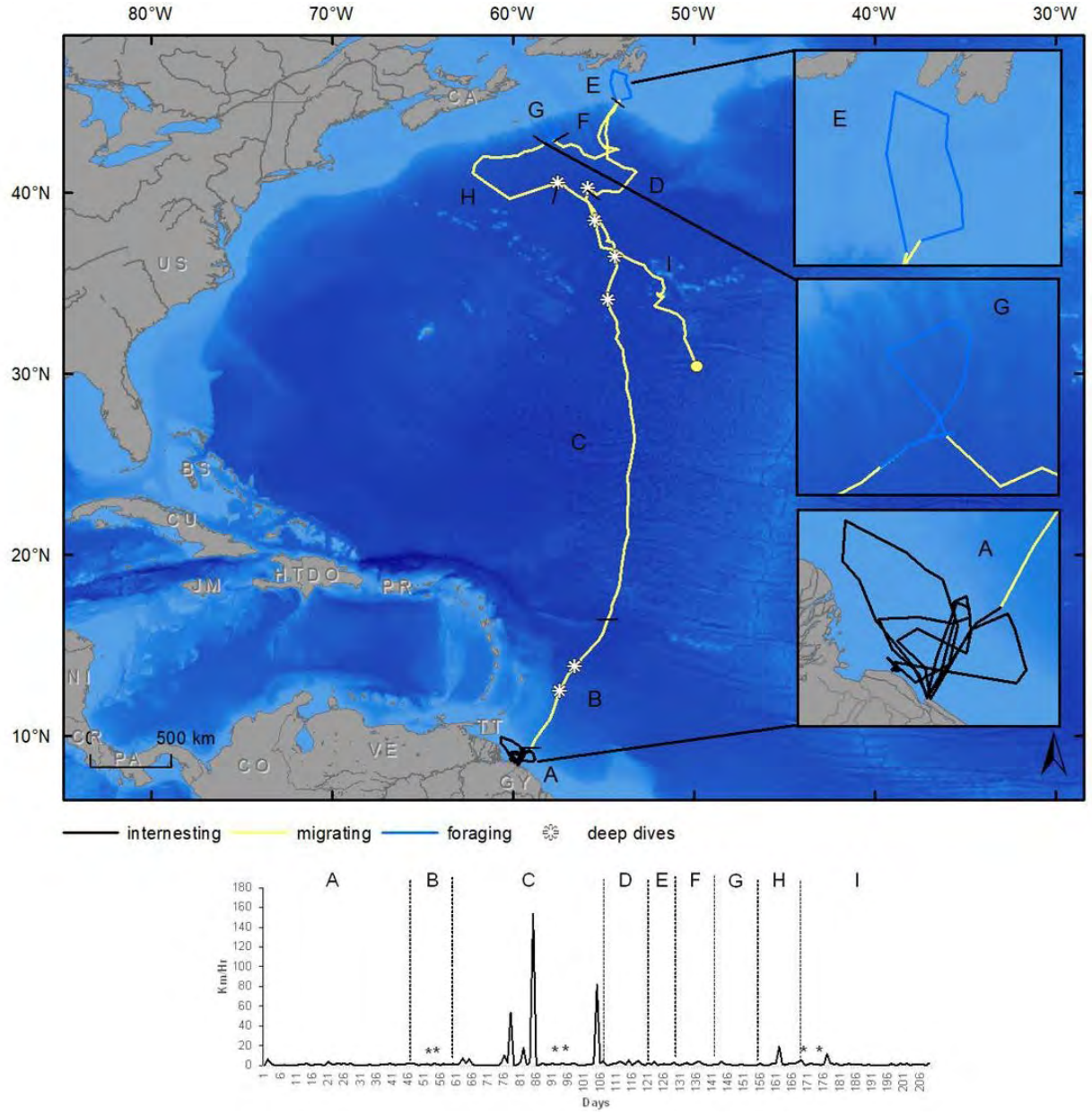
Note: Approximate locations of deep dives are marked with a *. Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Kari left the nesting beach a few days after Rhoda, on 25 June 2019, swimming northeast into the North Atlantic and heading directly for foraging grounds in Canadian waters (Figure 3-56). Her migratory journey took 73 days to reach the coast of Newfoundland (Table 3-6). She made a slight course correction northward east of Guadeloupe, traveled through the Sargasso Sea, passed between the Corner Rise and New England Seamounts, turned east at 40° 0″ N latitude making a counterclockwise arc facilitated by the Gulf Stream current extension and then continued north at 41° 2″ N latitude onto the continental shelf waters of the Southern Grand

Banks of Newfoundland, Canada. Here she made a clockwise loop (see Section 3.4.2 for details). She then returned the way she came, again making a counterclockwise arc, this time to the west, traveling in and crossing out of the Gulf Stream extension, and heading south. At 37° 0″ N latitude she turned southeast and went through the Corner Rise seamounts and then continued traveling southward into the mid-Atlantic. Spikes in movement speeds occurred in the open ocean portions of her migration track and were associated with dynamic geostrophic flow, including ephemeral (i.e., oceanographic fronts and rings) and semi-permanent features (i.e., the Gulf Stream extension) (Figure 3-56 and Figure 3-60). Kari was the deepest recorded diver of the tagged turtles from the study, reaching a depth bin of 1,400 meters, but her migratory dives were most frequently in the upper 100 to 200 meters of the water column (Figure 3-27A and Figure 3-32B). She made two deep dives (more than 400 meters) in the early days of her migration, east of Barbados and Martinique, and then again in the passage between the seamount chains, as well as her entry and departure points of the Gulf Stream extension (Figure 3-27A and Figure 3-56). As with Rhoda, her dives did not last longer than 2 hours, but were more variable in duration (Figure 3-27C). She also spent most of the time swimming near the surface (Figure 3-27A). The peaks in the time-series of temperature records showed her entering the warm North Atlantic gyre, passing through a convergence zone in the mid-Atlantic, and twice crossing the Gulf Stream extension, while the valleys showed her moving onto the Canadian shelf waters influenced by the cold Labrador Current, where she experienced her lowest non-dive temperature (0°C) just off of Placentia Bay, Newfoundland, as well as cool waters in Shortland Canyon near the Gulf of Saint Lawrence (Figure 3-27B and Figure 3-56). The extent of the foray she made off the continental shelf of Canada encircled a Gulf Stream meander during that period (Figure 3-39), providing relatively warm water and active frontal activity.

Kari’s 1,400-meter dive was unique among the turtles in this study. Leatherbacks have previously been known to make dives deeper than 1,000 meters, but dives to these depths are rare and the reasons for them are unknown. Three possibilities have been proposed including thermoregulation, predator avoidance, and scouting prey than migrate vertically on a diurnal pattern. The “prey scouting” theory has emerged as the most credible of the three possibilities, and assumes that the turtles use these dives to locate concentrations of prey items and then return to the surface to wait for them to rise through the water column at night, when the turtles can consume them at their leisure, closer to the surface (Houghton et al. 2008).

Figure 3-56: Map of the Reconstructed Movement Track for Kari Colored by Behavioral Intervals



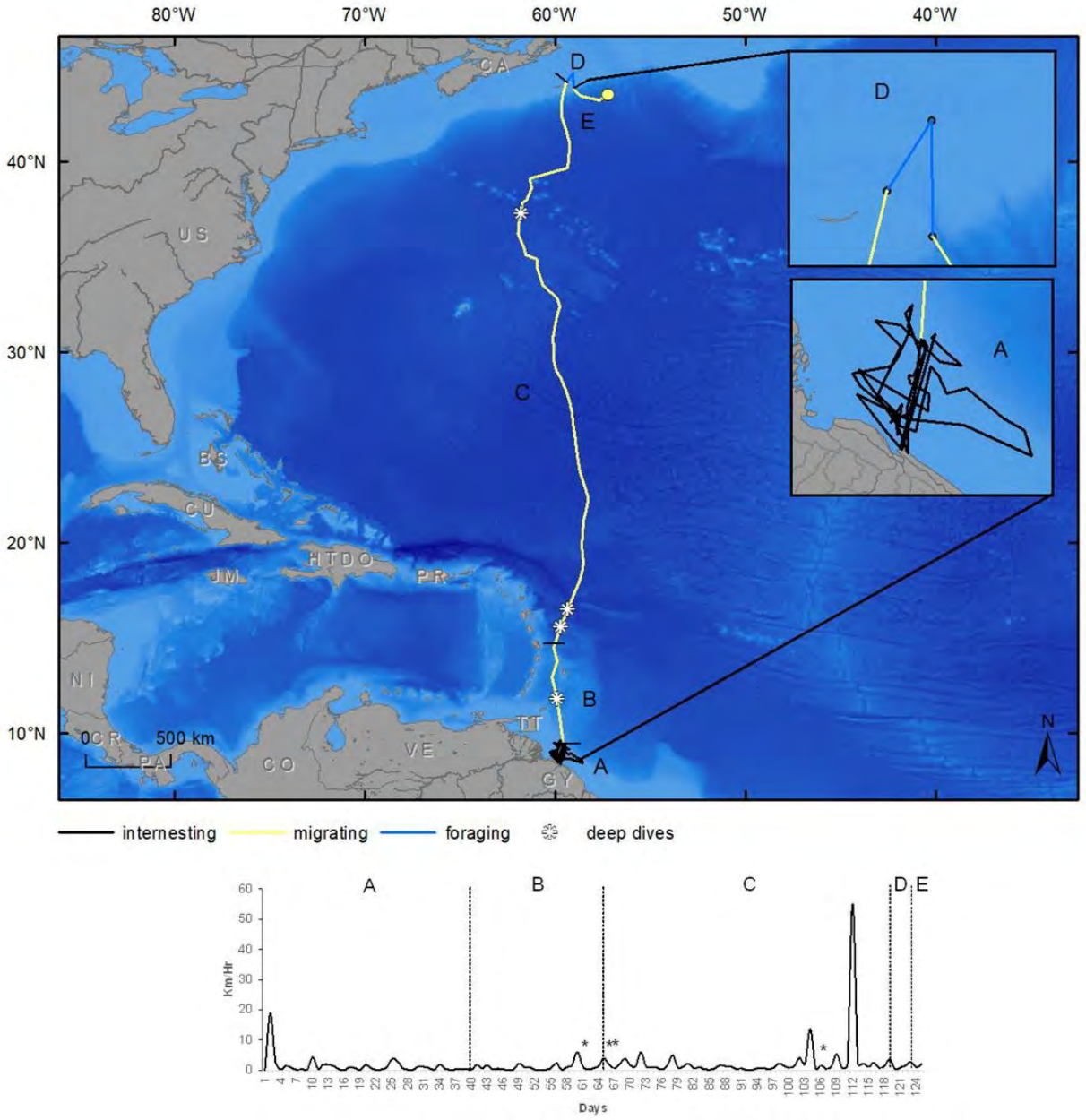
Note: Approximate locations of deep dives are marked with a *. Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Regina was the fourth leatherback turtle to leave the SBPA during this study. She began migrating on 7 July 2019, heading due north to Canada, taking 62 days to reach the Scotian Shelf just east of Sable Island, Nova Scotia (Figure 3-57, Table 3-6). Her course was similar to Kari's, passing between Barbados and Saint Vincent and the Grenadines, just as Christine and Rhoda did, but she then adjusted her direction east of Martinique and continued northward straight through the New England seamounts, crossing the Gulf Stream extension, and moving briefly onto the continental shelf, before turning and heading offshore into Shortland Canyon, where she stopped transmitting. The two largest peaks in her migratory movement rates were in

proximity to a cold core ring south of the chain of seamounts and her crossing the Gulf Stream extension just north of the seamounts (Figure 3-57 and Figure 3-39). Most of Regina's deep dives (more than 400 meters) took place early in her journey, the deepest of which was 680 meters, east of Grenada; she made another deep dive just prior to entering the New England seamounts (Figure 3-29A and Figure 3-57). She continued to make some moderately deep dives (more than 200 meters) through the chain of seamounts and across the northern side of the Gulf Stream extension. The rest of her dives were primarily within 150 to 200 meters depths (Figure 3-29A). Regina's dives were all less than an hour, but she made longer dives than the other leatherbacks (up to 40 minutes being the highest percentage) (Figure 3-34C). She most frequently dove to 50 meters (Figure 3-34B), but she also spent a significant portion of her time in the surface waters (Figure 3-34A). Like the other turtles, there was a rise in her temperature data observed as she moved into the open ocean water of the North Atlantic, followed by a decline in temperature as she passed through a convergence zone southwest of Bermuda, another dip immediately before she crossed the Gulf Stream extension, followed by a steady decline to 10°C when she moved onto the Scotian Shelf, and finally a slight rise as she moved back out to sea (Figure 3-29B and Figure 3-57).

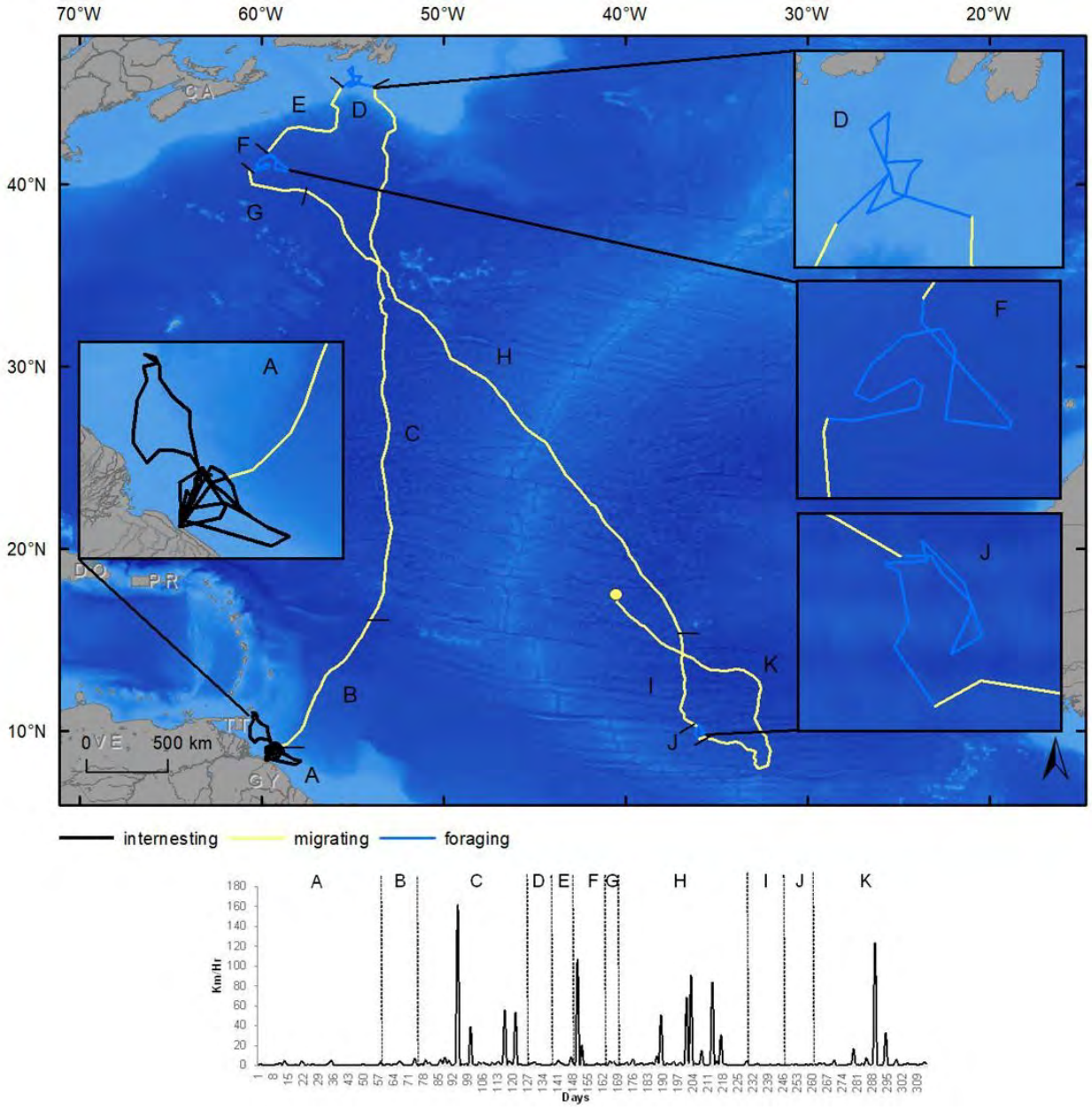
Teij was the last of the tagged turtles to leave the nesting beach, just 1 day after Regina, on 8 July 2019. Her migration route was nearly identical to that of Kari's, but taking her a week's less time to reach the Southern Grand Banks of Newfoundland, Canada, in just 67 days (Figure 3-50 and Figure 3-58; Table 3-6). She similarly made a slight course correction northward east of Guadeloupe, traveled directly through the Sargasso Sea, passed between the Corner Rise and New England Seamounts, but made no deviation in crossing the Gulf Stream current extension before moving onto the continental shelf and turning around outside of Placentia Bay, Newfoundland (see Section 3.4.2 for details). Teij then moved southward and offshore along the Laurentian Fan and then turned west at 43° 0″ N latitude, making a counterclockwise arc to the south, again crossing the Gulf Stream extension and heading southeast into the mid-Atlantic. Her track continued onward to 15° 01″ N, where she adjusted her course slightly to a due south direction until she reached 8° 0″ N and turned around and headed north-northwest again, presumably because of the cues from the strong westward flowing North Equatorial Current. The greatest peaks in her movement speeds were also in the open ocean and northwest-most extent of her migration track and were likely associated with dynamic geostrophic flow, including ephemeral (i.e., oceanographic fronts and eddies) and semi-permanent or permanent features (i.e., the Gulf Stream extension and its meanders, the North Equatorial Current) (Figure 3-58 and Figure 3-60). The Gulf Stream extension meander encompassed by Kari's track was also encompassed by Teij's track, which occurred from late September to mid-October 2019. There were no dive data associated with this tag.

Figure 3-57: Map of the Reconstructed Movement Track for Regina Colored by Behavioral Intervals



Note: Approximate locations of deep dives are marked with a *. Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

Figure 3-58: Map of the Reconstructed Movement Track for Teij Colored by Behavioral Intervals



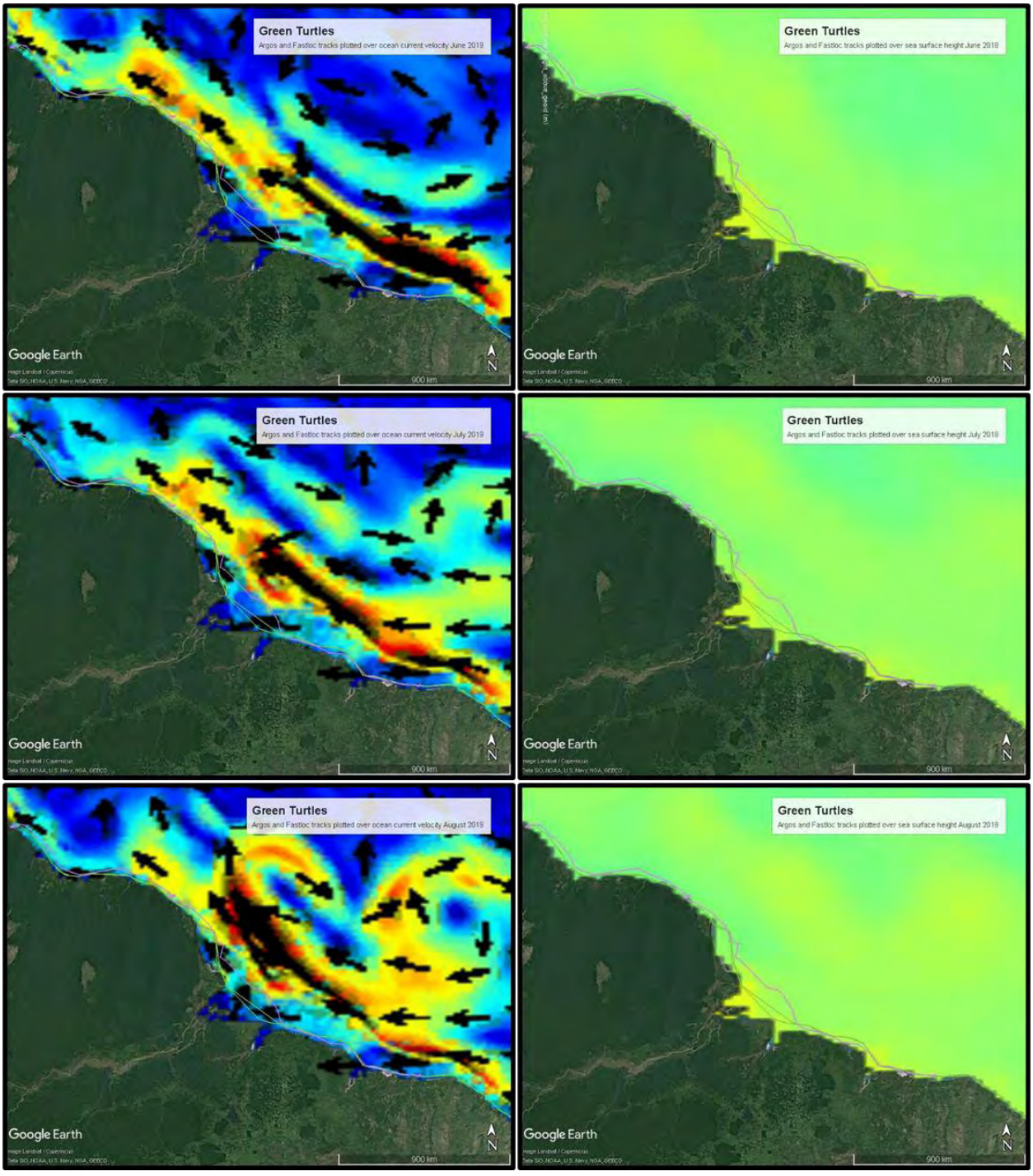
Note: Changes in movement rates plotted below the map indicate behavioral changes along the movement track and are denoted with letters in both the map and graph. The inset boxes are close-up versions of the inter-nesting and foraging areas.

As with the turtles tagged in 2018, the movements of turtles tagged in 2019 were overlaid on monthly-averaged geostrophic current imagery to examine the influence of ocean currents on their movements while at sea. Similar to the turtles tagged in 2018, the green turtles tagged in 2019 migrated in a very narrow band close to the shore where current magnitudes were minimal and where SSHs are lowest, except around the major river mouths in Brazil where SSH is elevated (Figure 3-59). This effect was strongest and most extensive in June, weakening in July and August during most of their migration. As with the turtles tagged in 2018, the movements of

green turtles tagged in 2019 were consistent with the corridor first identified by Baudouin et al. (2015) and with the energetic strategy proposed by Chambault et al. (2015).

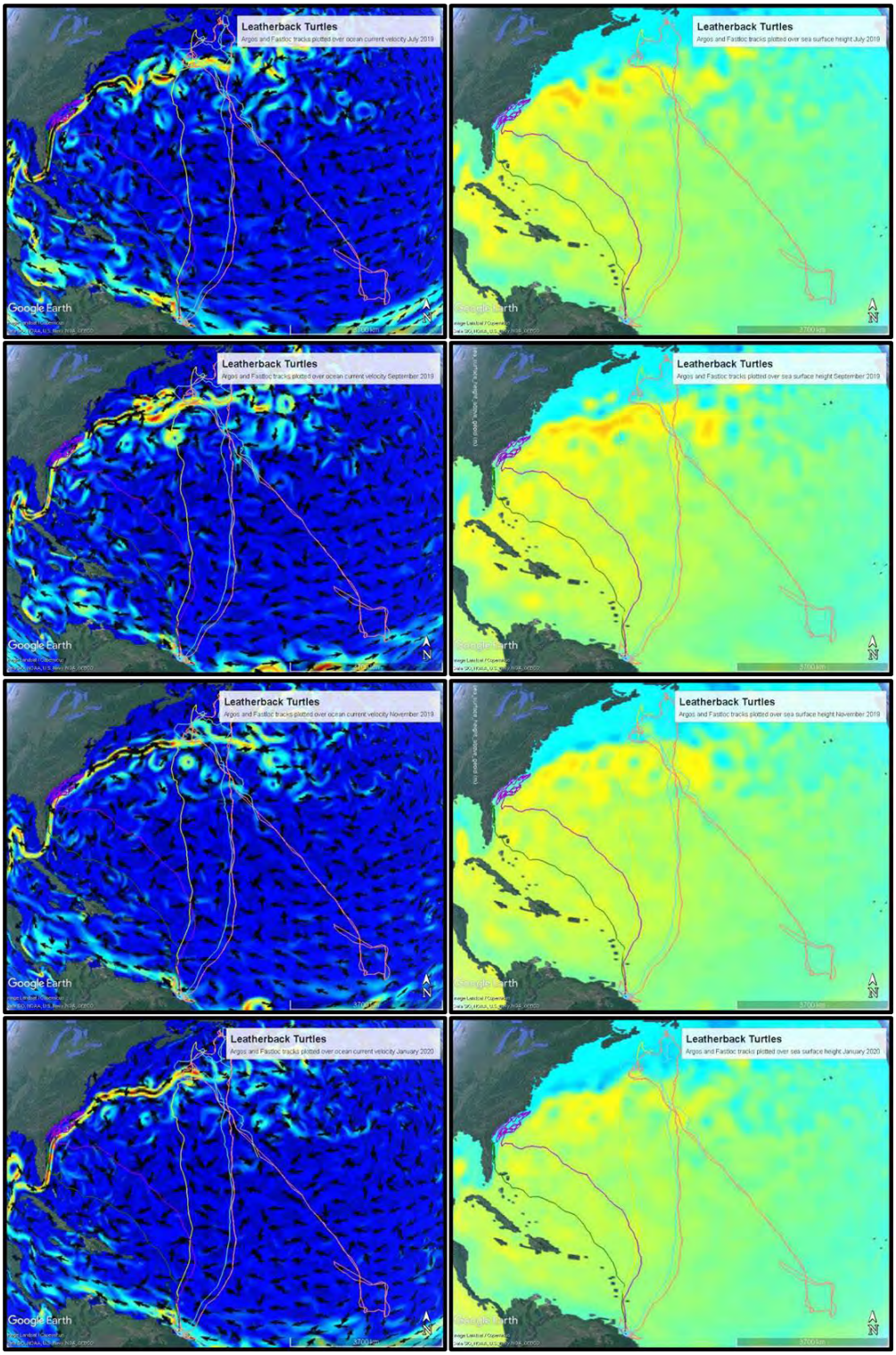
Leatherback turtles initiated migrations between late May and early July when altimetry indicated strong northwest movement of the Guiana Current near the SBPA. Christine, Rhoda, and Regina followed the current initially toward the Caribbean, while Kari and Teij traversed it directly moving across the prevailing flow. Leatherbacks have been documented to maintain remarkably consistent headings traveling through the North Atlantic subtropical gyre, with negligible drift associated with ocean currents (Dodge et al. 2015). The small bumps observed in their tracks were minor deviations reflecting these ocean dynamics, while larger arcs and jumps indicated more significant deviations specifically related to the Gulf Stream current and its extension and meanders (Figure 3-60).

Figure 3-59: Combined 2019-tagged Green Turtle Migration Tracks



Note: Migration tracks superimposed over mean-monthly ocean altimetry data, where geostrophic current vectors are displayed in the left hand panels and SSHs are displayed in the right hand panels for June–August 2019 (top to bottom). Warmer colors indicate higher magnitude or height, respectively.

Figure 3-60: Combined 2019-tagged Leatherback Turtle Migration Tracks



Note: Migration tracks superimposed over mean-monthly ocean altimetry data, where geostrophic current vectors are displayed in the left hand panels and SSHs are displayed in the right hand panels for July, September, and November 2019 and January 2020 (top to bottom). Warmer colors indicate higher magnitude or height, respectively.

3.4. Foraging Period

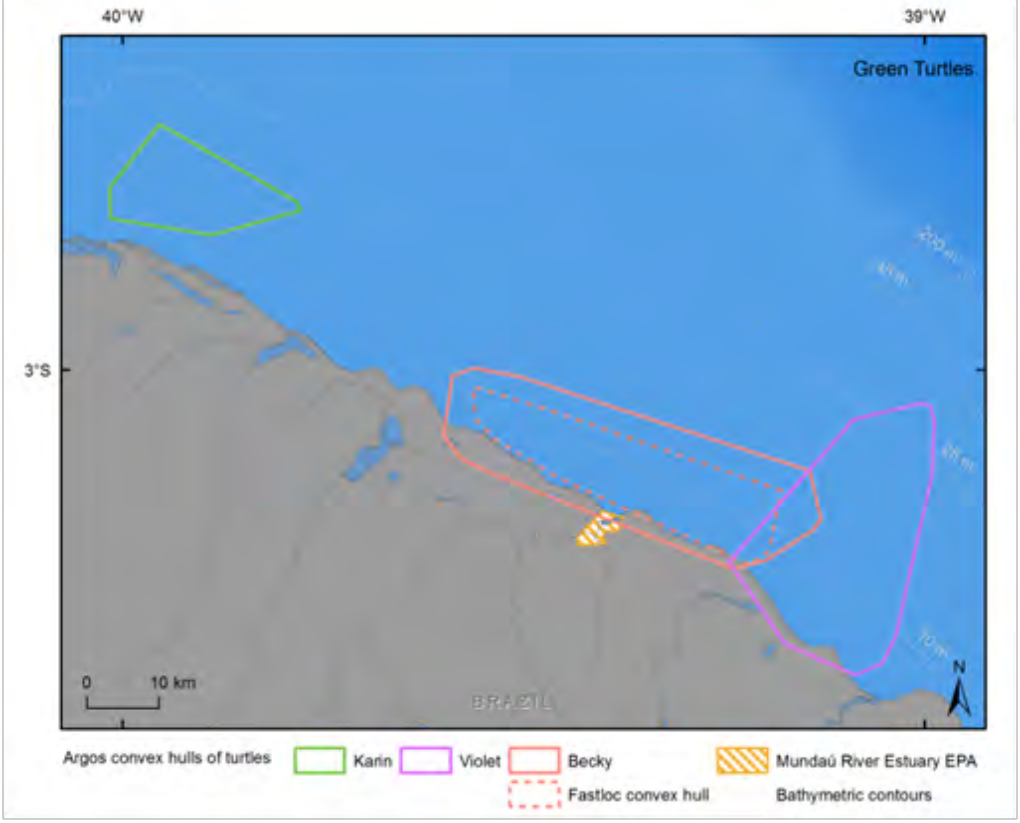
When using remote tracking technologies, foraging sites are typically identified by changes in the movement behaviors of the individuals being monitored. These behaviors include area-restricted search and dive patterns. These behavior metrics are inferences for foraging, not direct evidence, but are standard methodologies used in the field of research. Area-restricted search is based on the premise that food is spatio-temporally uneven in distribution in the environment and, as a consequence, a predator will increase the frequency of its changes in direction and decrease its speed of movement when it encounters a patch of food (Kareiva and Odel 1987). This is observed as sinuous versus straight lines along an animal's movement track. We used these components (changes in speed and turning angles; Figure 3-52 through Figure 3-58) along with changes in the depths of dives (Figure 3-26 through Figure 3-30), when possible, to identify foraging locations for the turtles in this study. This is much more straightforward for green turtles than for leatherbacks because the former feed primarily on seagrass, which is stationary, benthic, and somewhat predictable (Short et al. 2007), and they tend to settle into a foraging ground and set up residency for extended periods of time. Leatherbacks, on the other hand, feed on gelatinous prey, which is both mobile and sporadic (i.e., less predictable) in the environment, so these turtles must move among disparate patches to feed and search throughout the water column to find their food (Duron and Duron 1980; Eisenberg and Frazier 1983). Frontal zones aggregate planktonic organisms (Mann and Lazier 2006), therefore, migrating to regions with predictable frontal features would be a good foraging strategy for leatherback turtles and has indeed been observed in both coastal and offshore environments (Houghton et al. 2006; Eckert 2006).

3.4.1. 2018 Expedition

None of the leatherback turtles were tracked to their ultimate foraging grounds in 2018. Three green turtles were tracked to their ultimate destination, the foraging grounds in the State of Ceará, Brazil. This region was first described as a green turtle foraging area by Pritchard (1976) based on tag returns of turtles from the Guianas. Since that time, molecular techniques and satellite tracking have provided further evidence supporting a well-established, mixed-stock foraging aggregation of green turtles at Almofala, Brazil (Naro-Maciel et al. 2007; Godley et al. 2003), which attracts animals from Ascension Island and the lower Caribbean. As far as is known by the authors of this report, no satellite tagging study has been published documenting the foraging grounds of green turtles from Guyana. The turtles in this study settled in the vicinity of Almofala, Brazil, and were tracked for an average of 43 +/- 6.2 days (mean +/- 1 SD) (Figure 3-41, Figure 3-42, Figure 3-43; Table 3-3). Two of the three turtles overlapped geographically in area, adjacent to the Mundaú River Estuary Environmental Protection Area (Figure 3-61). The three green turtles displayed similar habitat use (area) and movements (dispersal from foraging centroid) among individuals and their locations were at similar distances from shore as during the inter-nesting period (Figure 3-2). For all individuals except Karin, turtles used slightly deeper water depths than during the inter-nesting period (7.9 +/- 6.7 meters [mean +/- 1 SD]) (Figure 3-6). The coastline between the Orinoco River in Venezuela and the Amazon River in Brazil is one of the world's muddiest due to high suspended-sediment discharge from the Amazon River

being transported westward along shore as mud banks (Anthony et al. 2010). The region to the east is therefore the nearest habitat permitting the growth of seagrass, the primary food source for green turtles, which requires adequate light transmission to grow (Short et al. 2007).

Figure 3-61: Spatial Foraging Footprints of 2018-tagged Green Turtles near Almofala, Brazil



3.4.2. 2019 Expedition

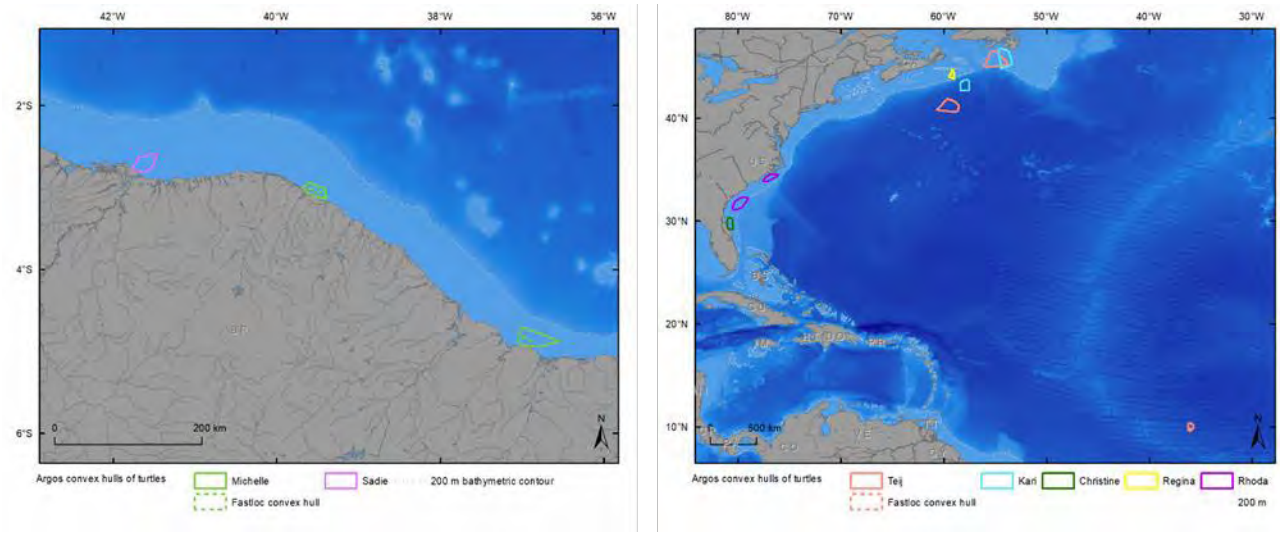
Similar to 2018, both green turtles tagged in 2019 traveled to foraging grounds located in the State of Ceará, Brazil (Figure 3-61) and were tracked for an average of 77 days once they had arrived (± 21.2; mean ± 1 SD) (Figure 3-50, Table 3-6). Michelle initially stopped in the well-known green turtle foraging ground (Naro-Maciel et al. 2007; Godley et al. 2003) near Almofala. Michelle foraged in this area for 24 days, but then moved farther down the coast and settled into another site in the state of Rio Grande do Norte, where she remained for 68 days when her transmissions ceased (Figure 3-52, Table 3-6).

Sadie settled into a foraging ground farther north, in the State of Piauí near Parnaíba, Brazil, where she was tracked for her final 62 days of transmissions (Figure 3-53, Table 3-6). The time-series plot of her dive depths shows a flattening off at 20 meters, consistent with benthic diving behavior within the 20 meters isobath – which is ideal for grazing upon seagrass (Figure 3-26A). Both green turtles used slightly deeper water depths than during the inter-nesting period (8.2 meters ± 4.8; mean ± 1 SD) and displayed similar habitat use (area) and movements (dispersal

from foraging centroid) among sites, and their locations were at similar distances from shore as during the inter-nesting periods (Figure 3-22).

For the first time in this study, we identified both coastal and oceanic foraging habitats for the leatherbacks that they occupied for 3 to 58 days (Figure 3-54 and Figure 3-62, Table 3-6). The indicators for these periods were area-restricted search movement, coupled with a change in dive behavior marked by a progression of shallow dives; this behavior was consistent in both types of habitats. All five leatherbacks used at least one coastal foraging site, and two turtles (Teij and Kari) also had one or more oceanic foraging sites.

Figure 3-62: Spatial Foraging Footprints of 2019-tagged Green and Leatherback Turtles in the North Atlantic



Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have been previously described as critical foraging habitat for leatherback turtles (James et al. 2005, 2006) and indeed capture studies in this area have previously confirmed flipper tag recoveries from the Guianas (James et al. 2007). Between early September and mid-October 2019, Kari, Regina, and Teij displayed foraging behavior in this region. Kari and Teij spent 9 and 13 days foraging in the coastal zone, respectively, outside Placentia Bay, Newfoundland, and another 15 and 16 days, respectively, foraging over abyssal depths (more than 3,000 meters) off of Nova Scotia (Figure 3-56, Figure 3-57, Figure 3-58; Table 3-6). Kari's data showed that her dives were mostly in the upper 30 meters of the water column during these periods (Figure 3-8A). Regina's foraging site was in nearby coastal water, adjacent to Sable Island, Nova Scotia (Figure 3-58) where she remained for only 3 days (Table 3-6). Her dives were also confined to the upper 30 meters during this behavioral phase, although potential depths were down to 200 meters (Figure 3-29A).

The coastal zone of the southeastern United States has also been identified as important foraging habitat for leatherbacks (Eckert et al. 2006; Fossette et al. 2014; Stewart et al. 2016). We observed three foraging periods and locations here, interspersed from late July 2019 to the end of February 2020.

Christine demonstrated foraging behavior off northern Florida for 12 days in July (Figure 3-54, Table 3-6). Her dives were less than 20 meters during this time, indicating that she was diving near to the seafloor (approximately 30 meters) (Figure 3-28A). Meanwhile, Rhoda displayed foraging behavior around Onslow Bay and Cape Lookout, North Carolina, for 58 days beginning in late August, and then again off of Georgia/South Carolina border for 40 days beginning in late January (Figure 3-55, Table 3-6). Her dives were mostly to 35 meters in the North Carolina foraging site, which was approximately the depth of that site, and less than 20 meters in the Georgia/South Carolina site, which was a deeper site extending to continental shelf break (i.e., 200 meters) (Figure 3-30A). Altimetry data showed that these positions kept the turtles outside of the Gulf Stream current influence during these periods (Figure 3-60).

Finally, we also identified a leatherback foraging event in the open ocean halfway between the east coast of South America and the west coast of Africa (Figure 3-58). Teij appeared to be foraging near a zone of divergent circulation (i.e., upwelling) spawned from the North Equatorial Current during a 15-day period in January (Figure 3-60, Table 3-6). There were no dive data associate with this tag, but water depths are approximately 5,000 meters at this location.

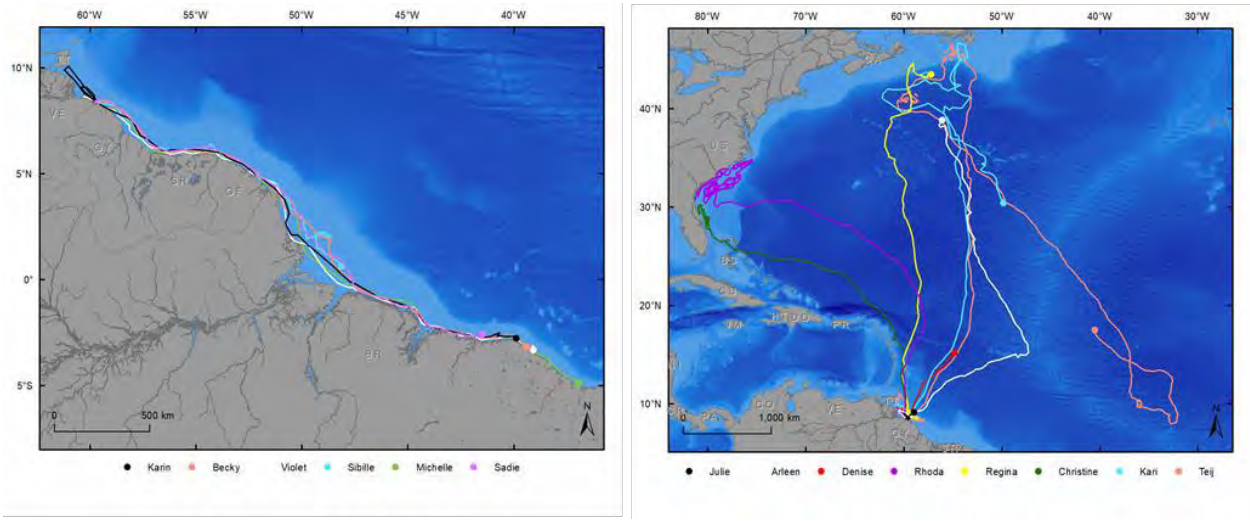
Leatherback turtles used deeper water depths during foraging than during the inter-nesting period (1,159.1 meters $\pm$ 954.6; mean $\pm$ 1 SD) and turtles foraging in Canadian waters occupied deeper waters than turtles foraging in the southeastern United States (2,955.5 meters $\pm$ 2,154.3; mean $\pm$ 1 SD and 32.2 meters $\pm$ 14.1; mean $\pm$ 1 SD, respectively) ($F_{1,177} = 203.2$, $p < 0.001$). Habitat use (area) and distances from shore were similar between inter-nesting and foraging periods for leatherbacks, but movement (dispersal from foraging centroid) among sites was greater than during the inter-nesting period ($\chi^2 = 11.740$, df = 1, $p < 0.001$; Figure 3-22). Although these metrics were somewhat larger for turtles foraging in Canadian waters than for turtles foraging in the southeastern United States, they were not statistically different.

3.4.3. Interannual Variation

For turtles tagged in 2018 and 2019, inter-nesting habitat-use patterns were quite similar within species, with turtles staying relatively close to the SBPA, but for turtles tagged in 2019, the study tracked more turtles during their migrations to foraging areas (Figure 3-63).

Leatherbacks tagged in 2019 traveled to waters off Canada (three turtles) and the southeast United States (two turtles) for foraging following their nesting season. Only one of the three leatherbacks tagged in 2018 was on track to reach its foraging grounds off Canada when transmissions ceased. Both of the green turtles tagged in 2019 traveled to Brazil foraging sites following the nesting season. They followed very similar paths along the coastline southeast of the SBPA and this was similar to the paths taken by all four green turtles tagged in 2018.

Figure 3-63: Satellite Tracks of All Six Green (left) and Eight Leatherback (right) Turtles Tagged in 2018 and 2019 Tracked from Shell Beach Protected Area through Their Inter-nesting Intervals and to Their Foraging Grounds



4. CONCLUSION

The results of this study provided a wealth of new information about Guyana's nesting sea turtles. Although sample sizes were small, they provided the first look into the at-sea behaviors of green and leatherback turtles in this region. They expanded our knowledge on the at-sea behaviors of green and leatherback turtles in this region in a manner not possible by other methods. The SBPA is an important yet under-described nesting area for green and leatherback sea turtles that migrate to disparate foraging grounds in Brazil and the North Atlantic, respectively. Within the inter-nesting period, important similarities between species and year are evident. The study shows that turtles may remain in the inter-nesting zone for several months, venturing northwest into the territorial seas of Venezuela and Trinidad and Tobago, laying multiple clutches of eggs, and displaying strong site fidelity. Green turtles tended to stay near the nesting beach, generally within the 5-meter isobath, while leatherbacks tended to range farther offshore, generally on the continental shelf (depths less than 200 meters) with occasional forays over the continental slope (to depths around 1,000 meters). During this period, turtles remained primarily in the upper 10 meters of the water column near to shore, but leatherbacks made occasional deep dives during their forays within the continental shelf between nests. During migration, green turtles consistently followed a narrow corridor along the coastline, avoiding the effects of the opposing Guiana and North Brazil western boundary currents to arrive at shallow water seagrass foraging sites in northern Brazil where they remained for extended but undefined periods. Leatherback turtles dispersed into the high seas, taking remarkably similar routes across the North Atlantic gyre to distant foraging grounds in the southeastern United States, Canada, and mid-Atlantic, where they are known to search for jellyfish on which to feed. In some cases, they remained in these areas for prolonged periods, but in others they moved to other sites quickly, presumably depending upon the availability of prey resources that they encountered. Although they occasionally made very deep dives – in one case to the astounding depth of 1,400 meters, the leatherback turtles in this study generally concentrated their foraging dives in the upper 30 meters of the water column.

While significant efforts were made to maximize tag retention and life (as well as data quality and quantity), transmitter life was the primary limitation in this study. For the 2019 Expedition, all tags were prepared with a coat of high-quality antifouling product prior to deployment, which appears to have helped preserve the tags' structural integrity and extend transmitter life as compared to tags deployed in the 2018 Expedition.

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APPENDIX R

List of Marine Fishes in Guyana

Resubmitted without changes

March 2022

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Scientific Name
Acanthocybium solandri
Acanthostracion quadricornis
Acanthurus hepatus
Achirus achirus
Achirus declivis
Achirus lineatus
Ahlia egmontis
Albula vulpes
Allocyttus verrucosus
Alutera monoceros
Alutera schoepfi
Alutera ventralis
Aluterus monoceros
Aluterus scriptus
Amphiarius phrygiatus
Amphiarius rugispinis
Anableps anableps
Anarchias similis
Anchoa spinifer
Anchovia clupeoides
Anchovia surinamensis
Anchoviella brevirostris
Anchoviella cayennensis
Anchoviella lepidentostole
Anisotremus surinamensis
Anisotremus virginicus
Antennarius scaber
Anthias asperilinguis
Anthias nicholsi
Antigonia capros
Antigonia combatia
Apionichthys dumerili
Aplatophis chauliodus
Archosargus probatocephalus
Archosargus rhomboidalis
Ariosoma balearicum
Arius quadriscutis
Aspistor quadriscutis
Aspredinichthys filamentosus
Aspredinichthys tibicen
Aspredo aspredo
Auxis rochei
Auxis thazard
Bagre bagre
Bagre marinus
Bairdiella ronchus
Balistes capriscus
Balistes carolinensis
Balistes vetula
Bathystoma aurolineatum
Bathystoma rimator
Bathystoma striatum

Scientific Name
Batrachoides surinamensis
Bellator militaris
Belone sp.
Bollmania sp.
Bothus robinsi
Bothus ocellatus
Brachyplatystoma filamentosum
Brachyplatystoma vaillantii
Brama dussumieri
Calamus pennatula
Calamus proridens
Caranx crysos
Caranx hippos
Caranx latus
Carcharhinus acronatus
Carcharhinus brevipinna
Cathorops arenatus
Cathorops melanopus
Cathorops spixii
Caulolatilus guppyi
Centropomus ensiferus
Centropomus pectinatus
Centropomus unidecimalis
Ceratoscopelus maderensis
Chaetodipterus faber
Chaetodon bimaculatus
Chaetodon ocellatus
Chilomycterus antillarum
Chloroscombrus chrysurus
Coloconger meadi
Colomesus psitacus
Conodon nobilis
Coryphaena hippurus
Ctenosciaena gracilicirrhus
Cubiceps pauciradiatus
Cyclopsetta chittendeni
Cyclopsetta fimbriata
Cynoponticus savanna
Cynoscion acoupa
Cynoscion arenarius
Cynoscion jamaicensis
Cynoscion microlepidotus
Cynoscion nothus
Cynoscion similis
Cynoscion steindachneri
Cynoscion virescens
Dactylopterus volitans
Dasyatis geijskesi
Dasyatis guttata
Decapterus punctatus
Decapturus macarellus
Diaphus brachycephalus

Scientific Name
Diaphus mollis
Diapterus auratus
Diapterus rhombeus
Diplectrum formosum
Diplectrum radiale
Echeneis naucrates
Eleotris pisonis
Elops saurus
Elops smithi
Engyophrys senta
Epinephelus morio
Eqeus lanceolatus
Etropus crossotus
Etrumeus teres
Eucinostomus argenteus
Eucinostomus gula
Euthynnus alletteratus
Exocoetus sp
Fistularia petimba
Fontitrygon geijskesi
Gempylus serpens
Genyatremus luteus
Gobioides broussonnetii
Gobionellus oceanicus
Gobionellus sp.
Gymnothorax ocellatus
Gymnura micrura
Haemulon aurolineatum
Haemulon boschmae
Haemulon carbonarium
Haemulon melanurum
Haemulon sciurus
Haemulon steindachneri
Haemulopsis corvinaeformis
Halieutichthys aculeatus
Harengula clupeola
Harengula jaguana
Hemicaranx amblyrhynchus
Heteroconger longissimus
Hippocampus longirostris
Holocanthus tricolor
Holocentrus ascensionis
Holocentrus bullisi
Hoplias malabaricus
Hoplunnis macrura
Hypanus guttatus
Hypopthalmus edentatus
Hypostomus plecostomus
Ichthyapus ophioneus
Isopisthus parvipinnis
Katsuwonus pelamis
Kyphosus incisor

Scientific Name
Lactophrys tricornis
Lagocephalus laevigatus
Lampadena anomala
Lampadena luminosa
Lampadena urophaos atlantica
Lampanyctus alatus
Lampanyctus nobilis
Larimus breviceps
Lepidophanes guentheri
Lepophidium brevibarbe
Leptocephalus spp.
Lestidiops mirabilis
Lobotes surinamensis
Lonchurus elegans
Lonchurus lanceolatus
Lutjanus analis
Lutjanus aya
Lutjanus purpureus
Lutjanus synagris
Lycengraulis batesii
Lycengraulis grossidens
Macrodon anciclos
Macrodon ancylodon
Menticirrhus americanus
Menticirrhus littoralis
Micropogonias furnieri
Micropogonias undulatus
Monocanthus ciliatus
Monocanthus hispidus
Mugil cephalus
Mugil curema
Mugil incilis
Mugil liza
Mustelus higmani
Myctophum obtusirostris
Myliobatis goodie
Myrophis punctatus
Myxine c.f. robinsorum
Narcine bancroftii
Naucrates ductor
Nealotus tripes
Nebris microps
Negaprion brevirostris
Nematopalaemon schmitti
Neoconger mucronatus
Nesiarchus nusutus
Notarius grandicassis
Odontognathus mucronatus
Ogligopites palometa
Ogocephalus vespertilio
Oligophites saurus
Oligoplites palometa

Scientific Name
Ophichthus puncticeps
Opisthonema oglinum
Orthopristis ruber
Oxyporhamphus micropterus similis
Paralichthys sp.
Paralonchurus brasiliensis
Paralonchurus elegans
Pareques acuminatus
Parexocoetus brachypterus
Pellona fharroweri
Peprilus paru
Pimelodus blochii
Plagioscion squamosissimus
Plagioscion surinamensis
Poecilia reticulata
Polydactylus oligodon
Polydactylus virginicus
Pomacanthus arcuatus
Pomacanthus paru
Pomadasys corvinaeformis
Porichthys plectrodon
Potamarius sp.
Priacanthus arenatus
Prionodes phoebe
Prionotus beanii
Prionotus ophyras
Prionotus punctatus
Prionotus stearnsi
Pristipomoides aquilonaris
Pseudauchenipterus nodosus
Pseudobatos percellens
Pseudocaranx dentex
Ptereleotris helenae
Pterengraulis atherinoides
Pterois lunulata
Pterois volitans
Rachycentron canadum
Remora brachyptera
Rhinobatos percellens
Rhinoptera bonasus
Rhomboplites aurorubens
Rhynchoconger flavus
Saurida normani
Sciades couma
Sciades herzbergii
Sciades parkeri
Sciades passany
Sciades proops
Scoliodon terrae-novae
Scomberomorus brasiliensis
Scomberomorus cavalla
Scombrolabrax heterolepis
Scorpaena agassizii
Scorpaena bergii
Scorpaena brasiliensis
Scorpaena plumieri
Selar crumenophthalmus
Selene setapinnis
Selene vomer
Seriola rivoliana
Spariosoma aqualidum
Sphoeroides dorsalis
Sphoeroides marmoratus
Sphoeroides testudineus
Sphyraena barracuda
Sphyraena borealis
Sphyraena guachancho
Stellifer brasilensis
Stellifer chaoi
Stellifer microps
Stellifer rastrifer
Stephanolepis hispidus
Syacium gunteri
Syacium papillosum
Symphurus plagusia
Symphurus tessellatus
Synodus foetens
Synodus intermedius
Synodus poeyi
Thunnus alalunga
Thunnus albacares
Thunnus lepturus
Trachinocephalus myops
Trachinotus carolinus
Trachinotus cayennensis
Trachurus lathami
Trichiurus lepturus
Trinectes paulistanus
Upeneus maculatus
Upeneus parvus
Urotrygon microphthalmum

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APPENDIX S

Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Reports

Resubmitted without changes

March 2022

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Enhanced Coastal Sensitivity Mapping—Ecosystem Services (Regions 1–4)—FINAL REPORT

Liza Phase 1 Development Project
Esso Exploration and Production Guyana Limited

April 2020

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EXECUTIVE SUMMARY

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorisation for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On June 1, 2017, the Guyana EPA approved the Environmental Impact Assessment (EIA) submitted as part of the Application for Environmental Authorisation and issued an Environmental Permit for the Phase 1 Development Project. As a condition of the Environmental Permit, the EPA required EEPGL to conduct field studies to verify (i.e., ground truth) selected shoreline and coastal habitat classifications contained in the coastal sensitivity maps provided in the approved EIA. The specific focus on ecosystem services was a direct request from the EPA during post-permit alignment meetings held in August 2017. Although oil spill modeling scenarios do not suggest the potential for impacts to shorelines along the coast of Guyana when standard response and mitigation measures are employed, EEPGL agreed to provide a baseline of ecosystem services for coastal communities for Regions 1–4.

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities and provide cultural fulfilment.

There are four standard categories of ecosystem services: *provisioning, regulating, cultural* and *supporting* services, defined as follows:

- **Provisioning services:** The goods or products obtained from an ecosystem such as food, freshwater, timber, fiber and other goods.
- **Regulating services:** The benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards.
- **Cultural services:** The non-material benefits obtained from an ecosystem such as recreation, spiritual values, and aesthetic enjoyment.
- **Supporting services:** The natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Despite the environmental importance of ecosystems and the biodiversity that underpins them, they are often undervalued and their importance underestimated in terms of the benefit they provide to human welfare. Therefore, in order to full understand the relationship between people and nature, it is critical to utilize a methodology that involves participation by the individuals who interact with the ecosystems under study.

In October 2017, a workshop was held by Environmental Resources Management (ERM) and Environmental Management Consultants (EMC) to discuss with key stakeholders (including Government, non-governmental organizations (NGOs), academics, indigenous community representatives, and civil society) the purpose of the ecosystem services study, the schedule,

and the proposed methodology for conducting the study. It was determined that a Community Based Participatory Research (CBPR) approach with local communities would be utilized in order to conduct a screening and scoping of ecosystem services. The CBPR approach is a partnership approach to research that equitably involves researchers, expert organizations, and community members in all aspects of a research process.

The methodology agreed upon using the CBPR approach comprised a data collection effort broken down into two parts. The first part was a screening exercise, through which local specialists from EMC, accompanied by an ERM socioeconomic expert, conducted stakeholder interviews with coastal community leadership and members to identify a comprehensive list of the ecosystem services that are potentially present along those coastal communities. The second part was a scoping exercise, involving field observations with representatives of the same group of community leadership and members who contributed to screening, with the objectives of establishing a complete list of ecosystem service beneficiaries; defining the value of ecosystem services to beneficiaries; identifying (through field verification) habitats and resources that provide ecosystem services; and assessing the existing condition and trends of these habitats and resources. The Study Area was defined as the coastal area throughout Regions 1 through 4, up to a distance of 500 meters from the shoreline.

After finalizing the screening and scoping protocols, in November and December 2017, the EMC/ERM specialists met with 25 coastal Neighborhood Democratic Councils (NDCs) and town councils in Regions 2, 3, and 4 to learn first-hand about their activities related to ecosystem services. Over 164 local community members participated in the meetings and many accompanied the team into the field after each meeting to help visually observe and map the ecosystem services. In April 2018, the same team of specialists met with 14 Community Development Councils (CDCs)/Village Councils (VCs)/Town Councils (TCs) in Region 1, during which 205 community members participated in the screening and scoping exercises. Given the high population of indigenous peoples throughout Region 1, a representative from the National Toshaos Council (NTC) participated in the entire exercise for Region 1. Each NDC/CDC/VC/TC interview and subsequent field engagement lasted for approximately one-half day.

The team entered data at each meeting and in the field directly into handheld tablets linked to the Liza Project Geographic Information System (GIS) database, and also took notes on general comments and observations. Based on the findings of the study, provisioning services were determined to be the primary service provided by the coastal ecosystem in Regions 1-4, accounting for 69 percent of the location-specific services identified in the four regions; cultural, regulating, and supporting services accounted for 20 percent, 9 percent, and 2 percent, respectively, of the location-specific services identified in the four regions. The detailed results of the study, including data at each NDC/CDC/VC/TC level are captured in this report, as well as in the Liza Project GIS database. The findings of the ecosystem services assessment were used primarily to: (1) validate assessments made in the Liza Phase 1 EIA; (2) provide baseline data for the Liza Phase 2 and Payara EIAs; and (3) provide detailed mapping for use in prioritizing oil spill response activities.

1. INTRODUCTION

1.1. Overview

This report provides an introduction to the concept and treatment of ecosystem services along the coastal communities in Regions 1, 2, 3, and 4 of Guyana. Ecosystem services are typically defined as the benefits that people obtain from the natural environment, as further defined and described in Section 1.2. The report was prepared by Environmental Resources Management (ERM) and Environmental Management Consultants (EMC). The work described herein corresponds with the Liza Phase 1 Post-Permit Studies requested by the Guyana Environmental Protection Agency (EPA) in the Environmental Permit issued to Esso Exploration and Production Guyana Ltd. (EEPGL) for its Liza Phase 1 Development Project[1].

Along with the **Enhanced Coastal Sensitivity Mapping—Biodiversity (Regions 1-4)** report and related geospatial mapping (submitted under separate cover), this report fulfils the Permit requirement in clause 1.5 to conduct field studies to verify (i.e., ground truth) selected shoreline and coastal habitat classifications contained in the coastal sensitivity maps provided in the approved Liza Phase 1 Development Project ("the Project") Environmental Impact Assessment (EIA). The focus on ecosystem services was a direct request from the EPA during post-permit alignment meetings held in August 2017. Although oil spill modeling scenarios do not suggest the potential for impacts to shorelines along the coast of Guyana when standard response and mitigation measures are employed, EEPGL agreed to provide a baseline of ecosystem services for coastal communities from Region 1 to Region 4.

The information presented in this report specifically provides for the screening, scoping, and validation of ecosystem services utilizing an internationally recognized ecosystem services methodology combined with geospatial analysis, as described in Section 2. The purpose is to further validate the ecosystem services findings in the Liza Phase 1 EIA, as well as provide specific details on coastal communities and their use of coastal resources to better inform EEPGL's oil spill response planning.

1.2. Scope Development

ERM and EMC held a coordination and planning workshop in October 2017 in Georgetown, with key stakeholders including Government, non-governmental organizations (NGOs), academics, indigenous community representatives, and other expert entities to discuss the purpose of the ecosystem services study, the applicability and the proposed methodology. It was determined that a Community Based Participatory Research (CBPR) approach with local communities would be utilized in order to conduct a screening and scoping of ecosystem services. The objective of the study was to provide data to establish a baseline of the relationship between coastal communities and the natural environment. The results of the study are captured in this report, as well as in the Liza Project Geographic Information System (GIS) database, and Liza

[1] Environmental Permit No. 20160705-EEDPF, dated June 1, 2017

Project Stakeholder Engagement Plan. The Study Area was defined as the immediate coastal area throughout Regions 1 through 4, up to a distance of 500 meters from the shoreline.

In November and December 2017, local specialists from EMC, accompanied by an ERM socioeconomic expert, conducted stakeholder meetings with 25 coastal Neighborhood Democratic Councils (NDCs) and town councils in Regions 2, 3, and 4 to learn first-hand about their activities related to ecosystem services. A total of 164 local community members participated in the meetings, and many from each NDC accompanied the team into the field after each meeting to help visually observe and map the activities.

In April 2018, the same team of specialists met with 14 Community Development Councils (CDCs)/Village Councils (VCs)/Town Councils (TCs) in Region 1, during which 205 community members participated in the meetings. Given the high population of indigenous peoples throughout Region 1, a representative from the National Toshaos Council (NTC) participated in the entire exercise. The NTC participation was to ensure all the engagements were fair and impartial and the concerns of the Indigenous communities were raised and addressed. The participation of the NTC was beneficial to the exercise, since communities were more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, had more confidence in the process and participated freely in the discussions.

The team entered data at each meeting directly into handheld tablets linked to the Liza Project GIS database, and also took notes on general comments and observations. The results of these meetings and field observations are described in this report, along with Ecosystem Service-specific maps for each NDC/CDC/VC/TC. Map books have been created from the GIS information contained in the database, and are provided under separate cover. Additionally, integrated map books (including both ecosystem service and biodiversity information) will be included in EEPGL's Oil Spill Response Plan.

During May to July 2019, following the screening, scoping, and assessment exercise, the same team of socioeconomic experts conducted a validation effort of the ecosystem services baseline data collected during the previous assessment phase. The team visited the same coastal NDCs, CDCs, VCs, and TCs (Haimokabra and Waramuri in Region 1 were visited simultaneously since Haimokabra is considered a satellite village of and shares leadership with Waramuri). This additional validation step enhances the accuracy of the original effort by allowing stakeholders to review and comment on the results of the screening, scoping, and assessment exercise. Any changes or additions to individual ecosystem services from the exercise were documented and larger trends that could have occurred over time as a result of specific ecosystem management interventions (e.g., mangrove programs) or extrinsic factors (e.g., population changes) were identified.

1.3. Definition of Ecosystem Services

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities and provide cultural fulfilment.

There are four standard categories of ecosystem services: *provisioning, regulating, cultural and supporting* services, defined as follows.[2]

- **Provisioning services:** The goods or products obtained from ecosystems such as food, freshwater, timber, fiber and other goods.
- **Regulating services:** The benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards.
- **Cultural services:** The non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment.
- **Supporting services:** The natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Additional details about the types of services under each category are provided in Appendix A.

[2] Millennium Ecosystem Assessment (MA). 2005. Synthesis Report. Island Press, Washington DC.

2. METHODOLOGY

2.1. Ecosystem Services Screening

A screening exercise was undertaken with the NDCs/CDCs/VCs/TCs prior to field observations in order to identify a comprehensive list of the ecosystem services that are potentially present along coastal communities in Regions 1, 2, 3, and 4. This step does not attempt to consider the importance of the services to beneficiaries or the likelihood of the Project impacting them in the event of an unplanned oil spill; it simply asks whether a service is likely to be present or not in each costal area.

For a service to be considered present, it must meet two criteria:

1. Habitats present in the Study Area are believed to provide this service or are similar to habitats elsewhere that provide this service; and
2. People are believed to benefit from the service, either at the local, national, or global level, and/or the Project is expected to benefit from this service.

Appendix A provides the screening checklist that was used by the team when interviewing. The table uses a standard list of ecosystem services adapted from internationally accredited sources.[3] All services identified as present or potentially present were then "screened in" to be considered when going into the field for observation, data collection, and mapping of the exact locations where such services exist.

For Region 1, the team supplemented the standard screening checklist with Region 1-specific questions derived from the Shell Beach Protected Area (SBPA) Management Plan[4], and questions developed by the Sea Turtle Census Initiative/Chelonian Research Institute turtle experts conducting the sea turtle telemetry work at Shell Beach Protected Area (also as part of the Liza Phase 1 Post-Permit Studies). These Region 1-specific topics are called out in the screening checklist.

[3] World Resources Institute (WRI). 2013. Weaving Ecosystem Services into Impact Assessment: A Step-by-Step Method. WRI, Washington, DC.
[4] PAC and EPA. 2014. Shell Beach Protected Area Management Plan 2015 – 2019 Volume 1, FINAL – DECEMBER 15, 2014

PHOTO 1: INTERVIEWS WITH VILLAGE LEADERS AND VILLAGERS (REGION 1)

BY ORDER OF MANAGEMENT

PHOTO 2: INTERVIEWS WITH NDC MEMBERS AND LOCAL COMMUNITY (REGIONS 2-4)

2.2. Ecosystem Services Scoping

Following completion of the screening exercise, the team and members of the local community used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This step aimed to:

- Establish a complete list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify the habitats and resources that provide ecosystem services in the Study Area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The descriptions and examples of "scoped-in" services for the Study Area, based on stakeholder input and field verification information, are provided in the scoping tables and broken down by NDC/CDC/VC/TC. During the engagements, the team, where appropriate, also asked for baseline data at the NDC/CDC/VC/TC level, including population statistics, numbers of beneficiaries utilizing each service or partaking in various livelihoods, incomes generated from livelihoods, and other socioeconomic baseline data. These data, when available, are captured in the overview of each Region, as well as in the detailed scoping tables. This information can also be found in the Liza Project GIS Database.

PHOTO 3: FIELD OBSERVATIONS WITH CDC/VC/TC MEMBERS AND LOCAL COMMUNITY (REGION 1)

PHOTO 4: FIELD OBSERVATIONS WITH NDC MEMBERS AND LOCAL COMMUNITY (REGIONS 2-4)

2.3. Ecosystem Services Prioritization

The ecosystem services prioritization has been designed to be consistent with international best practice, using the 2012 International Finance Corporation (IFC) Performance Standards (PS) as guidance. The prioritization process focuses on identifying services which that are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

a) **Importance of ecosystem services** to beneficiaries was assessed according to the following criteria and assigned a rating from low to essential based on:

- Intensity of use – e.g., daily, weekly or seasonal use; quantitative data were used if available and relevant;
- Scope of use – e.g., household versus community level, commercial use only, subsistence only or both;
- Degree of dependence – e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community; and
- The importance expressed by stakeholders and beneficiaries, including cultural and historical importance.

The weight given to each of these components varied slightly depending upon the service, but the importance to stakeholders and beneficiaries took precedence over other criteria with respect to the ultimate rating. Where a service was of greater or lesser importance to different stakeholder groups, two (or more) ratings were assigned so that impacts on these groups can be assessed individually.

b) **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The 'replaceability' of a service was assessed according to the following criteria and assigned a rating from high (many alternatives) to low (few or no alternatives):

- The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and man-made substitutes (e.g., availability of man-made items as an alternative to handicrafts);

- The accessibility, cost and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
- Preference / appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign a priority rating to the service (see Figure 2-1 below). **Ecosystem services *with high or critical* priority ratings are considered to be 'priority' ecosystem services.** As noted above, some services may have different importance ratings for different beneficiary groups, and therefore may be rated 'priority' services for some beneficiaries but not for others.

FIGURE 2-1: ASSIGNING A PRIORITY RATING TO ECOSYSTEM SERVICES

		Replaceability of Service		
		High *(many spatial alternatives)*	**Moderate** *(some spatial alternatives)*	**Low or Not Replaceable** *(few to no spatial alternatives)*
Importance of Service to Beneficiaries	**Essential**	*High*	*Critical*	*Critical*
	High	*Medium*	*High*	*Critical*
	Moderate	*Low*	*Medium*	*High*
	Low	*Low*	*Low*	*Medium*

2.4. Ecosystem Services Validation

Following completion of the above described steps, it was decided to revisit each of the NDCs, VCs, CDCs, and TCs to:

- Validate that the information compiled was correct;
- Verify that the Coastal Resources Maps were accurate;
- Collect any new data relating to ecosystems benefits since the previous engagements; and
- Collect updated socioeconomic data.

During the validation exercises, the team presented the findings and maps and asked the stakeholders a series of questions, as detailed below:

- Is the information presented for your district (NDC/TC/CDC/VC) correct?
- If not, what do we need to change/adjust?
- Are the locations for the various services presented on the map correct?

- Are the main economic activities/livelihoods in the area the same as one year ago? If not, what has changed?
- Has there been any notable growth or decline in any particular sector? What sector? What has changed?
- Has there been any increase in coastal resources over the past year? What purpose and where?
- Has there been any new use of coastal resources within the area over the past year? What purpose and where?
- Has there been any change to previous mapped points?
- What is the general description of the change?
- What is the current population estimate or trend (increased or decreased over past year)? What is contributing to the trend?
- Are there any other notable socioeconomic data that you wish to have documented?

The responses received during the validation exercise are incorporated below, presented by region. Raw data as it was recorded can be found in Appendix G: Validation Data Summary. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time elapsed between the 2017/2018 original data collection and the 2019 validation exercise.

3. ECOSYSTEM SERVICES FINDINGS AND PRELIMINARY CONCLUSIONS

3.1. Overview of Findings

Based on the findings of the assessment, provisioning services were the primary service provided by the coastal ecosystem in Regions 1-4, accounting for approximately 51.5 percent of the location-specific services identified in the four regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants;
- Traditional resource use in Region 1, including traditional medicine;
- Animals hunted primarily for food (recreational hunting is covered separately under cultural services);
- Aquatic transportation in remote areas where no alternative methods exist and commercial transportation facilities; and
- Income generators or services supporting income generation (e.g., boat building, repairs, transportation services).

Cultural services were the second most prevalent ecosystem service, representing approximately 35 percent of the location-specific services identified in the four regions. The most common cultural services identified include:

- Cultural value placed on traditional practices such as use of a location for prayer services;
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing; and
- Value placed on the aesthetics provided by landscapes and seascapes.

Regulating services were the third-most prevalent ecosystem services, representing approximately 8.5 percent of the location-specific services identified in the four regions. The most common regulating services identified include:

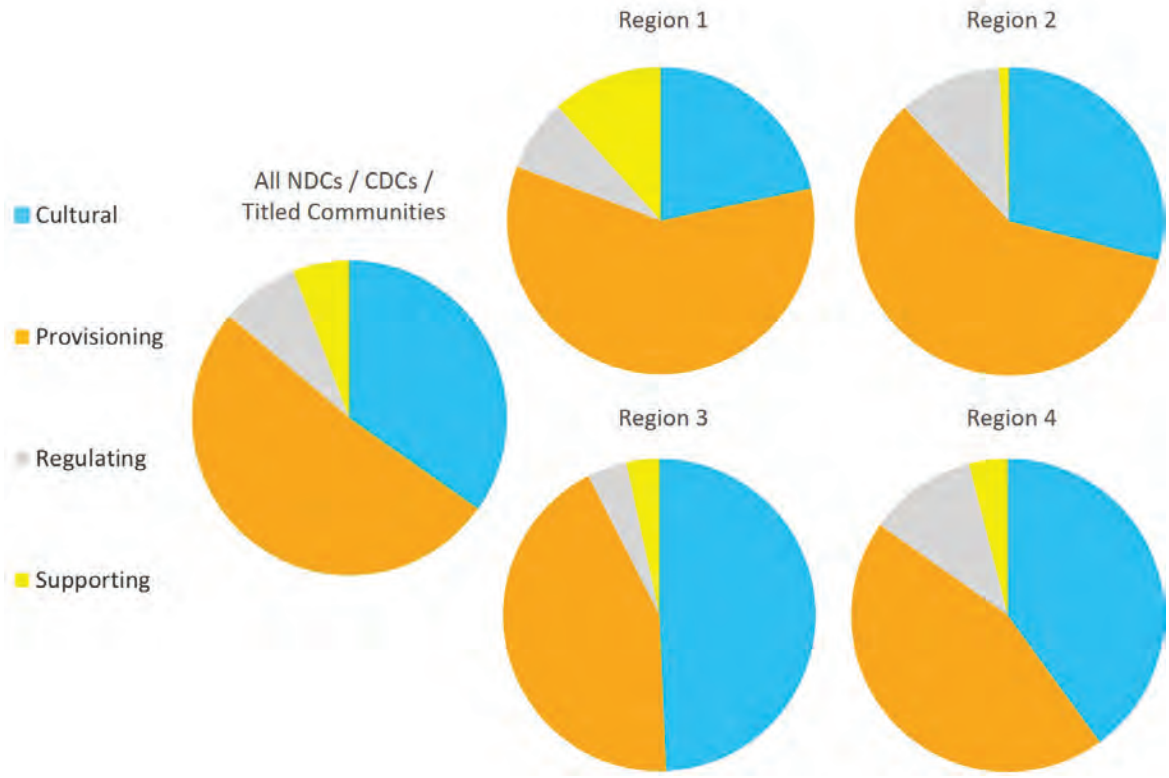
- Shoreline and riverbank protection and the role of mangroves in protecting crops, buildings, recreation areas from waves, wind and flooding; and
- Erosion protection and the role of vegetation in regulating erosion on slopes.

Supporting services are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. The service “Habitat Provision” is typically an exception, which is sometimes valued as an “end-use” service by stakeholders in addition to its supporting

role. Therefore, the relatively low prevalence of identified supporting services, representing approximately 5 percent of the location-specific services identified for the three regions, is not atypical; the services identified relate primarily to the fact that some stakeholders value mangroves for their maintenance of species populations and their ability to allow ecological communities to recover from disturbances, in addition to their regulating role of shoreline protection.

Figure 3-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories.

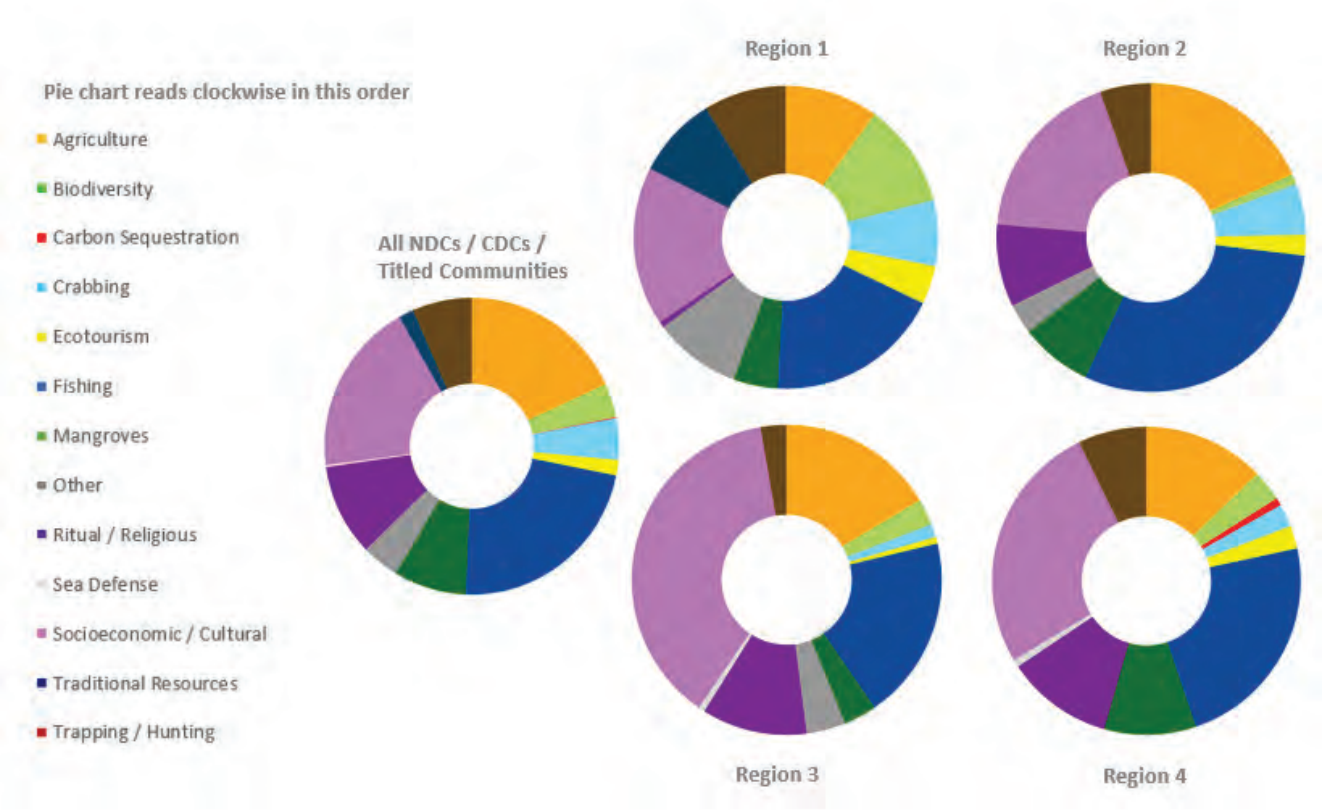
FIGURE 3-1: DISTRIBUTION OF ECOSYSTEM SERVICE CATEGORIES



NOTE: "All NDCs" pie chart includes Regions 1 through 6, which, when combined, indicates provisioning at 55.5 percent, cultural at 31 percent, regulating at 9.5 percent, and supporting at 4 percent.

Figure 3-2 summarizes the distribution of specific ecosystem service types across the categories. The service types match those used in the map books described herein.

FIGURE 3-2: DISTRIBUTION OF ECOSYSTEM SERVICE TYPES



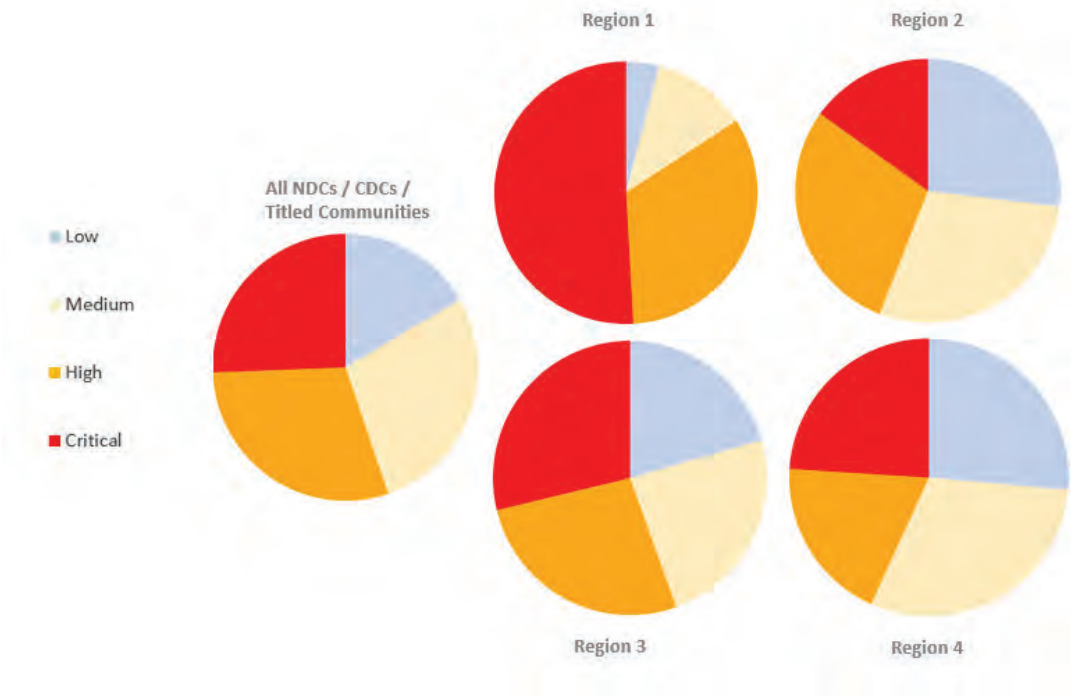
NOTE: "All NDCs" includes Regions 1 through 6 which, when combined, indicates fishing at 23 percent, socioeconomic/cultural at 19 percent, agriculture at 18 percent, ritual/religious at 10 percent, mangroves at 8 percent, trapping/hunting at 7 percent, crabbing at 5 percent, other at 4 percent, ecotourism and traditional resources each at 2 percent, and sea defense and carbon sequestration each at under 1 percent.

3.2. Summary of Findings by Region

Detailed findings for each identified ecosystem service, as well as priority ratings, are provided in Appendices B, C, D, and E and are summarized in Sections 4 to 7. As one of the primary goals of this study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 1-4, the ratings vary widely depending upon the responses from each NDC/CDC/VC/TC. For example, in one NDC in Region 2, livestock farming along the coastal wall was reported to be low priority, whereas in an adjacent NDC, the same service was considered a critical priority - since a larger number of families rely on the livestock and there are no other locations for livestock to graze. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figure 3-3 summarizes the distribution of priority ratings for the location-specific ecosystem services identified.

FIGURE 3-3: DISTRIBUTION OF ECOSYSTEM SERVICE PRIORITY RANKINGS



NOTE: "All NDCs" includes Regions 1 through 6, which, when combined, indicates critical at 26 percent, high at 28 percent, medium at 28 percent, and low at 18 percent.

For overview and general comparison purposes only, the **highest priority rating for each service in each Region is included in the table below.** As described in the methodology, services with *high* or *critical* priority ratings are considered to be 'priority' ecosystem services and would be a primary focus in the event of oil spill response. The overview table also helps to visualize which services did not feature as having importance to beneficiaries across the regions.

Table 3-1 summarizes the highest priority rating assigned in each region for each ecosystem service and Figure 3-4 shows a map of where all of the 'priority' (i.e., critical or high rating) ecosystem services are located, regardless of type or region.

TABLE 3-1: HIGHEST ECOSYSTEM SERVICE PRIORITY RATINGS FOR EACH REGION

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4
Provisioning Services				
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Critical	Critical	Critical	Critical
Cultivated crops	Critical	Critical	Critical	High
Livestock farming	High	High	High	High
Food: wild plants and honey	*	N/A	N/A	Medium
Food: wild meat	High	High	Low	Medium
Biomass fuel	*	N/A	N/A	N/A

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4
Timber and wood products	*	N/A	Low	N/A
Non-wood fibers and resins	*	N/A	Low	N/A
Traditional Resource Use/ Traditional Medicine	High	N/A	N/A	N/A
Freshwater for household use	Critical	N/A	High	N/A
Freshwater for irrigation use	N/A	N/A	Critical	N/A
Aquatic transportation/ports	Critical	Critical	Critical	Critical
Social/Economic commercial activity	Critical	Medium	Critical	Critical
Social/Housing	High	N/A	High	Critical
Regulating Services				
Global climate regulation	N/A	N/A	N/A	N/A
Regulation of water timing and flows	N/A	N/A	N/A	N/A
Flood regulation	N/A	N/A	N/A	N/A
Erosion regulation	Critical	Critical	Critical	Critical
Shoreline protection / Mangroves / River defense	Critical	High	Low	High
Pest regulation	N/A	N/A	N/A	N/A
Pollination	N/A	N/A	Medium	N/A
Disease regulation	N/A	N/A	N/A	N/A
Cultural Services				
Cultural, religious, or spiritual value	Low	Critical	Critical	Critical
Aesthetic value of natural landscapes, historical landmarks	N/A	Medium	Low	High
Tourism and recreation	High	High	Critical	Critical
Non-use value of biodiversity	N/A	N/A	N/A	N/A
Supporting Services				
Habitat provision, coastal protection	High	Critical	Critical	Medium
Primary production, biodiversity	Critical	N/A	N/A	Critical
Nutrient cycling	N/A	N/A	N/A	N/A
Water cycling	N/A	N/A	N/A	N/A
Soil formation	N/A	N/A	N/A	N/A

N/A – Not applicable; service not identified in the region
* - Service identified in the region but as part of Traditional Resource Use/Traditional Medicine

FIGURE 3-4: IDENTIFIED LOCATIONS OF CRITICAL AND HIGH PRIORITY ECOSYSTEM SERVICES – REGION 1

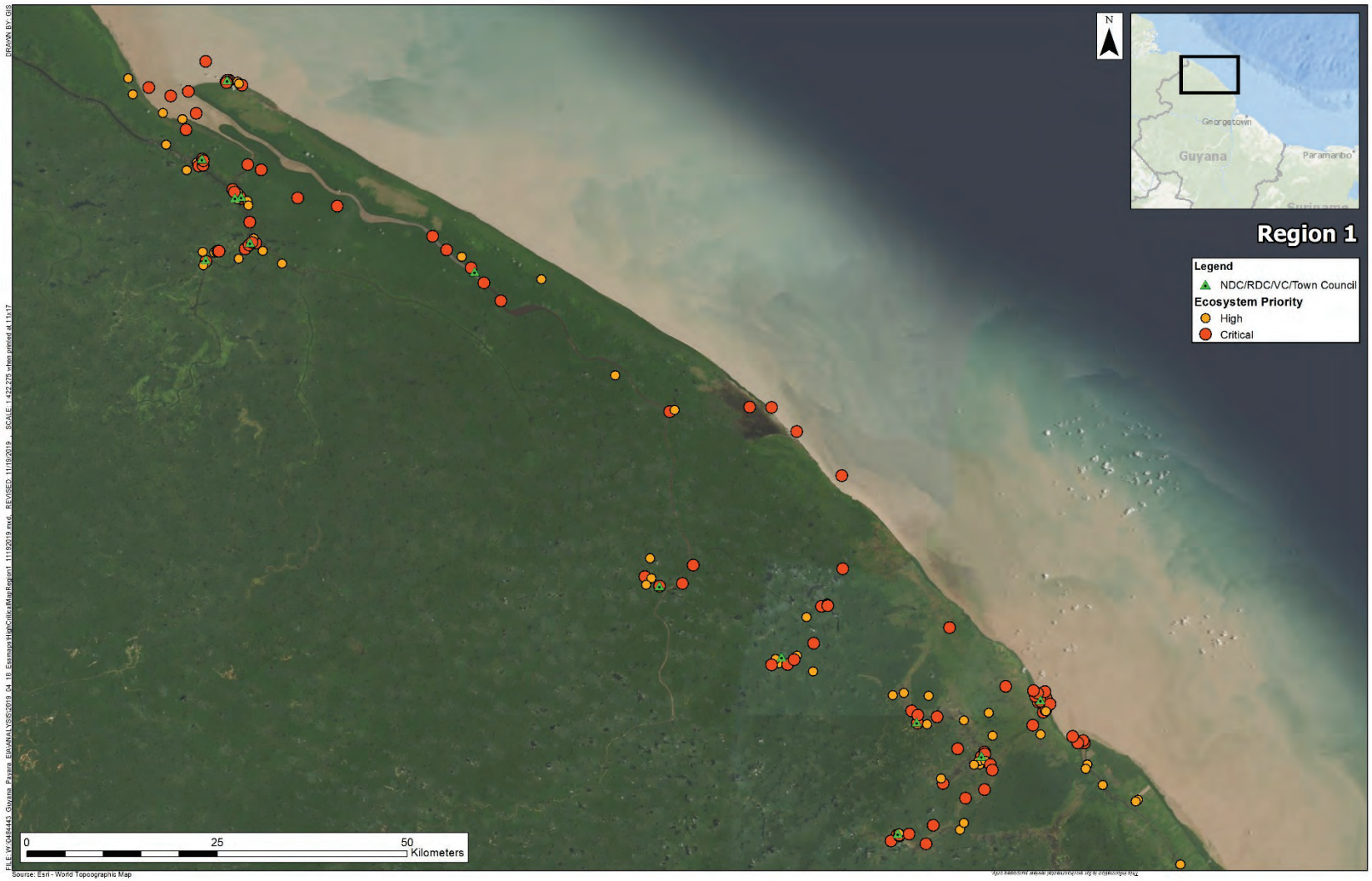


FIGURE 3-5: IDENTIFIED LOCATIONS OF CRITICAL AND HIGH PRIORITY ECOSYSTEM SERVICES – REGIONS 2-4

3.3. Use of Findings

The findings of the ecosystem services assessment will be used primarily to: (a) validate assessments made in the Liza Phase 1 EIA; and (b) provide detailed mapping for use in prioritizing oil spill response activities. In addition, the data can be leveraged for future EIAs and for ethnographic analysis, where understanding how stakeholders view their relationship with the natural environmental may be required.

The data described in the Liza Phase 1 EIA came from a variety of primary and secondary sources, including stakeholder engagement with government entities, fisherfolk, civil society, commercial businesses, NGOs, and academics. Based upon the data in hand at the time of the Liza Phase 1 EIA, it was determined that the Project's only potential impact on ecosystem services would be as a result of an unplanned event, where various environmental and socioeconomic resources could be negatively impacted in the event of a Tier III oil spill (and assuming no spill response and mitigation measures). The Liza Phase 1 EIA discusses various aspects of ecosystem services and related socioeconomic resources along the coastal communities, including:

- Mangroves are important providers of a number of ecological services upon which fish, wildlife, and humans rely (Section 7.4.3.2) and loss of such could weaken a critical component of the country's sea defense system and expose the coastal population to increased coastal flooding hazard (Section 7.4.4.7).
- Decreased fishery and agricultural yields as a result of an oil spill could potentially impact the fishery and agriculture sectors that currently account for a large part of the country's GDP (Section 7.4.4.1).
- Fishing, cultivation of traditional crops such as vegetables and fruits, crabbing, shrimping, and hunting of coastal game are important for subsistence and an oil spill could have a negative impact on food availability, and thus health, in coastal communities (Section 7.4.4.2).
- The coast is important for religious and traditional ceremonies for religious and ethnic groups in Guyana (Section 7.4.4.7).

As depicted in Table 3-1, the findings of the ecosystem services assessment are consistent with the assessment in the Liza Phase 1 EIA regarding potential resources that could be affected by an oil spill. Specifically, the findings corroborate that according to residents of the coastal communities, fishing, agriculture, farming, marine transport, marine related commercial activity, erosion regulation, mangrove protection, recreation, religious practices, and historical landmarks are priority services that should be accounted for when assessing potential impacts of an oil spill.

For Region 1 specifically, the findings also validate aspects of the SBPA Management Plan[5], specifically Section 2.3, which states, "Currently and historically, these communities have

[5] PAC and EPA. 2014. Shell Beach Protected Area Management Plan 2015 – 2019 Volume 1, FINAL – DECEMBER 15, 2014

utilized natural resources found in the area. Fishing, crabbing, hunting, manicole palm and timber harvesting are common among communities. Communities also engage in farming, mostly for subsistence to meet household needs but farm products may also be sold to others within the community."

The data in this report may also help the scientific community and government agencies fulfill some of the Shell Beach research needs as outlined by the PAC and EPA in Section 5 of the SBPA Management Plan, specifically:

- Baseline inventory of ecosystems (high priority need);
- Survey of impact of traditional resource uses within and at the periphery of SBPA (urgent priority need); and

Community inventory and mapping exercise to identify cultural aspects and places of importance and protection for Amerindian communities within and in areas surrounding the SBPA (high priority need). Additionally, the findings of the ecosystem services assessment provide an improved understanding of the specific locations where priority ecosystem services are present along the coast, and this information will be used to support the update of EEPGL's OSRP (i.e., with respect to prioritizing response activities in the event of an oil spill).

4. REGION 1 COASTAL ECOSYSTEM SERVICES FINDINGS

4.1. Population

Figure 4-1 shows the location of the communities in Region 1 with which the team engaged to perform the work.

FIGURE 4-1: AMERINDIAN COMMUNITIES IN REGION 1

Source: EMC

Population estimates for these communities are based upon data provided by the communities' leadership and community health workers during the ecosystem services-related engagements. Population was on the increase in almost all of the communities due to migration from Venezuela.

TABLE 4-1: POPULATION ESTIMATES - REGION 1

CDC/VC/TC Name	Population Estimate
Fathers Beach	23
Manawarin	2,000
Waramuri and Haimakabra	3,100
Santa Rosa	10,500

CDC/VC/TC Name	Population Estimate
Assakata	473
Warapoka	650
Three Brothers	120
Mabaruma Town Council	8,000
Aruka Mouth	300
Morawhanna	100
Smith's Creek	248
Imbotero	353
Almond Beach	51

4.2. Summary of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) services within the CDCs/VCs/TCs are summarized below:

TABLE 4-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE VCs/CDCs – REGION 1

CDC/VC/TC Name	Type of Service	Brief Description
Father's Beach	Regulating	Mangrove forest on the shoreline provides critical defense from the impacts of the sea and along the banks of the Moruca River.
	Provisioning	Farmers utilize land along the seashore in the mangroves and in some coastal areas for cash crop farming, including coconuts.
		Commercial and subsistence fishing conducted between the Pomeroon River Mouth and Father's Beach, including crabbing.
		Mangroves are used for crafting and construction. Many plants (including mangroves) are used for medicinal purposes. Shells are used in agriculture and for construction.
		Freshwater from wetlands is used for domestic purposes.
		The area supports commercial and other activities such as boat repairs, fuel sale, etc.
		Transportation is only by boats through a canal from the ocean.
Manawarin	Provisioning	There is an abundance of wildlife within the forests and rivers; hunting of wildlife is done for local use and some birds are caught for commercial purposes.
		All households engage in subsistence farming. Some produce is sold.
		Fishing in the sea between the Pomeroon Mouth and Father's Beach and at different locations in freshwater streams; most residents conduct crabbing.
		Freshwater from rivers and creeks is used for domestic purposes and drinking.
		Many plants are used for medicinal purposes, cooking, and crafting.
		Commercial activities and transportation services are located in the village landing area.
		Commercial activities including numerous small shops, fuel sales, and transportation services are located in the village landing area.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects the river banks from motor boats and water currents.

CDC/VC/TC Name	Type of Service	Brief Description
	Supporting	There is an abundance of wildlife in the forest and rivers including a feeding area for giant river otters feeding in the river.
Waramuri and Haimakabra	Provisioning	Commercial fishing on both sides of the Moruka River mouth between Iron Punt and Cozier Canal. Crabbing is done seasonally in the main crabbing areas of Father's Beach to east of Pomeroon Mouth. Villagers fish throughout the year in the creeks, savannas, and lagoons behind the beach.
		Numerous species of animals are found in the rivers and environment. A few people are involved in trapping for trade. Some hunting of wildlife and duck egg collection.
		Some timber species are harvested for lumber in the area.
		All households undertake subsistence and commercial farming.
		Freshwater from rivers and creeks is used for domestic purposes and drinking. The river network is critical for fishing and transportation.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects the river banks from motor boats and water currents.
Santa Rosa	Provisioning	Commercial fishing is done daily between the Pomeroon River and Iron Punt. And in the rivers at Dog Creek and Luri Creek. Almost all villagers seasonally catch crabs. A few people regularly do commercial crabbing.
		Cattle and some pigs are grazed in the savannas close to the village.
		Some hunting for sustenance is done at Luri Creek and Baramani Lake.
		Freshwater from creeks and rivers is used for domestic purposes and drinking. The rivers are critical for transportation.
		The village is the trading hub for the Moruca Sub District of Region 1.
		Traditional plants and resources are used for domestic and cultural purposes.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers, including mangrove forest at Moruca mouth, protects the river banks from motor boats and water currents.
	Supporting	The village and surrounding areas are populated by numerous species of birds, fishes, and mammals, including jaguars. Ite palms, which also provide habitats for birds, are found throughout the community.
Assakata	Provisioning	Fishing on at least a monthly basis by most residents. Commercial fishing is done along the shore at Iron Punt, and at Baramannie Lake and Luri Creek.
		Locals engage in cash crop farming and cultivation of cassava for sustenance.
		Community depends on freshwater from rivers and creeks for domestic use and drinking. Some villagers use groundwater from water wells.
		Some plants are used for medicinal purposes and forest resources are collected for household items.
		Many fishes and birds are found in the wetlands.
		Iguanas, tapirs, labba, deer powis, and wild ducks are caught on the seashore on fishing and hunting trips.

CDC/VC/TC Name	Type of Service	Brief Description
		Small businesses with people actively involved in the village cash economy.
		Access to the community is via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects banks from motor boats and water currents.
	Cultural	The village has a freshwater lake that can be used as a tourist attraction, along with some shell mounds.
Warapoka	Provisioning	All households engage in farming and some of the produce is sold.
		The village has numerous small businesses and a tourism center. There are also government/administrative facilities. These provide employment to people who contribute to the cash economy
		The villagers fish throughout the year in rivers, creeks, and lakes. Commercial fishing is done at Baramanni Lake and Luri Creek. Shrimp is caught in the rivers around the village.
		Some animals are caught on the seashore on fishing and hunting trips. Duck and other bird eggs are collected. Trapping and sale of wildlife is done.
		Many plants are used for medicinal purposes and honey is gathered from bees for sale. Cabbage sticks are cut in combination with fishing and other exercises.
		Access to the community is via boats through the river network.
	Regulating	Extensive vegetation covering the rivers protects the banks from boats and water currents.
	Supporting	Numerous species of birds, fishes, and mammals, including harpy eagles, river otters, tapir, deer, acouri and labba, are found in the rivers and environment.
Three Brothers	Provisioning	Fishing along the coast between Waini Point and Iron Point. Commercial fishing in Luri Creek and Baramini Lake. Sea turtles enter the river in the dry season.
		Numerous species of animals in the rivers and mangrove forests. Sea turtles, jaguars, giant otters, and harpy eagles are present in the area.
		All families have farms. Crops are grown for home use and sale.
		Mangrove is used for building and in farms. Medicinal plants are collected from the beach. Cabbage palm is cut and sold.
		Freshwater from creeks and rivers used for domestic purposes and drinking water. Waterways are used for transportation.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects the river banks from boats and water currents.
	Supporting	Numerous species of birds, fishes, and mammals, including crabs, are found in the rivers and mangrove forests. There are plenty of ducks in the wetlands bordering with SBPA.
Mabaruma Town Council	Provisioning	The Kumaka waterfront and Mabaruma is used for transportation, commerce (including boat building) and administrative; it is the main transportation hub for the Region
		Shrimp is caught in a limited manner in the shrimp season. There are daily fishing trips to Waini point. There are several fishing sites. Crabs are also sold daily at the Kumaka waterfront.
		60% of people have farms and cultivate cassava, ground provision, and cash crops.

CDC/VC/TC Name	Type of Service	Brief Description
		Freshwater from rivers, creeks, and natural springs is used for domestic purposes and drinking by the outlying community. Water wells are also used.
		Cabbage sticks are cut for sale. Medicinal plants are harvest from beach. Mangroves are used in tanning, and construction.
		Iguanas, labba, agouti, and wild ducks are the main animals hunted. Many bird species, including toucan, macaws, parrots, and small rodents such as anteaters are also trapped.
		Sawmill, lumberyard, and boat building enterprise.
	Cultural	Shell mound within the town, and several hotels for tourists.
	Supporting	The town covers six villages and has a high diversity of flora and fauna, including rubber trees that line the main road. Numerous species of birds, fishes, and mammals are found in the rivers and inland environment.
Aruka Mouth	Provisioning	Fishing in the sea at Waini Point. Some people catch shrimp in the shrimp season. Fishing in the rivers and creeks on a daily basis. Freshwater fishes are found nearby in the rainy season when the waters are fresh.
		Numerous species of birds and fishes along with monkeys are found in the area. There are no wildlife traders in the village.
		Some families have farms that are impoldered[6]. Cassava, plantains, and ground provisions are the main crops.
		The crab catchers utilize forest products for the crab quakes. Mangrove is used for building, in farms and also for firewood.
		The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking.
		Access to the community is mainly via boats through the river network.
	Regulating	The rivers are protected by extensive mangroves growing on the river banks. The mangroves protect the river from the impacts of the motor boats and water current.
	Supporting	Numerous species of birds and fishes, along with monkeys, can be seen in the area.
Morawhanna	Provisioning	Most fish are caught in the sea. Most of the fresh catch is sold to vessels from Venezuela. Freshwater fish are caught in the river in the rainy season when the water is fresh. Fish are also found in the wetlands and creeks.
		The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. Bottled drinking water is purchased from Mabaruma.
		Wharf facilities provides a hub for trade in the area increasing economic activities to the settlement.
		Access to the community is mainly via boats through the river network.
	Regulating	The banks of the Barima River are covered by extensive mangroves protecting the banks from the impacts of the motor boats and water current.
	Supporting	The area has a roosting spot with scarlet ibises and egrets roosting for the night. Numerous species of other birds, fishes, mammals, and crabs are found in the rivers and mangrove forests.

[6] Made (an area of the seabed) into a piece of low-lying land by reclaiming it from the sea or a river

CDC/VC/TC Name	Type of Service	Brief Description
Smith's Creek	Provisioning	Villagers conduct commercial fishing along the coast and in the Barima River and Smith's Creek throughout the year. Crabbing popular at the markets on Tuesdays and Saturdays. Crabs are also sold to hucksters on the ferry to Georgetown
		Some households have farms for subsistence and local use.
		The community depends on freshwater from the rivers and creeks.
		Access to the community is mainly via boats through the river network.
	Regulating	The rivers are covered by mangroves protecting the banks from the impacts of the motor boats and water current. The mangroves also act as roosting habitats for many birds.
	Supporting	There are many species animals in the forests and lake. Many ducks and egrets are seen in the area but not hunted.
Imbotero	Provisioning	Each household has a boat that they can use with either with outboard engine or by paddling to the fishing ground.
		Some households have farms for subsistence and local use.
		The villagers fish throughout the year in the rivers, creeks, and lakes mainly for saltwater fishes.
		There are numerous species of animals including tapir, deer, acouri, and labba found in the rivers and forest.
		The village can facilitate tourism activities such visit to the border with Venezuela and Shell beach.
		Access to the community is mainly via boats through the river network.
	Regulating	The creeks and rivers are covered by extensive mangroves and palms protecting the banks from the impacts of the motor boats and water current.
	Supporting	There are numerous species of birds, fishes, and mammals including tapir, deer, acouri, and labba found in the rivers and forest. Jaguars and black caiman are also seen in the area.
Almond Beach	Provisioning	The entire community resides along the beach and all households have farms located on the beach which grow food for subsistence and commercial purposes.
		Commercial fishing done from Waini Mouth to Tiger Beach in the sea. Freshwater fish are caught in the wetlands beyond the beach throughout the year; hassar contributes significantly to fisherfolk income.
		Supports eco-tourism activities through collaboration with the PAC.
		There are numerous species of birds, fishes, and mammals including jaguars present in the area. Iguanas and some mammals are hunted for food.
		Access to the community is mainly via boats through the river network and ocean.
	Supporting	There are numerous species of birds, fishes, and mammals, including agouti, tapir, deer, acouri, and labba, found in the areas close to the beach. Leatherback turtles nest on the beach and harpy eagles are also sighted.

4.2.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 1 is fishing in the rivers and creeks, the ocean, and the mangroves of the riverine floodplains. Along the coast, fishing is

particularly active at the westernmost end of Shell Beach at the mouth of the Waini River, and easternmost end at the mouth of the Moruca River. However, most communities use an area along the Beach referred to as Iron Punt for these activities. This area can be accessed from the ocean, as well as from inland via the Luri Creek. By using Luri Creek, the communities also have access within this area to fish, birds, and crabs, particularly in the dry season, and some hunting in the wet season. The main commercial products from the ocean include many types of catfish, curass, gillbacker, snapper, bangamary, butterfish, mullet, snook, queriman, and trout. There is almost no shrimping in the region, as the waters are rough and only a handful of people have access to the type of equipment needed (Chinese seine). The long stretches of mangrove in the salty sections of the waterways provide an important nursery function for a number of commercial fish and shellfish species. The natural ponds and swamps, particularly those behind Shell Beach, collect seawater from the spring tide, catching the young shrimp and fish that are looking to migrate into lesser salty water until they mature into adulthood. The numerous rivers, creeks, and swampy areas throughout Region 1 have an abundance of freshwater fish including huri, yarrow, patwa, peacock bass, imary, casi, sunfish, wabrea, and many others that are caught and eaten on a regular basis and also sold in the local markets. The fish are caught with hooks and nets and also trapped in the vegetation that is pulled to the shore.

There are vast savannahs along the banks of many of the rivers and creeks which flood with the onset of the rainy seasons (May/June and November/December/January), so most daily freshwater fishing occurs in the dry season, when fish are in the rivers and not in the outlying savannahs. At the onset of the rainy seasons, many fisherfolk will burn the savannahs to ensure easier catching of fish as they migrate from the rivers to the bush islands[7]. The migrating fish are spotted in the shallow waters of the burned savannahs and are “chopped” with knives or caught by hand.

Crabbing is a significant activity for communities in Region 1. Crabbing in mangroves along the beach area is common, especially during the crab seasons. Residents from the coastal communities within the region, as well as from some areas of Region 2, venture to the beach during the crab season. Crabbing is done for both subsistence and small-scale commercial sale throughout the year. For some communities, especially those further north in the region, most adults (including women) are involved in crabbing throughout the year as a major economic activity.

A majority of the households in the region have multiple farms growing cassava as the main staple for daily subsistence, as well as other crops (such as ginger and coconuts) for sale in local markets. Cash crop cultivation is a main feature in this region, with much of the produce consumed by the family or sold to the local school or the local market. Some agricultural farming occurs directly on the coast at Father’s Beach and Almond Beach.

The communities depend on various types of wild meat (including iguana, labba, deer, turtle, wild ducks, etc.) for subsistence, which they hunt themselves. In some of the areas, the trapping of animals for trade is prohibited by the village or is not a popular activity. However,

[7] The bush islands refer to the high grounds in the flooded savannahs where families have their households and farms. Some of these islands have been occupied by the same family for over two hundred years.

hunting/trapping is prevalent in some communities, such as in the Luri Creek area, in the Baramani Lake, and within some communities' private lands.

Wood is collected for use as firewood by some households, particularly for the principal cooking tasks such as making of cassava bread or pepper pot. Driftwood is collected on the beach and from some of the river banks to be used for cooking. A small number of people use wood and non-wood fibers, including mangrove trees and coconut shell, for handicrafts and household items. A limited amount of mangrove bark is shipped to Georgetown by the ferry for use in tanning operations. The bark is also used for medicinal purposes by the Amerindians. Mangroves are used widely in the construction of houses and other household structures. Some mangrove poles are used by farmers to support their plantain trees and by fisherfolk as seine poles. In Region 1, mangroves are considered a community resource and are therefore legal for traditional community use.

Palms and vines, including Ite, Kufa, Nibbi, and Kufra, are utilized for making craft and household items. Manicole palm is harvested for commercial purposes by most communities and is sold to a factory based in the region. Medicinal plants, especially noni, are collected from the beach for use by the communities.

The communities depend on the waterways for potable and domestic water supply, and in most cases, they are the only form of transportation available.

Wild bees provide a critical service of pollination for the farmers. Wild bees are found in the mangroves and sometimes in the villages. While most locals avoid beehives, they are often raided by experienced individuals who can turn a good profit on honey sales at local markets.

A few people in some villages rear chickens and other birds in order to sell bird meat. However, there is generally a marked absence of livestock such as sheep, goats, and cattle in the villages, except for in the town of Mabaruma. It was reported that jaguars often feed on livestock and therefore livestock rearing is not popular. Attacks by jaguars on hunting dogs have also restricted the hunting capacity of many households.

4.2.2. Regulating Services

The entire shoreline of Region 1 is covered with mangroves with mudflats or shell deposits leading to the ocean. These mangroves contribute to erosion prevention along the shoreline by protecting it from waves, wind, and flooding. Mangroves are also found along the banks of the many coastal rivers within the region, thus also protecting the riverbanks from erosion. These were noted by stakeholders as critical services.

It should be noted that although many stakeholders commented that burning the savannahs assisted with pest control, they did not see this as a regulating service and so therefore, it was not captured as such in the data tables or on associated maps.

4.2.3. Cultural Services

The only cultural service observed on the beach is by a single Hindu family of Mabaruma that uses the Waini Beach a few times per year. The beach and coastlines are considered living

heritage by the Amerindians, but not for spiritual reasons. The local people, particularly of the Mabaruma Town Council, utilize Waini Point and Shell Beach for recreation, including kite flying and picnics, particularly at Easter.

Cultural heritage sites were also identified by local villagers, including shell mounds near Haimacobra Village, Waramuri Village, and Assakata Village, as well as a sacred site (200-year-old church) near Santa Rosa Village.

4.2.4. Supporting Services

The only supporting service identified through the engagement process was habitats for biodiversity. The region is rich in biodiversity, with villagers reporting numerous species of birds, fishes, and mammals. Leatherback turtles use the beach in the Almond Beach area for nesting. Harpy eagles are sighted in Almond Beach, and nesting areas for harpy eagles are located in Warapoka and Three Brothers villages. Jaguars are also common in some villages and black caiman have been sighted by villagers in Imbotero. In addition, there is a roosting area for scarlet ibises along the main rivers.

4.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by CDC/VC/TC and provided in the scoping tables located in Appendix B.

Figure 4-1 shows the ecosystem service locations, by type, identified by the Region 1 village leaders and villagers during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology outlined in Figure 2-1. Detailed maps by CDC/VC/TC are provided in the Coastal Mapping mapbook (separate from this report).

Figure 4-2 shows the ecosystem service “general areas,” by type, identified by Region 1 village leaders and villagers during the engagement process. This mapping to show general areas is provided for only Region 1 due to the fact that some areas identified by village leaders and villagers could not be field-verified (based on limitations to access along the SBPA and Region 1 coast). The general areas are intended to provide additional context for the location of ecosystem services in the region.

FIGURE 4-2: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES—REGION 1

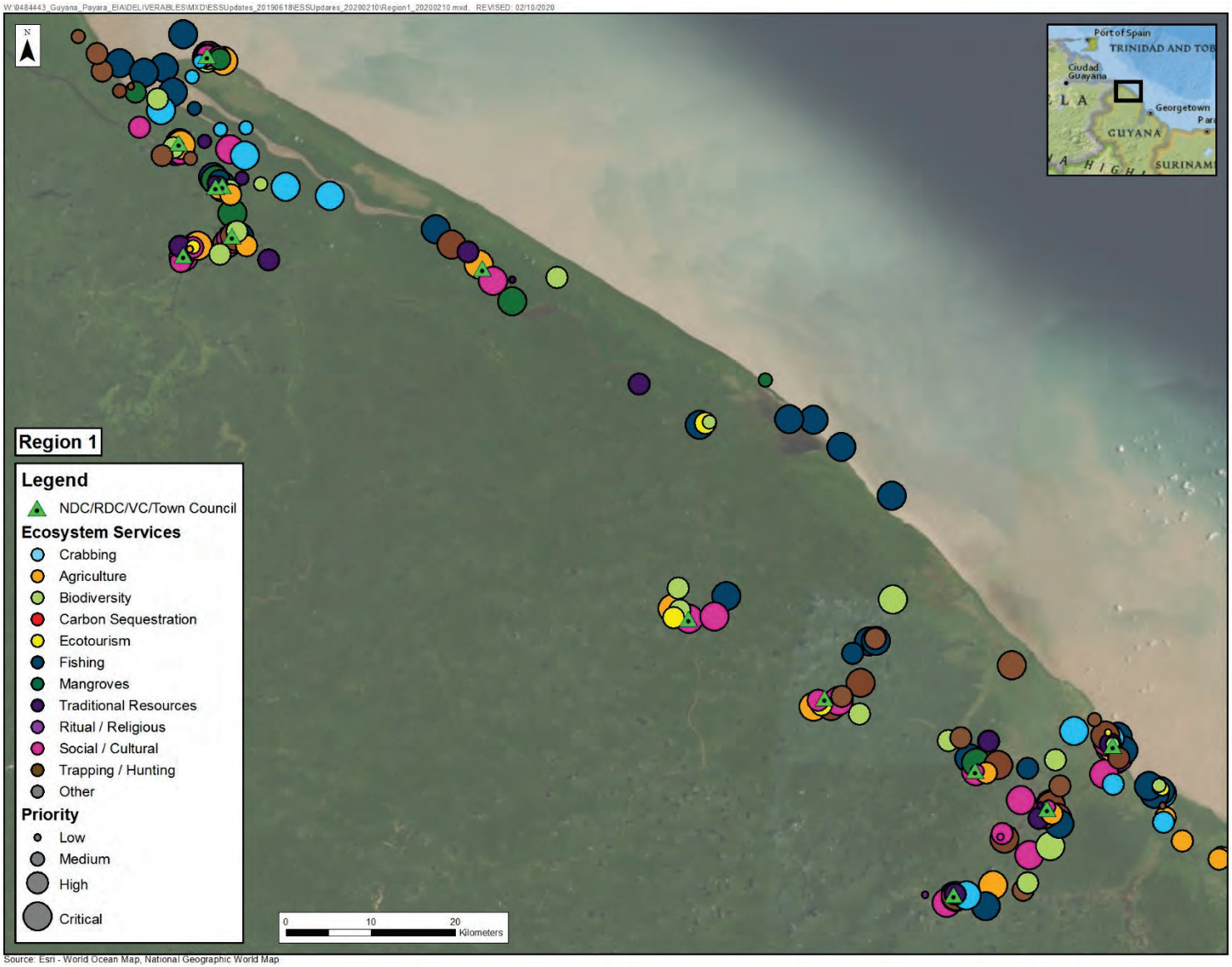
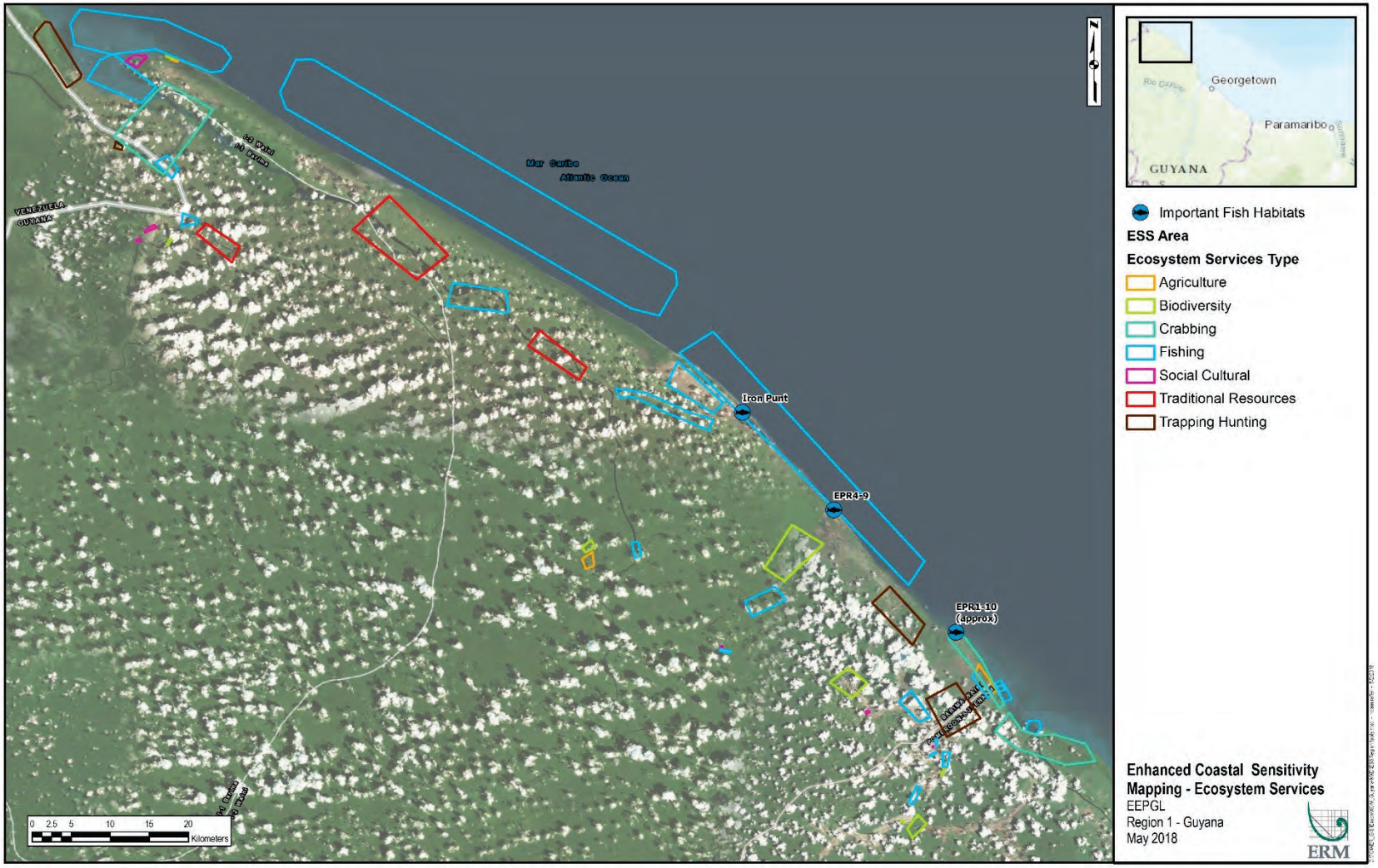


FIGURE 4-3: IDENTIFIED GENERAL AREAS OF ECOSYSTEM SERVICES TYPES—REGION 1



5. REGION 2 COASTAL ECOSYSTEM SERVICES FINDINGS

5.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 5-1: POPULATION ESTIMATES - REGION 2

NDC Name	Population Estimate	Other Details
Charity/Urasara	7,800	Population relatively stable
Evergreen/Paradise	7,500	High Hindu population
Aberdeen/Zorg-en-Vlygt	6,000	In Queenstown alone, which is largest village on coast
Anna Regina Town Council	22,000	Close to 50% Hindu population; population increasing due to Venezuelan migrants
Annandale/Riverstown	10,840	Population increasing due to Venezuelan migrants
Good Hope/Pomona	10,000	Population increasing due to Venezuelan migrants and Amerindians moving from inland areas of Region 2

5.2. Summary of Findings

The services rated as “critical” or “high” priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 5-2: SERVICES RATED AS “CRITICAL” OR “HIGH” PRIORITY WITHIN THE NDCs – REGION 2

NDC Name	Type of Service	Brief Description
Charity/Urasara	Provisioning	Families and farmers utilize land along coast for crop cultivation
	Provisioning	Commercial fishing at mouth of and within Pomeroon River, especially crabbing
	Provisioning	The Big Bird Fish Complex is a major facility that serves as a landing for large-scale artisanal fishing and processes fish for export
	Supporting	Mangroves provide habitats for birds, crabs and other wildlife and protect the shoreline
Evergreen/Paradise	Provisioning	Families and farmers utilize land along seawall for cash crops and subsistence farming as well as livestock farming
	Provisioning	Commercial fishing at Andrews Koker, including crabbing
Aberdeen/Zorg-en-Vlygt	Provisioning	Commercial fishing at Capoey Koker, including crabbing and livestock farming along seawall
	Provisioning	Hunting of iguanas for meat and sale

NDC Name	Type of Service	Brief Description
	Regulating	New mangrove growth provides shoreline protection and a habitat for iguanas, crabs and birds
	Regulating	Bamboo groynes have been installed at various points along the shoreline
	Cultural	Recreation along the seawall and cremation site along the shoreline
Anna Regina Town Council	Provisioning	Farmers utilize land along the seawall for subsistence farming. Coconuts, bananas, plantains and cash crops are planted
	Provisioning	Commercial fishing landing sites in Hampton Court, Walton Hall, Lima, Sparta, and Anna Regina
	Cultural	Daily visits to a popular hotel close to the seashore for recreation, including softball cricket matches on the beach behind the hotel
Annandale/Riverstown	Provisioning	Main port is essential for access to other areas, including the islands; the ferry dock is used for businesses and trade
	Provisioning	Fishing landing sites at several locations including Abram Zuil
	Cultural	Religious activities along beach primarily at Golden Fleece temple
	Cultural	Recreation along the seawalls at Perseverance, Golden Fleece, Cullen Beach and Suddie
Good Hope/Pomona	Provisioning	Ports, wharfs and shipyards at Vilvoorden and Riverside are essential to commercial business; speedboat ferry at Supenaam is a major port
	Provisioning	Commercial fishing at Vilvoorden, Pomona, and Riverstown
	Provisioning	Large-scale cultivation of crops on Tiger Island
	Regulating	Tiger Island is a critical sea defense to erosion and flooding
	Cultural	Recreation on Tiger Island

5.2.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 2 is fishing. The main commercial products include catfish, snapper, snook, and crabs in the summer season. Some catching of shrimp also occurs. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. This is a priority service in Anna Regina, which is one of the only towns in Region 2.

Crop cultivation is present in many communities along the coast, and ranges in scale from subsistence farming of staple grains, including rice, to export-oriented farming of coconuts and watermelons.

The scale of livestock farming ranges considerably within communities in Region 2. Some households keep a few chickens, pigs, and cattle in their yards for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be

either dual purpose or specialize in dairy or beef. Beef is generally not consumed on a regular basis by the local population.

Some households in Region 2 collect wild plants, fruits, berries, mushrooms, other wild plants, honey, and nuts, primarily for subsistence use. This practice is limited in the Study Area and while mangroves provide the habitat for honey production, it is not common in Region 2 despite the fact that many people interviewed understood how honey production could be a major source of income.

A small number of households report depending on various types of meat (including iguana, etc.) for subsistence, whether they hunt it themselves or purchase it. Although hunting iguana is illegal, reports of hunting for meat increased during the validation exercise. Nonetheless, it is not likely a major source of food or income in the area.

Some wood and non-wood fibers, including mangrove trees and coconut husks, are used in handicrafts and household items in some of the coastal communities, although this is not extensive.

Potable water sources for communities include the Pomeroon River, rainwater, and groundwater. Households in larger communities are serviced by the national public water system. However, private wells are the most common source of potable water in the NDC. In rural areas, water is obtained from the lake or private wells excavated on household properties.

Region 2, especially in the northern coastal communities adjacent to the Pomeroon River, is significantly reliant on aquatic transport. Waste and pollution in the Pomeroon River and coastal habitats presents one of the biggest challenges for coastal communities.

Commercial activities abundant in these areas include those supporting the marine industry such as boat building, ship repairs, fuel services, and products needed by sailors and fisherfolk. It is quite evident that at almost all landing areas used by fisherfolk, including Supenaam, there are shops in close proximity selling alcohol and other consumable products.

5.2.2. Regulating Services

Shoreline protection is a major consideration along the entire Region 2 coastal area. Mangroves and coastal vegetation play a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. Mangroves along Region 2 are in various stages of growth, with many areas along NDC 1, 2, and 3 having undergone natural erosion cycles over the past 20 years.

The Ministry of Agriculture's National Agricultural Research & Extension Institute's (NAREI's) re-growth programs are most active in the Evergreen/Paradise NDC and Annandale/Riverstown NDC areas. The mangrove restoration projects in Walton Hall, Richmond, and Lima are reported by stakeholders to be doing considerably well. However, with all of the new mangrove plantings, there are now concerns over the nuisance of sand flies and mosquitoes as well as the noise from new species of birds in the area. This has been especially challenging in Anna Regina.

Natural shoreline protection services can be replaced by man-made engineering solutions, if needed. However, these are generally expensive to build and maintain over time.

Tiger Island is a critical ecosystem service in Good Hope/Pomona NDC to prevent erosion and flooding considering there is no other manmade or natural sea defense.

5.2.3. Cultural Services

Natural spaces or species with cultural, spiritual, or religious importance are considered "living heritage." The most prominent of these is the Hindu tradition of planting prayer flags at various points along the shoreline – most typically associated with shore access.

Locals utilize the areas along the seawalls for recreation, including walking, running, kite flying, and general recreation. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors.

5.2.4. Supporting Services

The natural processes of soil formation, nutrient recycling and accretion have contributed to ideal locations for commercial activities including, ports, wharfs, and dwelling places. The port at Supenaam is critical to the local economy, housing numerous ships offloading and loading their cargo. The primary wharves are at Paradise and Vilvoorden while other landing sites are used on the beaches where boats can land safely during the high tide.

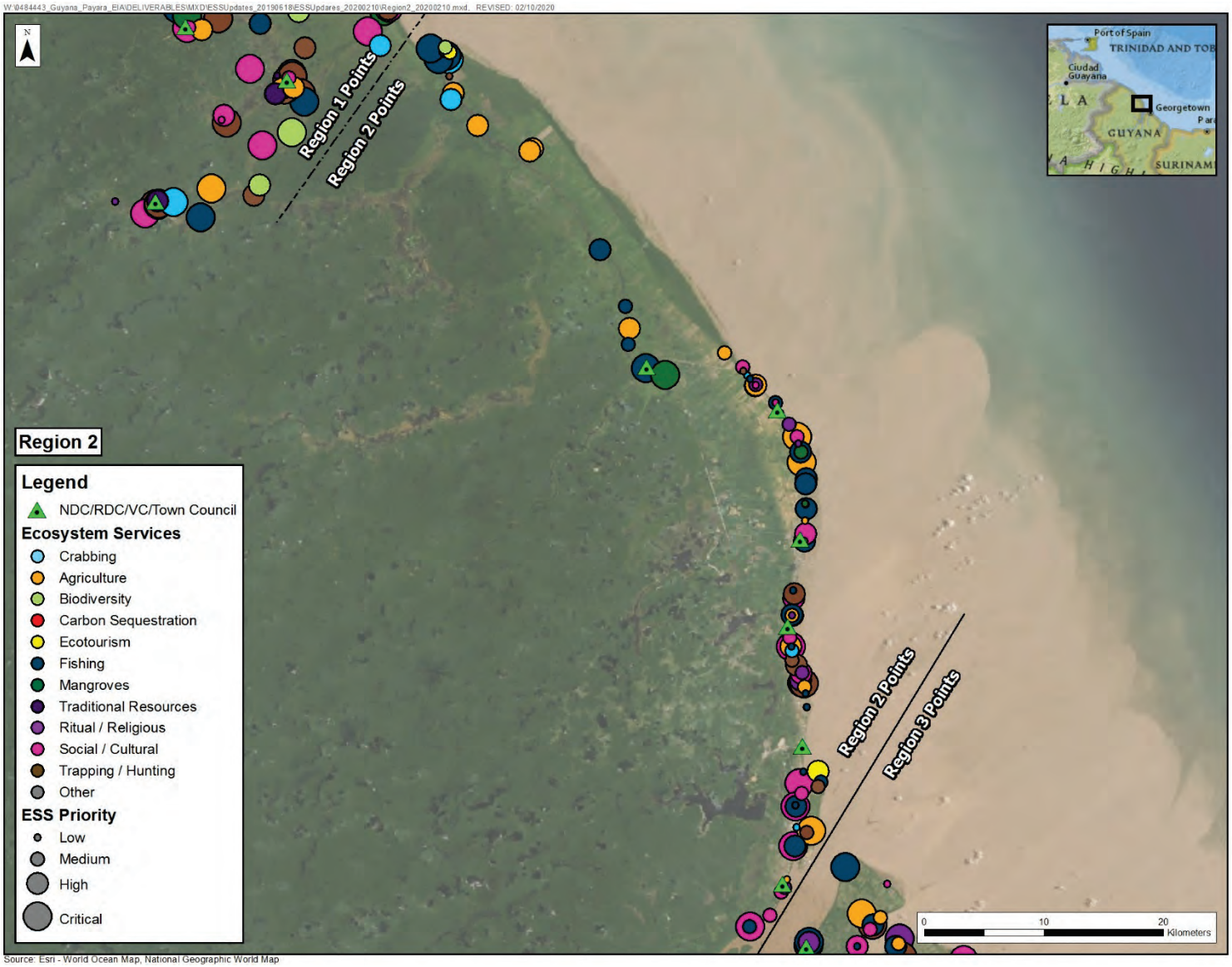
Along the Pomeroon River, mangroves provide habitat for biodiversity including scarlet ibis.

5.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix B.

Figure 5-1 shows the ecosystem service locations identified by the Region 2 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol) – critical, high, medium, or low – utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 5-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 2



6. REGION 3 COASTAL ECOSYSTEM SERVICES FINDINGS

6.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 6-1: POPULATION ESTIMATES - REGION 3

NDC Name	Population Estimate	Other Details
Wakenaam (island)	3,300	Decreasing due to migration
Leguan	2,700	Decreasing due to migration to Region 3 and North America
Mora/Parika	12,000	Growing due to migration to the NDC
Hydronie/Good Hope	4,200	Growing
Greenwich Park/Vergenoegen	2,600	
Tuschen/Uitvlugt	35,500	Increasing due to the growing housing schemes in several villages
Stewartville/Cornelia Ida	30,000	
Hague/Blankenburg	4,200	
La Jalousie/Nouvelle Flanders	5,500	Population increasing due to new housing schemes
Best/Klien/ Pouderoyen	25,000	Population increasing due to migration to the area

6.2. Summary of Findings

The services rated as “critical” or “high” priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 6-2: SERVICES RATED AS “CRITICAL” OR “HIGH” PRIORITY WITHIN THE NDCs – REGION 3

NDC Name	Type of Service	Brief Description
Wakenaam (island)	Provisioning	Commercial fishing at mouth of and within Essequibo River
	Provisioning	Freshwater from the Essequibo River is relied on island-wide for its irrigation of rice paddies and other crops during the dry season
	Provisioning	Crop cultivation is present in most areas of the island along the river dam and reserves
	Provisioning	Ports, wharfs, and shipyards, inclusive of boat building, on the river dam; commercial wharf at San Sousi for transport of fuels, rice, and other products that are shipped or imported to the island
	Provisioning	Speed boat landing site at Maria’s Pleasure for passenger transport to Parika and Leguan

NDC Name	Type of Service	Brief Description
Leguan	Provisioning	Transportation services to Parika and other areas
	Provisioning	Commercial fishing at Waterloo and Success
	Provisioning	The entire island depends on freshwater from the Essequibo River
	Cultural	Organized tours to historic sites including St. Peters Church
	Cultural	Hindu religious activities along the seashore and the presence of a cremation site
	Regulating	Erosion regulation as the island is at risk to erosion and much of the shore is not protected by manmade concrete defense
Mora/Parika	Supporting	Marine transport services and related economic activities at Parika stelling and saw mill
	Provisioning	Economic activity at fisheries wharf where boats load, refuel and discharge catch
	Provisioning	Residents squat along the river dam and use freshwater for domestic purposes
	Supporting	Biodiversity Reserve where locals protect two small islands that are roosting areas for hundreds of birds in the Essequibo River
	Cultural	Big Kiss temple on the river dam for worship activities
Hydronie/Good Hope	Provisioning	Economic activity from fishing at Ruby Koker and wharf supporting sea going vessels at Bushy Park, including ship repairs
	Provisioning	Livestock farming in the Ledestein to Good Hope area
	Provisioning	Two new wharfs established along the shoreline
	Cultural	Recreation at Bushy Park Beach, a popular tourist attraction for locals and people from other parts of the country
	Cultural	Hindu religious activities along the sea dam and the presence of a mosque at Ruby Koker
Greenwich Park/Vergenoegen	Provisioning	Fishing at Vergenoegen Outfall and cash crop cultivation along the coast
	Provisioning	Informal housing at Barnwell
	Cultural	Recreation at the seawall and Hindu religious activities along the shoreline
Tuschen/Uitvlugt	Provisioning	Fishing from the Zeeburg Seawall and Boeraserie Koker
	Provisioning	Shrimp processing at Zeeburg and Uitvlugt
	Supporting	Coastal protection from concrete sea defense
	Cultural	Recreation at Cinderella Park at Zeelugt Temple on the sea defense reserves at Uitvlugt
	Provisioning	Grazing of Animals at Zeelugt and Uitvlugt

NDC Name	Type of Service	Brief Description
Stewartville/Cornelia Ida	Provisioning	Fishing at Leonora boat landing area and farming along coast
	Supporting	Shrimp and fish processing on the Anna Catherina and Leonora seawall/reserve
	Supporting	Coastal protection from concrete sea defense
	Cultural	Religious practices at Cornelia Ida
	Provisioning	Informal housing at Anna Catherina sea defense reserves
Hague/Blankenburg	Provisioning	Fishing boat landing area at Hague seawall
	Provisioning	Crop cultivation and livestock farming along the sea shore
	Cultural	Recreation at the seawall and Hindu religious activities along the shoreline
La Jalousie/Nouvelle Flanders	Provisioning	Fishing from Windsor Forest Koker
	Cultural	Religious rituals at cremation site at Ruimzeigt and religious activity at La Jalousie
	Cultural	Recreation along seawall Windsor Forest
Best/Klien/ Pouderoyen	Provisioning	Transportation at Transport Wharf, GPL Wharf, Sawmill and Speedboat stelling; waterway used by boat builders
	Provisioning	Informal housing at Phoenix Park and Best Village
	Provisioning	Waterway is used by boat builders for access to launch boats built on the riverbank

6.2.1. Provisioning Services

The primary ecosystem services along the coastal zones in Region 3 are fishing and farming on the islands. The main commercial fish catch includes various types of catfish, snapper, bangamary, snook, mullet, and shrimp. The smaller boats catch shrimp and fish, while some boats change to catch shrimp in the season when it is abundant.

Crabs are caught during the period of July and August during spawning season. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. Some people catch crabs throughout the year by hunting them in the mangroves. The system of inland rivers is also critical to the growth of the rich biodiversity of the sea. Rivers provide spawning grounds, shelter, and nutrients for the rich aquatic life.

Crop cultivation is present in many communities along the coast, and ranges in scale from subsistence farming of staple grains, including rice, to export-oriented growing of coconuts and plantains on the islands. Cash crops are grown on the sea defense reserves by residents who live in the area adjacent to the reserves. Several people squat on the reserves and make ample use of the land for crops, fruits, and grazing grounds for livestock.

The intensity of livestock farming ranges considerably within the NDCs of Region 3. Generally, the communities have more sheep and goats, as this is consumed by a wider range of individuals than cows. Hindus do not eat beef but use cow's milk for many purposes including

religious activities. Some households keep a few chickens, pigs, and cattle in their yards for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be either dual purpose or specialize in dairy or beef.

Households in Region 3 rarely collect wild plants, fruits, and honey, for subsistence use or commercial use. While mangroves provide the habitat for honey production, it is not common in Region 3. One tanner uses the mangrove bark for his leatherwork on a limited basis. Some wood and non-wood fibers, including mangrove trees and coconut husks, are used in handicrafts and household items in some of the coastal communities, although this is not extensive.

Small groups of individuals will catch iguanas found living among the mangroves or thick vegetation of the sea dam. These reptiles are captured for sale and can attract G$6,000 for a large adult. Some people catch the birds on the seashore but on a limited basis. The shore is rapidly changing due to natural erosion and accretion and thus the bird population is constantly on the move. Since it is illegal to hunt some species of birds, hunting is likely underreported; in any case, it is likely not a major source of food or income in the region. The existence of various islands of large bird colonies where birds roost peacefully is testimony to the attitudes of the locals to the birds.

Potable water is available for communities from groundwater and many residents harvest rainwater. A few people rely on the fresh water from the river and irrigation canals for household purposes. The people squatting are more likely to use the seawater for some tasks. They have to fetch water some distance from their homes for drinking or cooking purposes. Transportation is mainly land based along the coast except for a few instances when the seacoast is used.

Commercial activities abundant in these areas include those supporting the marine industry, such as boat building, ship repairs, fuel services, and products needed by sailors and fisherfolk. It is quite evident that at almost all landing areas used by fisherfolk, there are shops in close proximity selling alcohol and other consumable products.

6.2.2. Regulating Services

Almost the entire shoreline is protected by rocks or concrete structures. Short lengths of earthen dams exist that are strengthened by rocks (riprap). Mangroves and coastal vegetation play a minor role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. The migrating mud flats are on the move and consequently areas rich in mangroves are being washed away while new beaches are built elsewhere.

The NAREI re-growth program was most active in the La Jalousie/Nouvelle Flanders NDC but those mangroves are now almost completely washed away. With all of the new mangrove plantings and natural growth in the Best/Klien/Pouderoyen NDC, there are now concerns over the nuisance of sand flies and mosquitoes. The new mangrove growth will provide allow for pollination, which is essential to the agricultural coastland.

The shallowness of the natural shoreline makes protection services susceptible to change and these must be replaced by man-made engineering solutions before the natural protection is washed away. However, these are generally expensive to build and maintain over time.

6.2.3. Cultural Services

Natural spaces or species with cultural, spiritual, or religious importance are considered "living heritage." The most prominent of these is the Hindu tradition of praying and the planting of prayer flags at various points along the shoreline – most typically associated with shore access. African religious practices are almost nonexistent in the area and are generally done in secret. In some areas, temples or temporary structures are built for the main worship days. On Sundays, many families visit the sea early in the morning to pray and swim.

Locals utilize the areas along the seawalls for recreation, including walking, running, kite flying, and general recreation. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors. There is a cremation site in the La Jalousie/Nouvelle Flanders NDC that is used daily by the Region 3 population.

6.2.4. Supporting Services

The sea and river dam, inclusive of the reserves, houses a number of commercial and household activities. The natural processes of soil formation, nutrient recycling and accretion have contributed to ideal locations for commercial activities including, ports, wharfs, and dwelling places. The port at Parika is critical to the local economy, housing numerous ships offloading and loading their cargo. The primary wharves are at Parika, Vreed-en-Hoop and other landing sites are used on the beaches where boats can land safely during the high tide.

6.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix C.

Figures 6-1 and 6-2 show the ecosystem service locations identified by the Region 3 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol) – critical, high, medium, or low – utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 6-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 3 (1 OF 2)

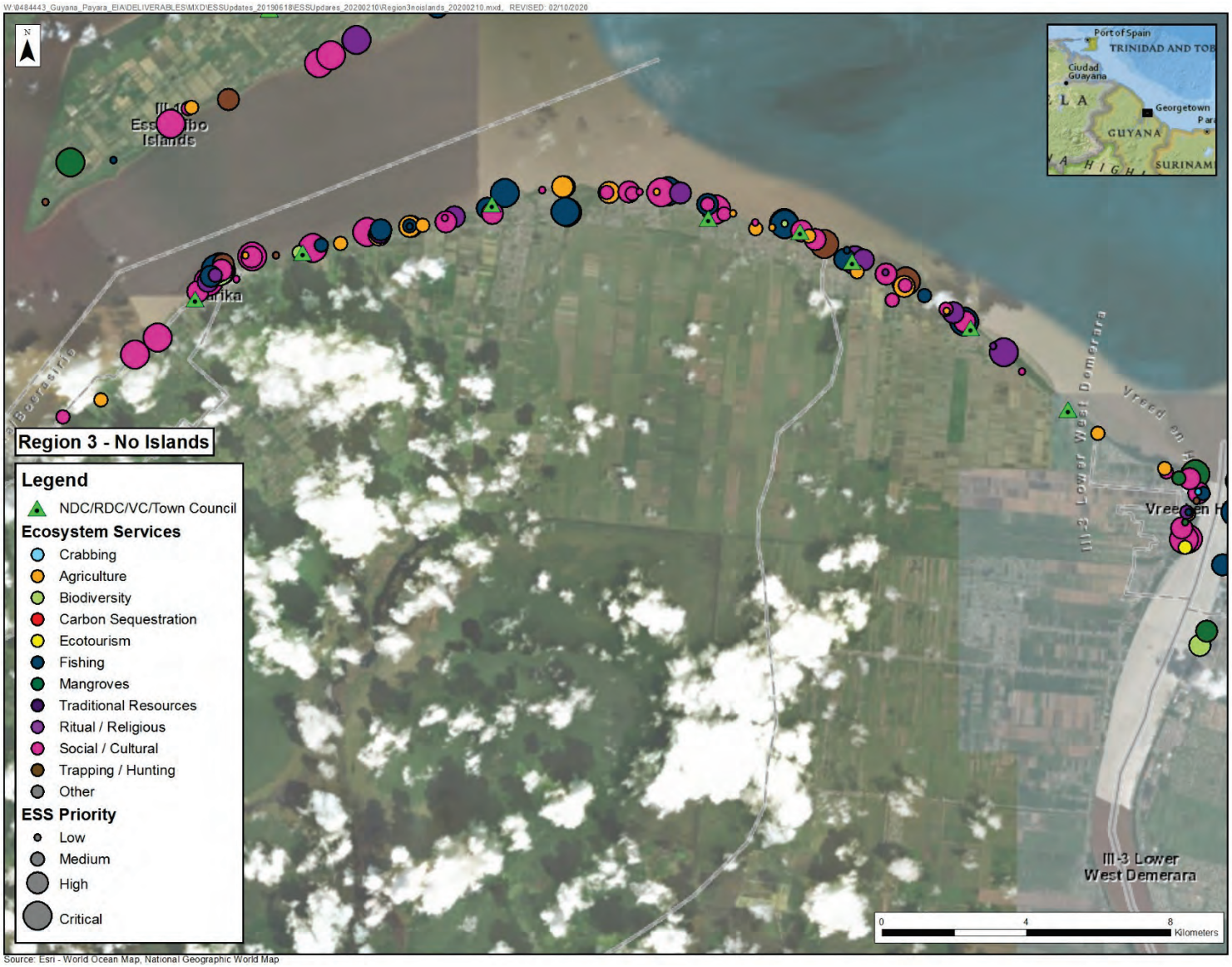
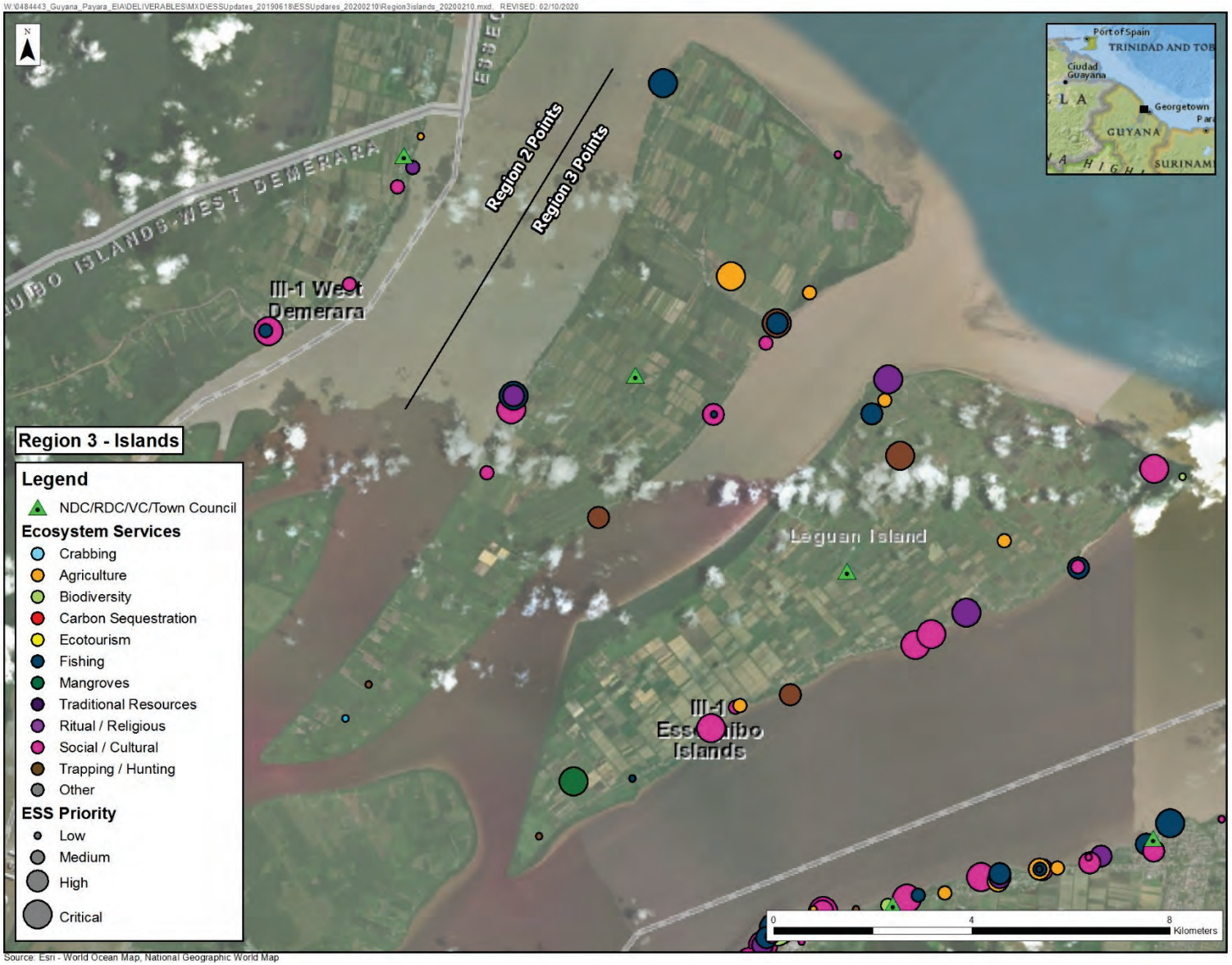


FIGURE 6-2: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 3 (2 OF 2)



7. REGION 4 COASTAL ECOSYSTEM SERVICES FINDINGS

7.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 7-1: POPULATION ESTIMATES - REGION 4

NDC Name	Population Estimate	Other Details
Georgetown City	132,000	Increasing in suburban housing areas
Industry/Plaisance	25,000	Should be increasing due to new housing schemes
Better Hope/ LBI	30,000	Increasing due to natural population growth
Beterverwagting/Triumph	7,000	
Mon Repos/ La Reconnaissance	40,000	Increasing
Buxton/Foulis	7,000	
Unity/Vereeniging	13,000	
Haslington/Grove	27,000	Population increasing due to new housing schemes
Enmore/Hope	8,000	

7.2. Summary of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 7-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE NDCs – REGION 4

NDC Name	Type of Service	Brief Description
Georgetown City	Supporting	Economic and social benefits from Port Georgetown and associated wharfs
	Provisioning	Commercial and subsistence fishing along the shore throughout the city
	Regulating	Erosion regulation as the coastland is at risk to erosion, although protected by concrete defense
	Cultural	Recreation from Kingstown along seawall
	Cultural	Tourism - two of the main hotels in Guyana are located on the sea shore
	Provisioning	Birds roost in the mangroves close to the Demerara Harbour Bridge
	Cultural	Religious activities at the Kingston shore/beach
Industry/Plaisance	Provisioning	Commercial fish landing site at Industry and Plaisance
	Cultural	Recreation, exercise and Hindu religious practices along the Cummings Lodge–UG Road area

NDC Name	Type of Service	Brief Description
Better Hope/ LBI	Provisioning	Fishing and salt fish drying from Montrose, Success and Better Hope
	Regulating	Erosion regulation as the coastland is at risk to erosion, although protected by concrete defense
	Provisioning	Locals utilize land along the sea wall at Better Hope for grazing livestock
Beterverwagting/Triumph	Provisioning	Fishing landing area in Triumph
	Cultural	Locals use the Triumph end of the NDC to exercise, recreate, or socialize.
Mon Repos/ La Reconnaissance	Provisioning	Fishing at fisheries landing areas in Mon Repos Koker and Lusignan Koker
	Cultural	Religious activities at Mon Repos
	Provisioning	Boat building & repairs
	Regulating	Mangrove cover is increasing and providing shoreline protection
Buxton/Foulis	Provisioning	Fishing at Stratsphey
	Provisioning	Informal housing at Bladen Hall in the mangroves
	Cultural	Recreation, exercise and Hindu religious activities at the Melanie to Non Pariel seawall
	Regulating	NAREI plots at Mon Repos and Vigilance for mangrove restoration.
Unity/Vereeniging	Provisioning	Fishing areas at Unity shoreline and Helena Koker, and wharfs in the Mahaica River supporting trade and the local economy
	Provisioning	Agriculture and grazing at Unity shoreline
	Supporting	Coastal defense, as the concrete sea defense is supported by natural vegetation including mangroves
	Cultural	Unity beach is frequented for recreation and aesthetic value of landscapes
	Cultural	Daily bird tours in the Mahaica River to spot numerous bird species
	Provisioning	Coconut estates encroach on the reserves along with some cash crops
	Cultural	Aesthetic value of natural landscapes throughout the area
Haslington/Grove	Provisioning	Fishing at landing areas Greenfield, Hope, Haslington and Victoria, including at mudflats
	Supporting	Mangrove Reserve supporting conservation, apiculture
	Cultural	Mangrove Reserve supporting ecotourism
	Cultural	Cove & John to Victoria seawalls for recreation and religious activities; Cove & John attracts thousands for the special religious days
	Provisioning	Grazing of animals at Hope Sea

NDC Name	Type of Service	Brief Description
Enmore/Hope	Provisioning	Fishing at the Enmore Koker
	Cultural	Enmore shoreline is a popular place for Hindu religious activities

7.2.1. Provisioning Services

The primary ecosystem service along the coastal zone of Region 4 is fishing. The main fish caught include various types of catfish, trout, paggy, snapper, bangamary, snook, mullet, and shark. Some fisherfolk catch shrimp, particularly those launching from the Demerara River and lower East Coast of Demerara. The fisherfolk from the coast switch to shrimp in the season when it is abundant.

Crabs are caught in the period July to August during their spawning season in areas where they are available. Some people catch crabs throughout the year by hunting them in the mangroves. The sea crabs are found in small puddles left on the mudflat when the water recedes. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. The system of rivers is also critical to the growth of the rich biodiversity of the sea. The Demerara and Mahaica Rivers provide spawning grounds, shelter, and nutrients for aquatic life.

Housing is the main activity on the coastland, followed by agriculture. Communities along the coast engage in subsistence farming of vegetables and fruits. Commercial farms grow sugarcane, staple grains (including rice), coconuts, and cash crops. Cash crops are also grown on the sea defense reserves by residents who live in the area adjacent to the reserves. A number of people who squat on the reserves make ample use of the land for crops, fruits, and grazing grounds for livestock. Mangroves are an important ecosystem service provider for the agricultural economy in this region as they house numerous pollinators.

The intensity of livestock farming increases as one leaves the city of Georgetown and progresses to the Mahaica area. Generally, the communities have more sheep and goats, as opposed to cows, as these are consumed by a wider range of individuals. Some households living in close proximity to the sea defense keeps a few chickens, pigs, and cattle in their yards for household consumption and sale.

Households in Region 4 rarely collect wild plants, fruits, berries, mushrooms, honey, and nuts, for subsistence use or commercial use mainly because they are in limited supply. This practice is limited in Region 4, although mangroves provide the habitat for honey production. Honey is known to be produced by two people using the mangroves on the coastland; these individuals agreed that honey production could be a major source of income. Honey is sold at G$3,500 per liter, and these individuals reportedly sell approximately four liters daily. Some wood and non-wood fibers, including mangrove trees and coconut husks, and driftwood are used in handicrafts and household items in some of the coastal communities, although this is not extensive.

Small groups of individuals will catch iguanas found living among the mangroves or thick vegetation of the sea dam. These reptiles are captured for sale and can attract G$6,000 for a

large adult. Some people shoot the birds on the seashore, but on a limited basis as the shotgun attracts police attention. It is illegal to hunt some species of birds, so hunting is not encouraged by the police. Birds do not constitute a major source of food or income in the region.

Potable water is available for communities from groundwater and many residents harvest rainwater. A few people rely on the canals for household purposes. The people squatting are more likely to use the salt water or water from the drainage canals for some tasks. The people squatting have to fetch water some distance from their homes for drinking or cooking purposes. Transportation is mainly land based along the coast except for a few instances when the seacoast is used.

Commercial activities dominate Georgetown, inclusive of fishing by commercial trawlers and large boats. Supporting services in the area offered to the industry include boat building, ship repairs, fuel services, entertainment and household products needed by sailors and fisherfolk. Specialized businesses offer services to the crews of visiting vessels, including food, beverages, transportation, and entertainment.

7.2.2. Regulating Services

Almost the entire shoreline is protected by rocks or concrete structures. Short lengths of earthen dams exist in a few NDCs that are strengthened by rocks (riprap). Mangroves and coastal vegetation play an increasing role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. The migrating mud flats are being deposited in this region and they provide substrate for new mangroves to thrive. The new mangrove growth will provide regulating services, of which pollination is essential to the agricultural coastland. The mangroves will also promote a more diverse biodiversity and increase in the abundance of fishes in the ocean.

The NAREI re-growth program was most active in Region 4 compared to Regions 2 and 3, although some replanted areas have now almost completely washed away. The new mangrove plantings in Better Hope/ LBI, Beterverwagting/Triumph, and Haslington/Grove NDCs and natural growth in Better Hope/ LBI, Beterverwagting/Triumph, Unity/Vereeniging, Haslington/Grove, and Enmore/Hope NDCs have increased concerns over the nuisance of sand flies and mosquitoes.

The mangroves help with flood regulation and sea defense on the shore. These services are essential to the coastal communities and the natural defense must be replaced by man-made engineering solutions before the natural protection is washed away.

7.2.3. Cultural Services

Natural spaces or species with cultural, spiritual, or religious importance are considered “living heritage.” These natural spaces are highly valued by the local communities, the most prominent of these being the Hindus. The believers practice the tradition of bathing, praying, and the planting of prayer flags at various points along the shoreline, particularly at the kokers. In some areas, temples or temporary structures are built for the main worship days. On Sundays, many

families visit the sea early in the morning to pray and swim. African religious practices are almost nonexistent in the area or are generally done in secret.

Locals utilize the areas along the seawalls for recreation, including walking, running, kite flying, and general recreation. At popular locations such as the Kitty Seawall in Georgetown, people from many other regions of Guyana visit for recreation purposes. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors. Birding tours are held daily in the Mahaica River for locals and overseas visitors. Mangrove Tours are held monthly in the Mangrove Reserves and as often as three times per day in the school tour season.

7.2.4. Supporting Services

Georgetown is the Capital City of Guyana and a historical port. The activities of the city based on the river and ocean systems are essential to the wellbeing of the nation. The sea defense and river dam, inclusive of the reserves, house a number of commercial and household activities. The natural processes of soil formation, nutrient recycling, and accretion have contributed to ideal locations for commercial activities including, ports, wharfs and commercial houses. The numerous wharves facilitate various services for ships, with docks utilized by passenger and fishing vessels. The mangroves are roosting areas for birds, with the area next to the Demerara Harbour Bridge being a particularly important site.

7.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix D.

Figure 7-1 shows the ecosystem service locations identified by the Region 4 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 7-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 4

APPENDIX A

Screening Checklist

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Ecosystem Service	Description, Examples
Provisioning Services	
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for harvesting
Food: wild plants, nuts, mushrooms, fruit, honey	Fruit, nuts, wild plants, etc. collected in natural areas for consumption or sale
Food: wild meat	Animals hunted primarily for food (recreational hunting is covered separately under cultural services); extent of wildlife trapping and trade (Region 1)
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale
Biomass for livestock production	Sedentary and nomadic livestock farming supported by native forage plants
Biomass fuel	Wood, dung and plant matter collected for charcoal or fuel
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp, paper – wood is used in house construction (importance varies by community)
Non-wood fibers and resins	For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber
Freshwater - household use	Freshwater for bathing, drinking, laundry, household use
Freshwater - irrigation & industry	Freshwater for irrigation or industrial use
Natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use
Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade
Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology
Transportation	In remote areas no alternative methods of transport; commercial transportation facilities such as wharfs, ferry stellings, etc.
Social / Economic	Income generators or services supporting income generation (e.g., boat building, repairs, transportation services)
Traditional Resource Use (Region 1)	Traditional medicine, manicole and morocut harvesting, logging, non-wood fibers and resins for sustenance and crafts, biomass for fuel, gathering wild plants and honey, turtle/wildlife trappings, and harvesting of shells
Regulating Services	
Regulation of air quality	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a “sink”) or emitting chemicals to the atmosphere (i.e., serving as a “source”)
Climate regulation: global	Vegetated areas sequester CO_2, with implications for global climate change
Climate regulation: local	Regulation of temperature, shade air, and quality by vegetated areas
Regulation of water timing and flows (including flood regulation)	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge
Water purification and waste treatment	Role played by vegetation in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds

Ecosystem Service	Description, Examples
Shoreline protection	Role of natural habitats (e.g., wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms
Fire regulation	Regulation of fire frequency and intensity (e.g., dense forest can provide firebreaks)
Pest regulation	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock
Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens
Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas
Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops
Cultural Services	
Spiritual or religious value	Natural spaces or species with spiritual or religious importance
Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources
Tourism and recreation	Use of natural spaces and resources for tourism or local recreation (e.g., swimming, boating, fishing); tourism potential and infrastructure needs (Region 1)
Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value
Cultural Services (Region 1)	Cultural aspects and places of importance and protection for Amerindian communities
Supporting Services [a]	
Habitat provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation
Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms.
Soil formation	Natural soil-forming processes throughout vegetated areas

[a] Supporting Services are intermediate ecological outcomes that are not directly used but rather support other ecosystem services. An exception is made for Habitat Provision, which is sometimes valued as an "end-use" service by stakeholders in addition to its supporting role.

APPENDIX B

Identified Ecosystem Services and Priority Ratings: Region 1 Coastal

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TABLE B-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 1 COASTAL

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
0101 Father's Beach - Population Estimate - 23 people							
Shoreline Protection; River Defense	Regulating Services	Extensive area of mangrove forest on the shore line protecting the sea shore from the impacts of the sea and along the banks of the Moruca River. The oldest coconut farms in the area (established in the 1950s) have been reclaimed by mangroves. There are mature mangroves and new mangrove growth in other areas. Erosion of mangroves is observed in some areas. There was a significant shell beach, which has eroded over the years. Shell is being used for construction in place of stone and is also used for landfilling and to provide nutrients for plants (fruit trees).	Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves **ES Linkages:** Agriculture, sea defense, settlements.	High	Low	Critical
Biodiversity - Habitats	Supporting Services	There are lots of animals within the mangroves including mammals, birds, crabs, fish, and reptiles. Jaguars are a common sighting and macaws and parrots are plentiful in the area eating the crops. Hunting is prohibited in the village and small animals are caught in the swamp for meat.	Mangroves, shoreline	Local people **ES Linkages:** Hunting, recreation	Moderate	Moderate	Medium
Food: Wild Meat	Provisioning Services	There are lots of birds, crabs, fish, and reptiles in the mangroves with crabs and fishes caught for commercial purposes. Some iguanas are caught on the seashore along with sea birds including curi and wild ducks for meat on a limited basis by a few people in the swamps behind the farms. Hunting by outsiders is banned.	Mangroves, shoreline	Local people	Moderate	Moderate	Medium
Agriculture, Cultivated Crops	Provisioning Services	Cash crops with coconuts, plantains, cassava, vegetables, and fruits are under cultivation in a stretch of twenty (20) acres along the sea shore in the mangroves. Some of the abandoned farmlands in the area have been reclaimed by the mangroves.	Sea dam, cultivated areas	Local farmers, residents	Essential	Moderate	Critical
Agriculture, Cultivated Crops	Provisioning Services	Coconut is the main crop grown by the community. A dry coconut sells for $ 45 and a water coconut sells for $ 50 at Charity. Copra sells for $45. Currently, coconut cockles are affecting the coconut grove.	Cultivated lands	Local communities (general population)	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Most people fish for food with three households who fish on a commercial basis in the sea between the Pomeroon River Mouth and Fathers Beach. They each sell about 200 lb. of fish on a weekly basis at $200-$300 per pound.	Marine habitat and Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabbing in mangroves along the beach area is common especially during the crab seasons. Residents from several villages, including as far as Pomeroon and Warapoka come into Fathers Beach to crab. Crap marching is disruptive to the community as the crabs tend to damage the dams which are critical for flood prevention and drainage. Other people catch crab throughout the year for both subsistence and commercial purposes.	Marine environment; Mangroves;	Local people	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Traditional Resource Use	Provisioning Services	Almost all plants including noni, mangroves, and others that are used by the locals for medicinal and spiritual purposes. These plants are plentiful on the beach. Mangroves are used for building construction plantain poles, seine poles, etc. Red mangrove is used to make craft and household items and buttonwood bark is used to make quake strings and shovel sticks. Residents also used the shell on the beach to provide nutrients for plants, use for construction of foundation for buildings, and use for fillings of yards. Shells are used for construction by the residents.	Biodiversity, Agriculture	Local people	Essential	High	High
Tourism and Recreation	Cultural Services	Community members and people from other areas use sections of the beach including Gwennie Beach, Papaya Beach and Bolton Area for recreation purposes.	Coastland	Local people	Low	Moderate	Low
Freshwater - Household Use	Provisioning Services	The community depends on rain water and some freshwater from the wetlands behind the farms. Water is used for bathing, washing, cooking, and drinking.	Coastal wetlands	Father's Beach	Essential	Moderate	Critical
Social/Economic Settlements	Provisioning Services	An entire community resides along the beach. Access to this community is from the beach only via a small channel in the high tide. This also supports commercial activities including fuel sales, boat building and repairs, engine repairs and the local bar is on the shore. People live on their farms in houses on stilts. In addition to the sale of fuel and conduct of boat repairs onshore, the community also provides these services offshore to stranded fisherfolk and other travelers. Persons in need of fuel or repairs can call and the personnel will respond.	Coastland	Father's Beach	Essential	Low	Critical
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Low	Critical
0102 Manawarin – Population Estimate 2,000 people							
Biodiversity- Habitat	Supporting Services	There is an abundance of wildlife within the forest and rivers. Giant river otters feeding area was observed in the river.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife – Hunting and Trapping	Provisioning Services	There are lots of birds, fish, mammals, and reptiles in the area with few birds caught for commercial purposes. Hunting and trapping is very limited in the area with more people focused on fishing and agriculture. However, about 25% of the population is engaged in some form of hunting. Species such as boas, anacondas, parrots, and macaws are caught and sold at Charity.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	All households have farms with plantains, cassava, vegetables, and fruits. Crops are for household use and some are sold to the school and other villages or in limited extent at Charity or Santa Rosa. More persons are farming but the market for the produce is lacking and it costs too much to transport the produce to Charity or Kumaka.	Forested areas, Bush Islands	Local farmers, residents	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	25% of the population fish in the sea between Pomeroon Mouth and Father's Beach targeting the Moruca Mouth area in seasons. Fishing has declined due to the lack of fishing vessels and supplies.	Marine habitat and Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Almost the entire village accesses the shoreline to catch crabs during the crab season. In addition, a few people catch crabs all year round and bring back to the village for sale.	Marine environment; Mangroves;	Local people	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers fish for food throughout the year at different locations following the movement of the fishes. In the dry season fishing is concentrated in the creeks and rivers.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. Some people harvest rainwater for domestic purposes and others use the groundwater from water wells. Freshwater in the creeks and rivers is used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	There are lots of plants including noni and others that are used by the locals for medicinal purposes. Some people cook the cabbage palm and also use the forests to gather materials for household items. Palms and vines including Ite, Kufa, Nibbi, and Kufra are utilized for making craft and household items. The community cuts wood for its internal construction and for sale. The current dispute with the village of Wakapao over the ownership of the resources has reduced the level of this activity.	Biodiversity, Cultural Heritage	Local people	Essential	High	High
Cultural Resources	Cultural Services	Rockstone is an old spiritual site that is far inland and away from the village. This site is used a few people in an infrequent manner.	Cultural	Locals	Low	Low	Low
Social/Economic	Provisioning Services	Commercial activities including numerous small shops, fuel sales, and transportation services are located in the village landing area used by more than 100 people daily.	Coastal wetlands, river ecosystems	Manawarin & Regions 1 & 2	Essential	Low	Critical
River Defense - Erosion Regulation	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the boats and water current.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Agriculture, sea defense	High	Low	Critical
Transportation	Provisioning Services	Access to the community is via boats through the river network entering the Moruka River and the Manawarin River. Numerous dirt road networks provide access from various points to the village.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0103 Haimakabra – Population estimate 600 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 50% of the male population is involved in fishing. 20 people catch fish in the sea on a fortnightly basis making two trips per month to catch snook, basha, bangamary, gillbacker, curass, etc., between Moruka Mouth to Iron Punt where they will camp. Fish is dried at the camps on the beach when ice is unavailable for storage.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally by almost everyone in the village, as well as regularly by a 10-12 people for sale at the weekly market at Santa Rosa.	Marine environment; Mangroves	Local people	Essential	High	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Biodiversity – Habitat Provision	Supporting Services	Numerous species of birds, fishes, mammals including manatees and river otters are found in the rivers. Giant river otters spotted in the area.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Hunting and Trapping	Provisioning Services	Several people in the village trap birds and other wildlife for trade. These are sold to a buyer who takes it to Charity for sale. Hunting of ducks and iguanas is done along the coast for meat by people who visit these areas. Timber species present in the area is utilized with lumbering prevalent, with about 20 chainsaws operating within the community. Each chainsaw operation employs about six people.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Cultivated Crops	Provisioning Services	Cassava is the main crop grown by the community for their staple. Fresh vegetables and fruits are grown for home use and for sale in the village. All households have multiple farms at different locations.	Cultivated lands	Local communities (general population)	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers fish for food throughout the year in areas close to their homes. In the dry season fishing is concentrated in the creeks and rivers. Special fishing trips are made to areas far from the village for commercial purposes.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Traditional resources are harvested in a limited manner and cabbage palm is only cut for cooking at home. Many people do not make traditional furniture or craft.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Social/Economic	Provisioning Services	The village in located on highland and is populated by houses, administrative buildings and village shops. The village has a sports ground.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks that are critical for fishing and transportation. Freshwater in the creeks and rivers is also used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Cultural Resources	Cultural Services	The village has a shell mound that can be used for tourist attraction in addition to its cultural value.	Cultural	Locals	Low	Moderate	Low
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Moderate	Critical
0104 Waramuri – Population estimate 2,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 30% of the males are commercial fisherfolk catching curass, snapper, gillbacker, highwater, cufum, and banga mainly on both sides of the Moruka River mouth between Iron Punt and Cozier Canal. Most of the fisherfolk lives in Haimakabra, a satellite of Waramuri.	Marine environment; Mangroves; river ecosystem	Local people	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabbing is done seasonally with every family making at least two trips to the main crabbing areas of Fathers Beach to east of Pomeroon Mouth.	Marine environment; Mangroves;	Waramuri villagers	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the creeks and savannas and lagoons behind the beach. In the dry season fishing is concentrated in the creeks and rivers with fishing trips to areas far from the village for commercial purposes. Some fish is sold fresh in the village. Some is dried and sold at Santa Rosa and Charity.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity – Habitat Provision	Supporting Services	Numerous species of birds, fishes, mammals including river otters, tapir, deer, and labba are found in the rivers and environment. Many ducks are seen but not caught. Many birds are seen in the savannas but not hunted.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Food: Wild Meat	Provisioning Services	A few people are involved in trapping. Along the beach wild animals are hunted including tapir, deer, iguana, wild ducks (muscovy), etc., with agouti and caiman caught. Snakes are caught and sold to visiting traders or sold at Charity. Duck eggs are also collected. Turtles were previously hunted but not anymore due to conservation efforts. Shore birds can be used for bait by the fisherfolk.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	Cassava is the main crop grown by the community for their staple by all households. Fresh vegetables and fruits are grown for home use and for sale to the school. Coconut cultivation is increasing in the village and water nuts are sold at Charity. Copra is sold at Pomeroon.	Cultivated lands	Local communities (general population)	Essential	High	High
Tourism and Recreation	Cultural Services	Shell mounds are located in the village that can be used for tourist attraction as a heritage site. This site is expected to be developed into a leading tourist attraction in the future as part of the village's plan to enhance eco-tourism activities.	Cultural	Locals	Moderate	Moderate	Medium
Traditional Resource Use	Provisioning Services	Traditional resources are harvested in a limited manner with the villagers embracing modernity. Most people cook with cooking gas using firewood in a limited manner. Noni is used for many medicinal remedies by villagers. Honey is gathered from wild bees along the beach and sells for 250 ml for $1000. Lumber is cut for domestic purposes and sometimes sold in the village. The ite palm is recognized by the village as the tree of life providing tibisiri for craft and hammocks, clothing, household items, roof material, fruit for drink making, and tacoma worm. The village has deposits of stone that are used in construction. Stone is mined and sold locally with some villagers selling to contractors in Santa Rosa.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	Moderate	High	Low
Social/Economic	Provisioning Services	The village in located on bush island (highland) and is populated by houses, administrative buildings, churches and over 20 village shops. The village has a sports ground and an internet service provider.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. The river network is critical for fishing and transportation. Freshwater in the creeks and rivers is also used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Shoreline Protection/River Defense	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the motor boats and water current. The shoreline area is preferred for farming since it is more fertile. However, large cultivated areas and the fisherfolk's camp were washed away. A lot of mangroves and other lands are also eroded from Shell Beach.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Transportation	Provisioning Services	Access to the community is via boats through the river network. Extensive networks of dirt roads exist connecting Waramuri and other settlements.	Rivers	Local People ES Linkages: Settlements, agriculture and socioeconomic	Essential	Low	Critical
0105 Santa Rosa – Population estimate 10,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	50 -100 people are fishing on a daily basis with some people making 2-3 trips per month. Fish is sold at $ 300 – 500 per pound at Moruca. One fisherfolk reports to sell over 1000 lb. of fish per trip making 2 trips per month. Fishing is done along the coast from Pomeroon River all the way to Waini Point, but mainly between the Pomeroon River and Iron Punt. Other fishing areas include Manawarin, Moruca, Baramanni, Biara, and Waini rivers. Dog Creek and Luri Creek are also visited in the dry season.	Marine habitat and Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few people for sale. About 20 people catch crabs for the market on Tuesdays and Saturdays. Out of season crabs are sold at $100 for one.	Marine environment; Mangroves;	Local people	Essential	Moderate	Critical
Livestock Farming	Provisioning Services	A small group of <10 people have a few heads of cattle and some pigs. These are grazed in the savannas close to the village and do not reach the coastland.	Animal Husbandry	Local communities (general population)	Essential	High	High
Biodiversity - Habitats	Supporting Services	The village and its surrounding area are populated by numerous species of birds, fishes, mammals including numerous jaguars. Ite palms are found throughout the community and are used by the villagers. Ite palms also house numerous birds.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife – Trapping & Hunting	Provisioning Services	Wildlife trade is banned in the village but some people keep animals as pets. However, people hunt wildlife for sustenance. Luri Creek and Baramani Lake are important areas where villagers conduct hunting of animals for meat. There is a ban on all hunting within the village. Deer is scarce but iguanas are plentiful. Recently many saki monkey were trapped by a wildlife trader.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers fish for food throughout the year and more so in the dry season. Special fishing trips are made to Dog Creek and Luri Creek for commercial purposes.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Traditional resources are harvested in a limited manner and cabbage palm is only cut for cooking at home. Many people do not make traditional furniture or craft but rely on household items made exclusively from wood. Turtle shells are used for spiritual practices. The mangroves are part of the cultural heritage of the community and must be protected. The Moruca Mouth is part of the ancestral lands of the Amerindian people of Santa Rosa. Plants are gathered from the beach and throughout the community for medicinal and other purposes.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Social/Economic	Provisioning Services	The village in located on highland and is populated by houses, regional and village administrative buildings and numerous shops. The village has three sports ground used on a daily basis by the youths.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. The rivers are critical for transportation with 100 -200 people travelling on a daily basis to Charity or Mabaruma.	Coastal wetlands, river ecosystems	Local Communities ES Linkages: Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Cultural Resources; Tourism, and Recreation	Cultural Services	The village has a sacred site that can be used for tourist attraction in addition to its native culture. The village also has a 200 year old church that can be cites as a heritage site. There is an historical site call Lalancha along the Barabara River where there was a battle between the Indigenous communities and the Venezuelans. The Moruca River and its numerous waterways are used for swimming, cultural acts, fishing, recreation, sports, and some spiritual practices.	Cultural	Locals Villagers, Region 1, Guyana	Moderate	Moderate	Medium
Commercial, Social/Economic	Provisioning Services	The village in the trading hub for the Moruca Sub District of Region 1. Numerous boats and small vessels arrive in the village to ply their trade two times weekly. Over 100 people leave/arrive in the area daily.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
River Defense / Erosion Protection	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the motor boats and water current.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Shoreline Protection	Regulating Services	Extensive area of Mangrove forest at Moruca Mouth protecting the river banks and shoreline. The mangroves keep the banks of the river intact and the shoreline is constantly eroding and rebuilding.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	High	Moderate	High
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Moderate	Critical
0106 Assakata – Population Estimate 473 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	50 of the 57 households participate in fishing activities on at least a monthly basis. The fisherfolk use Biara and Bara Rivers, Luri Creek, and Dog Creek as their main fishing ground to catch many types of fishes for sale in the village and at Santa Rosa. Currently no boats fish in the ocean.	Marine environment; Mangroves; Rivers, Creeks & Lakes	Villagers **ES Linkages:** Commerce, transport	Essential	Moderate	Critical
Agriculture, Cultivated Crops	Provisioning Services	Cassava is the main crop used as the local staple along with fish for a daily meal. Cash crop includes bananas, coconuts, fruits, vegetables, and vine crops.	Bush Islands, Forests	Local farmers, residents	Essential	Moderate	Critical
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. Villagers harvest rainwater for domestic purposes and others use the groundwater from hand dug water wells. Freshwater in the creeks and rivers is used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Traditional Resource Use	Provisioning Services	About 30 villagers cut approximately 2500 cabbage sticks per trip making at least a trip per month. Noni and other plants are used by the locals for medicinal purposes. Some people cook the cabbage palm and also use the forests to gather materials for household items. Lumber is cut for household and community projects.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally along the rivers, shore, and beach by almost everyone in the village, as well as regularly by a few people for sale. Every family makes about 2 trips per season. A few people catch crabs on the fishing trips for food and sale.	Marine environment; Mangroves;	Local people	Moderate	Moderate	Medium
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the rivers, creeks, and lakes. In the dry season fishing is concentrated in the creeks and rivers with fishing trips to Baramanni Lake, and Luri Creek for commercial purposes. Some fish is sold fresh in the village. Some is dried and sold at Mabaruma, Santa Rosa, and Charity. Morocut is caught in the freshwater rivers for sale.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	Numerous species of birds, fishes, mammals including river otters, tapir, deer, acouri, and labba are found in the rivers and environment. Many ducks are seen but not caught. The rich biodiversity is known to be along Luri Creek.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Iguanas, tapirs, labba, deer powis, wild ducks are caught on the seashore on fishing and hunting trips, or along Luri Creek and Baramani Lake. Nobody from the village is a wildlife trader. Conservation efforts have paid off, with a reduction in wildlife trapping and trade within the community.	Mangroves, shoreline	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High
River Defense	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the motor boats and water current. A lot of the vegetation has been burnt by the fisherfolk.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Tourism and Recreation	Cultural Services	The village has a freshwater lake that can be used as a tourist attraction along with some shell mounds in the village. The community will develop an ecotourism plan and seek funding from the government for the initiative.	Cultural	Locals Villagers, Region 1, Guyana	High	Moderate	High
Commercial, Social/Economic	Provisioning Services	The village has numerous small businesses with people actively involved in the cash economy. The village had its school and other government facilities that employ over ten people who contribute to the cash economy along with the pensioners.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the freshwater river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Low	Critical
0107 Warapoka – Population estimate 650 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are 20 people who fish in the sea at least two times per month. Catch includes queriman, bangamary, butterfish, curass, gillbacker, cufum, basha, and others. Shrimp is caught in the rivers around the village.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping & Crabbing	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Agriculture, Cultivated Crops	Provisioning Services	All households have farms located in the forests or on the bush islands. Small gardens are found at the homes of the villagers. Cassava is the main crop grown along with vegetables, fruits, and vine crops. Some of the food is sold locally to the school and the tourist center.	Forests, Bush Islands	Local farmers, residents **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Shoreline Protection	Regulating Services	Extensive area of mangrove forest at Iron Punt, Luri Beach, and Waini Point protecting the coast from the ravages of the sea. These area are used by the fisherfolk in different seasons.	Mangrove Forests	Local communities **ES Linkages:** Fishing, hunting, Erosion regulation, Pollination	High	Moderate	Medium
Cultural Resources	Cultural Services	The village has cultural sites used as tourist attraction along with key biodiversity sites. The tourism product of the village is developing and will grow with the success of the country.	Cultural	Locals Villagers, Region 1, Guyana	High	Moderate	Medium
Social/Economic/Commercial	Provisioning Services	The village has numerous small businesses including a growing tourism center with people actively involved in the cash economy. The village had its school and other government facilities that employ over fifteen people who contribute to the cash economy along with the pensioners.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally to Waini Point and Moruca Mouth by almost everyone in the village, as well as regularly by a few people for sale.	Marine environment; Mangroves;	Local people	Moderate	Moderate	Medium
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the rivers, creeks, and lakes. Fishing trips to Baramanni Lake, and Luri Creek for commercial purposes with fish sold fresh in the village and at Mabaruma and Santa Rosa.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Low	Critical
Biodiversity	Supporting Services	Numerous species of birds, fishes, mammals including harpy eagles, river otters, tapir, deer, acouri, and labba are found in the rivers and environment. Many birds are seen but not hunted. The entire environment has rich biodiversity with numerous species. Four river turtles are found within the area (red neck, side neck, jumbie head, and black turtle). Manatees are also observed in Luri and Muribu Creeks. The village has two harpy eagles nesting sites, with once currently active.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Iguanas, tapirs, labba, deer, powis, wild ducks are caught on the seashore on fishing and hunting trips. Duck eggs are collected for use. Within the village birds eggs are collected seasonally (blue tiger bird and qak). Many people are involved in trapping of wildlife for sale. People will come to the village to purchase wildlife including snakes, parrots, macaws, turtles, etc. Prices fluctuates are generally around $1,000 for parrot, $10,000 for macaw and $2,500 for a Boa.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High
Tourism and Recreation - Ecotourism	Provisioning	The village has an ecotourism house that has six rooms and space for hammocks. Tourists can visit historic sites, experience the Amerindian culture, and see the Harpy eagle amongst many species of birds. The community hopes to develop sport fishing as an ecotourism option in the many fishing sites close to the village at Luri Creek. About 20 persons are now employed in the tourism activities, increasing from 10 in 2018.	Forests, River, Savannas	Local communities **ES Linkages:** Commerce, Agriculture, Guides	High	Moderate	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Traditional Resource Use	Provisioning Services	Approximately 20 households or 80 men cut cabbage sticks at least once in combination with fishing and other resource use exercises per month. Noni and many plants are used by the locals for medicinal purposes and are gathered from the beach. Morocut is caught in the freshwater rivers for sale. People gather honey from wild bees at the beach and honey is sold at $1,000 per liter. Beekeeping is done by one individual within the community.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	High	High
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Low	Critical
0108 Three Brothers – Population estimate 120 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	More than 100 men from the three villages that make up the Three Brothers community catch fish in the sea making two trips per month to catch snook, basha, banga, gillbacker, curass, queriman etc. at Waini Point to Iron Punt. Some people use the Luri Creek to reach Iron Punt. The main fishing season for the sea is May-August.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Biodiversity	Supporting Services	Numerous species of birds, fishes, mammals including crabs are found in the rivers and mangrove forests. There are plenty of ducks in the wetlands bordering with SBPA. River dolphins were prevalent in the past but have not been sighted recently. This may be as a result of speed boats operating within the area and fuel spills in waterways. Both the neo-tropical and giant river otters are found within the area. There is a high presence of jaguars which take the dogs and livestock. Some sea turtles would also be observed up river. There are harpy eagle nesting sites within the area.	Coastal wetlands, Forested areas, Mangroves	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Food: Wild Meat	Provisioning Services	There are no wildlife traders in the village and no person from the village is involved in trapping but people from other villages will conduct this from time to time. Wild ducks and other birds are hunted for food. Iguanas and land turtles are utilized or sometimes sold. The dogs and chickens in the area are hunted by jaguars.	Coastal wetlands, Forested areas, Mangroves	Local people	Low	High	Low
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the season in the village by all households. There are crabs in the village that can be caught on a daily basis as some people do on occasions. People from outside the area are seen catching crabs at Waini Point on a weekly basis for the market.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Agriculture, Cultivated Crops	Provisioning Services	All families have farms that are impoldered. Cassava, plantains, and ground provisions are the main crops. Vegetables and fruits are also grown for home use and for sale in the village. The crabs can be a pest destroying the dams. There are a few commercial farms in the area but farming is generally on the decline, despite successes with ginger and other root crops.	Cultivated lands	Local communities (general population) **ES Linkages:** Transportation, Commerce	Essential	High	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	Fish is the main source of protein for the villagers who fish throughout the year in areas. Fishing trips are made to Luri Creek and Baraminni Lake for commercial purposes. Sea turtles enter the river in the dry season with the salt water as the fishes more inland.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Approximately 90% of the village cuts cabbage palm for sale to the company. Many people do not make traditional furniture or craft any longer. Mangrove is used for building and in the farms. Few people cook with firewood. Medicinal plants are collected from the beach.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. There are no groundwater wells in the area and people depend on rain as a safe source of drinking water. The waterways are also used for transportation of people and food.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Traditional Resource Use	Cultural Services	The village has a Crabwood Forest that is an important cultural resource and can be used for tourist attraction in addition to its native Warrau culture. This is being used to produce crabwood oil.	Cultural	Locals	Low	Moderate	Low
Mangroves River Defense – Erosion Protection	Regulating Services	The rivers are covered by extensive mangroves protecting the banks from the impacts of the motor boats and water current. The mangroves are quick to reclaim any lands not maintained by the community.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	Essential	Low	Critical
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0109 Mabaruma Town Council – Population estimate 8,000 people							
Socio/Economic: Transportation - Wharf facilities	Provisioning	The Kumaka waterfront is used for transportation, commerce, and administrative services by over 200 people daily. There were over 20 large vessels in the area docked. Main transportation hub for the Region	River	Local communities **ES Linkages:** Tourism, commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are over 20 fishing boats visiting the Kumaka market to sell their catch on a daily basis. Catch includes queriman bangamary, butterfish, curass, gillbacker, cufum, basha, and others. There are more than 100 fisherfolk within the Town living in the outlying district making at least weekly fishing trips lasting 3-5 days at sea. The smaller boats can do daily fishing trips to Waini Point. Shrimp is caught in a limited manner in the shrimp season (April – August) by less than 10 people. Fishing has increased due to the additional migrant fisherfolk now residents in the area.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping & Crabbing	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crab catching is done daily for sale at Kumaka and to hucksters working on the ferry to Georgetown. Blue crabs are found year round but red crabs are seasonal. Crab meat project initiated in some areas. Migrants also hunt for crabs for their sustenance.	Marine environment; Mangroves;	Local people, traders	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Agriculture, Cultivated Crops	Provisioning Services	Cassava and ground provision are the main crops used as the local staple along with fish for a daily meal. Cash crop includes bananas, coconuts, fruits, vegetables, and vine crops. About 60% of the people have farms particularly those living out of the urban center.	Bush Islands, Forests	Local farmers, residents	Essential	Moderate	Critical
Freshwater - Household Use	Provisioning Services	The outlying community depends on freshwater from the rivers, creeks, and natural springs. Some people harvest rainwater for domestic purposes and others use the groundwater from water wells provided by the government. Freshwater in the creeks and rivers is used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Villagers in Smiths Creek, Wicabri, and Aruka Mouth cut cabbage sticks for sale. Traditional medicine is used by the locals in a limited manner. Morocut is caught in the freshwater rivers for sale at Mabaruma at $ 300 per lb. Medicinal plants are harvested from the beach area. Mangroves are utilized be people living in swampy areas as post for construction and for building foundation. Mangrove barks are also harvested to be used in tanning.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, Commerce	Essential	High	High
Biodiversity	Supporting Services	The town covers six villages and has a high diversity of flora and fauna. The rubber trees that line the main road are imported from Asia. Numerous species of birds, fishes, mammals are found in the rivers and inland environment. Many birds are in the area but not caught for food or trade. Many Iguanas are in the town and caught and sold. Parrots and macaws can be seen in the evening sky with a bird roosting area close to the town. Numerous monkeys are living in the town and are considered a pest by the farmers.	Coastal wetlands, Forested areas, Rivers	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Trapping and hunting are conducted mainly in the riverine areas. Iguanas, labba, agouti, and wild ducks are the main animals hunted. Many bird species are trapped including toucan, macaws, parrots, etc. Anteaters, small rodents, etc. are trapped. It is estimated that there are 100 trappers within the area and 3 traders based at Kumaka.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High
Agriculture, Livestock Farming	Provisioning Services	Grazing occurs throughout the Town with many heads of cattle seen roaming the roadways and in pastures. Pigs are also kept in pens by farmers who do not allow them to roam. Sheep and goats are more rare but present in small numbers in the town. The animals have no interaction with the coastland.	Mangroves, Sea Dam, Pastures	Local communities, private cattle farmers	Moderate	High	Low
Shoreline Protection, River defense	Regulating Services	Extensive area of Mangrove forest covering the banks of the main rivers and the coastline offering valuable protection and stability. Honey bees are found within the mangroves but seldom interfered with by the locals.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Erosion regulation, Beekeeping	Moderate	Moderate	Medium
Socioeconomic, Sawmill. Lumberyard, and Boat Building/Repairs	Provisioning Services	Sawmill and lumberyard located in Mabaruma. Boat building at Mabaruma, with repairs done to vessels and engines, is also done within the sawmill and lumberyard area.	Coastal	Local fisherfolk, boat owners	Essential	High	High

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Tourism and Recreation - Ecotourism	Provisioning	The town has a few hotels to house tourists who can visit historic sites, experience the Amerindian culture, and see the town. Sport fishing is optional in the many fishing sites close to the Town. Green Park was built for recreation and relaxing that can be utilized by tourists as well. Locals visit Waini Point and Shell Beach on Easter and on special occasions. There is a Shell Mound within the Town. Daily flights have increased to the town and so has tourism activities.	Forests, River, Savannas	Local communities **ES Linkages:** Commerce, Agriculture, Guides	Essential	High	High
0110 Aruka Mouth – Population estimate 300 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 80% of the households or about 60 men catch fish in the sea at Waini Point making weekly trips per month to catch snook, basha, bangamary, gillbacker, curass, queriman etc. at Waini Point. Some people catch shrimp in the shrimp season that is April – August.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Biodiversity	Supporting Services	Numerous species of birds and fishes along with monkeys can be seen in the area. There are no wildlife traders in the village but any animal caught can be sold to the traders at Mabaruma. There were river dolphins and otters in the area that have migrated because of the pollution in the water (primarily from oil and gasoline from boats). Significant roosting areas for birds along river.	Coastal wetlands, Forested areas, Mangroves	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the season in the village by all households. There are 15 persons that catch crabs for the markets on Tuesdays and Saturdays. Crabs are caught at Waini Point and in the riverine areas. Crabs are purchased by traders and taken to Georgetown	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Essential	Moderate	Critical
Agriculture, Cultivated Crops	Provisioning Services	A total of 20 families have farms that are impoldered and provide food for the household. Cassava, plantains, and ground provisions are the main crops. The water seems to be getting higher and flowing over the dams. The crabs can be a pest destroying the dams and serves to discourage villagers from farming. The farm produce is sold at Kumaka on Tuesdays and Saturdays.	Cultivated lands	Local communities (general population) **ES Linkages:** Transportation, Commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers can be found fishing in the rivers and creeks for different fishes on almost a daily basis. Freshwater fishes are found nearby in the rainy season when the waters are fresh. The Morocut will be found in the fresh river water during the rainy season at this location.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	2-5 households in the village cuts cabbage palm for sale to the company. The crab catchers utilize forest products for the crab quakes. Mangrove is used for building and in the farms and also for firewood.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The village has a problem with access to safe drinking water. The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. There are no groundwater wells in the area and people depend on a spring that is located some distance from the river. The waterways are also used for transportation of people and food.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Mangroves, River Defense, and Erosion Protection	Regulating Services	The river banks are protected by extensive mangroves. The mangroves protect the river from the impacts of the motor boats and water current. The mangroves are quick to reclaim any lands not maintained by the community.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	Essential	Moderate	Critical
Food: Wild Meat	Provisioning Services	There are about ten persons from the community that hunt meat for sale at the Kumaka market. Wild birds are also caught in the season when they are plentiful.	Mangroves, shoreline, savannas, forest	Local people **ES Linkages:** Tourism, Commerce	High	High	Medium
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0111 Morawhanna – Population estimate 100 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 30-40 men from Morawhanna catch fish in the sea making three trips per month to catch snapper, snook, basha, banga, gillbacker, curass, quereman, etc. at Waini Point to Iron Punt. Most of the fresh catch is sold to vessels from Venezuela.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the season in the village by all households. There are 13-15 people who catch crabs for the markets on Tuesdays and Saturdays. Crabs are caught at Waini Point and in the riverine areas including Morawhanna.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Biodiversity	Supporting Services	The area has a roosting spot with scarlet ibises and egrets roosting for the night. Numerous species of other birds, fishes, mammals, and crabs are found in the rivers and mangrove forests. Hunting is not practiced by the villagers buys whistle birds from Venezuela.	Coastal wetlands, Forested areas, Mangroves	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	No farming currently done since all farmlands are flooded as the dams have been destroyed and people are discouraged to invest to empolder their lands. The crabs can be a pest destroying the dams in addition to the high tides affecting the area in the past three years.	Cultivated lands	Local communities (general population) **ES Linkages:** Transportation, Commerce	Essential	High	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	Freshwater fishes are caught in the river in the rainy season when the water is fresh. Fishes are also found in the wetlands and creeks that are more available in the dry season.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	No one from the village cuts cabbage palm for sale to the company. The village is of mainly mixed ethnic origin and people rarely make traditional furniture or craft. Mangrove is used for construction of houses and few people cook with firewood. Some people use noni and fegosa for medical purposes.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium
Social/Economic - Commercial	Provisioning Services	The village has a few fuel suppliers selling to villagers and other people in the region. Many people have shops and carry numerous products for sale on the riverfront. About 40 boats from Venezuela are selling fuel in the area. The ice plant is now operational supplying ice to the fisherfolk. Food and other supplies are provided to the crew of the numerous ships on a daily basis.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Freshwater - Household Use	Provisioning Services	The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. There are no groundwater wells in the area and people depend on rain as a safe source of drinking water. Bottled drinking water is purchased from Mabaruma. A new well in the village had reduced the dependence on river water.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0112 Smiths Creek – Population estimate 248 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	All males are fisherfolk with more than 100 men fishing in the Waini River and at Waini Point. The village has three large boats that make 2 trips per month each lasting 8-10 days at sea. Catch includes curass, snapper, gillbacker, highwater, cufum, and bangamary mainly at Waini Point to Iron Punt. The village also has 15-20 small boats that can make daily trips to Waini Point.	Marine environment; Mangroves; river ecosystem	Local people	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Everyone catches crabs for the markets on Tuesdays and Saturdays with a minimum 100 quakes supplied per market day valued at $1000 each. Crabs are also sold to hucksters on the ferry to Georgetown. Both blue and red crabs are sold (7-8 blue per quake and 10 red per quake). A crab processing facility is being established within the community with the support of the government.	Marine environment; Mangroves;	Waramuri villagers	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish in the Barima River and Smiths Creek throughout the year. In the rainy season freshwater fished including the morocut is caught in the area.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	There are many species of birds, fishes, and mammals including jaguars, tapir, deer, and labba are found in the rivers and forests. Many ducks and egrets are seen in the area but not hunted. One hunter traps birds at Macaw Point for sale to the traders (GYD$500 per pound).	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	Three people have farms in the area that is constantly flooded. Cassava and ground provisions are the staple crop for the households. Fresh vegetables and fruits are grown for home use and for sale in the village, to the school and at Mabaruma.	Cultivated lands	Local communities (general population)	Essential	High	High
Traditional Resource Use	Provisioning Services	Everyone is involved in the harvesting of manicole at different times with an average of 40 persons cutting per month. A family or crew can harvest 2500 sticks of manicole palms per trip, making a trip per month. Other traditional resources are harvested in a limited manner except materials related to crabbing. Most people cook with cooking gas using firewood in a limited manner. Noni, guava and mangroves is used for many medicinal remedies by villagers. Mangroves are utilized by people for construction and for building foundation and for firewood, fishing poles and medicinal uses.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	Moderate	Moderate	Medium

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Social/Economic	Provisioning Services	The village has a few fuel suppliers selling to villagers and other people in the region. Many people have shops and carry numerous products for sale on the riverfront.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. The river network is critical for fishing and transportation. Freshwater in the creeks and rivers is also used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities ES Linkages: Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
River Defense, Erosion Protection	Regulating Services	The rivers are covered by mangroves protecting the banks from the impacts of the motor boats and water current. The mangroves also act as roosting habitats for many birds. There are a lot of mangrove being cut to construct new houses for the migrants and being cleared for their dwelling places along the Barima River.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
Wildlife Trapping and Hunting	Provisioning Services	A few men hunt meat for food and trap animals for sale. Land turtles are hunted for meat and for sale to the trader at Kumaka.	Mangroves, shoreline, savannas, forest	Local people **ES Linkages:** Tourism, Commerce	High	High	Medium
0113 Imbotero – Population estimate 353 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are more than 100 men who fish. All men in the village are fisherfolk and some women also fish. Catch includes queriman bangamary, butterfish, curass, gillbacker, cufum, basha, and others. Each household has a boat that they can use with either with outboard engine or by paddling to the fishing ground.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping, Crabbing, commerce	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the crab season in the village by all households. There are also crabs in the village area caught on a daily basis. People from outside the area are seen catching crabs at Waini Point on a weekly basis for the market. The women of the village are reputed to be the better crab catchers catching 5–12 quakes per catching day.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Agriculture, Cultivated Crops	Provisioning Services	20 households have farms located in the savannas or forests that sometimes floods in the rainy season. Cassava is the main crop grown along with vegetables and fruits. Some of the food is sold locally to the school and in the village.	Forests, Bush Islands	Local farmers, residents **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Shoreline Protection	Regulating Services	Mangroves cover Waini Point and shell beach protecting the coast from the ravages of the sea. These areas are used by the fisherfolk in different seasons with some fishing camps onshore.	Mangrove Forests	Local communities **ES Linkages:** Fishing, hunting, Erosion regulation	High	Moderate	Medium

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Commercial, Social/Economic	Provisioning Services	The village has a school and that employs four teachers who contribute to the cash economy along with the pensioners. The trade in petroleum and some products from Venezuela boosts the local economy. The community now has a significant migrant population from Venezuela that has settled along the Barima River banks (Warraus settlement). The migrants have been given temporary status to live and utilize the village resources. As such, these have been an increased use of the same resources utilized by the community.	Human settlement, governance	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the rivers, creeks, and lakes mainly for saltwater fishes. Fishing trips to Baramanni Lake and Luri Creek are made a few times per year. Freshwater fishes are caught more frequently from Lion Creek.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	There are numerous species of birds, fishes, and mammals including tapir, deer, acouri, and labba found in the rivers and forest. Many birds are seen but not hunted. The entire environment has rich biodiversity with numerous species. Many jaguars and black caimans are prowling the area with jaguars eating 30 hunting dogs from the village. The Warraus from Venezuela have cleared patches of mangrove and built houses along the river.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Iguanas and birds are plentiful but the ducks are difficult to catch. The iguanas are caught and eaten regularly. Some birds including parrots, macaws, black headed parrots, rainbow parrots are caught at Macaw Point and these can be sold to the wildlife trader visiting the area or at Kumaka.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	High	Medium
Tourism & Recreation	Provisioning Services	The village has no plans for ecotourism. They are confident that people visiting the area will wish to see the border with Venezuela and visit shell beach. This can be part of a package offered to tourists.	Forests, River, Savannas	Local communities ES Linkages: Commerce, Agriculture, Guides	Essential	High	High
Traditional Resource Use	Provisioning Services	Resources including noni, sweet broom, pear leaf, Indian tobacco, and others are used for medical purposes. The fisherfolk cut manicole palm in the dry season while on their fishing trips. Mangroves are utilized by people for construction and for building foundation and for firewood, fishing poles and medicinal uses.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, commerce	Moderate	High	Medium
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0114 Almond Beach – Population estimate 51 people							
Agriculture, Cultivated Crops	Provisioning Services	All households have farms located on the beach and at risk of erosion. Cassava is the main food crop grown along with vegetables and fruits. Coconut is the main crop on the beach. Copra and both dried and water coconuts are sold at Kumaka. Erosion is still taking away mature and young trees as it washes the shell away every high tide. In general, farming has reduced due to a prolonged dry spell.	Forests, Bush Islands	Local farmers, residents **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Shoreline Protection	Regulating Services	Mangroves cover most of the beach with a wide buffer of shells. The shells are the first wall of protection for most of the beach protecting the coast from the ravages of the sea. These areas are used by the fisherfolk in different seasons with some fishing camps onshore.	Mangrove Forests	Local communities **ES Linkages:** Fishing, hunting, Erosion regulation	High	Moderate	High
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are three families who fish making two trips per month using from Waini Mouth to Tiger Beach in the sea. Catch includes queriman bangamary, butterfish, curass, gillbacker, cufum, basha, and others. Each household has a boat that they can use reach the fishing ground. Nobody catches shrimp and considers the shrimp seine to be inappropriate for the area. Fishing in the Atlantic Ocean depends on the catch, price, and cost of fuel. High gasoline prices have reduced fishing activities.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping, Crabbing, commerce	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught all year around by people from other areas. The villagers will catch some crabs when they are heading to Mabaruma on a market day. Crabs are caught in the crab season in the village by all households in their farms.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Tourism & Recreation - Ecotourism	Provisioning	The village has plans for ecotourism as they seek to collaborate with the PAC. Tourists were restricted in 2017 following the washing away of the beach with the tourism building. The rebuilding of the accommodations will see the return of tourists in the near future.	Forests, River, Savannas	Local communities **ES Linkages:** Commerce, Agriculture, Guides	Essential	High	High
Traditional Resource Use	Provisioning Services	Villagers use noni, pear leaf, wild mangrove, buttercup, and others for medical purposes. Villagers collect driftwood on the beach as their ancestors did for millennia. Turtle meat or eggs are no longer eaten by the villagers who are now strict turtle conservationists.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	Freshwater fishes are caught in the wetlands beyond the beach throughout the year. Fishing trips to Baramanni Lake and Luri Creek are made a few times per year as the villagers make trips to Santa Rosa. Saltwater has intruded in much of this area and depleted fish like hassar that were once plentiful.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	There are numerous species of birds, fishes, and mammals including agouti, tapir, deer, acouri, and labba found in the areas close to the beach. Many birds are seen but not hunted. Numerous iguanas are found on the beach and some are eaten by the villagers. Many jaguars are prowling the area with one killing a leatherback turtle two weeks prior to the visit to the beach. Several species of sea turtle nest on the beach. Harpy Eagle and armadillos are sometimes sighted.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Low	Critical
Food: Wild Meat	Provisioning Services	Iguanas and some mammals are hunted and eaten regularly, along with crabs. Ducks, on the other hand, are difficult to catch, so only the duck eggs are typically consumed. There is no one catching birds or any animals for trade in the village.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
Social/Economic Settlements	Provisioning Services	An entire community resides along the beach. The PAC is also based within this community.	Coastland	Almond's Beach, PAC	High	Moderate	High

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APPENDIX C

Identified Ecosystem Services and Priority Ratings: Region 2 Coastal

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TABLE C-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 2 COASTAL

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 1 - Charity/ Urasara – Population estimate 7,800 people							
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Provisioning	• Crabbing is practiced by hundreds of persons in the NDC over the July, August, and September crabbing season. Approximately ten families in the NDC are engaged in crabbing as an everyday activity for their livelihoods. Some of these persons travel to the Pomeroon Mouth for crabbing. • Crabbing in the Pomeroon River at Providence.	Marine habitat and Mangrove Forests	a) Commercial and subsistence crabbing at mouth of river and along the coast b) Subsistence crabbing in Pomeroon River	a) Essential b) Moderate	a) Moderate b) Low	**a) Critical** **b) High**
	Provisioning	• 5-6 commercial fisherfolk in area and their supply chain (buyers, sellers etc.) of the Pomeroon River. • All fisherfolk come to mouth of river. A few times per week. Catfish catch is approximately 100 pounds over 3 days catch valued at USD 500. • Fishing site for pin seine and pole seine in Essequibo Coast, Pomeroon River, and Moruca. • Waste and pollution of river and coastal areas has been the biggest challenge for fisherfolk over the years.	Marine habitat and Mangrove Forests	a) Commercial fishing along the coast and in mangroves b) Commercial fisherfolk fishing in the mouth of the Pomeroon River c) Commercial and subsistence fishing	a) Essential b) Essential c) High	a) High b) Low c) High	**a) High** **b) Critical** **c) Medium**
	Provisioning	• The Big Bird Fish Complex at Charity is a major processing facility that processes large amounts of catch for export.	Marine habitat and Mangrove Forests	Commercial landing site and fish processing facility	Essential	Low	**Critical**
	Provisioning	• Most families in the area depend on fishing for sustenance.	Marine habitat and Mangrove Forests	a) Subsistence fishing along the coast and in mangroves b) Subsistence fishing along the river banks	a) High b) Moderate	a) High b) Moderate	**a) Medium** **b) Medium**
Cultivated Crops	Provisioning	• Crop cultivation is present in many communities along the coast, and ranges in scale from subsistence farming of staple grains, to export-oriented growing of coconuts and watermelons. • Staple grains, including rice, are also farmed for both commercial and subsistence use. • There are close to 50 families who farm along the Pomeroon River.	Cultivated lands	Local communities (general population)	Essential	High	**High**
Livestock Farming	Provisioning	• Grazing on the sea dam and the sea defenses throughout the NDC.	Pasturelands	Local communities	Moderate	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: wild meat	Provisioning	• Within certain mangrove areas, there are a few men who hunt birds and iguana to sell on the open market near Charity. This activity is on the decline in the NDC.	Mangrove Forests	Local communities (general population) near Charity **ES Linkages:** Fishing	Low	Moderate	**Low**
Tourism and Recreation	Cultural	• Biodiversity: Important Bird Area for Scarlet Ibis	Mangrove Forests	Local communities (general population) of Region 2 and visitors to the Pomeroon River **ES Linkages:** Mangroves, fishing, tourism	Moderate	Moderate	**Medium**
Habitat provision, coastal protection	Supporting	• Extensive mangrove forests have provided habitats for birds, crabs, and other wildlife. The mangroves also protected the shoreline of the NDC. • However, there has been significant erosion of the sea dam, mudflats and mangroves along the shoreline of the NDC with the result that habitats for wildlife, birds, and crabs are reduced. This is especially prevalent at along the coast of the NDC and in the Pomeroon River.	Marine habitat and Mangrove Forests	Local communities **ES Linkages:** Fishing, crabbing mangroves	Essential	Low	**Critical**
NDC 2 - Evergreen/Paradise – Population estimate 7,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Crabbing is common during the July to September crab season, and crabbers from other parts of Region 2 utilize the area. • More than ten persons from the NDC catch crabs in the Summerset & Berks mangroves on a weekly basis for sale.	Mangroves	Commercial and subsistence crabbing in mangroves	Low	High	**Low**
	Provisioning	• Approximately 10 boat owners from the local area with an average of 2-3 fisherfolk working each boat every 2-3 days; more than 30 people in the Andrews Koker area rely on fishing for livelihoods. • Two other primary dock areas in Paradise with less than 10 fishing boats per day. • Fishing landing area at Dartmouth and Westbury with three boats. • Fish landing site in Evergreen with five boats. • Fishing landing site in Perth with six boats	Marine environment; beach; Kokers	a) Commercial fishing at Andrews Koker, including crabbers b) Commercial and subsistence fishing in Paradise c) Commercial and subsistence fishing at Dartmouth and Westbury d) Commercial fishing at Evergreen e) Commercial fishing at Perth	a) High b) Moderate c) Moderate d) Moderate e) Moderate	a) Moderate b) Moderate c) Moderate d) High e) High	**a) High** **b) Medium** **c) Medium** **d) Low** **e) Low**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Cultivated Crops	Provisioning	• In Paradise, approximately 10 families utilize land along the coastal wall for crops and subsistence farming. There are very few other places/lands where they could cultivate crops.	Cultivated lands	Local communities (general population)	High	Low	**Critical**
Livestock farming	Provisioning	• Along the sea defense walls, approximately seven households utilize the land for grazing, primarily cows, for livelihoods in St. Andrews and Perth to Dartmouth. • Cows, sheep, and goats are grated in the Evergreen to La Resource area	Pasturelands	a) Local communities (general population) in St. Andrews and Perth to Dartmouth b) Local communities in Evergreen to La Resource	a) Low b) High	a) High b) Moderate	**a) Low** **b) High**
Tourism and recreation	Cultural	• Locals utilize Paradise Beach and Andrews area (approximately 10-15 people a day at each location) for recreation, kite flying, etc. • Approximately 50 users per day are at the seawall along the southern portion of the NDC. • Unity Park is also used for recreation although few people utilize this over the seawalls. • Recreation at the Dartmouth Seawall especially on Sundays when dominoes are played.	Coastal and Marine	a) Local communities in northern portion of coastal NDC; Unity Park users b) Local communities in southern portion of NDC **ES Linkages:** Sea Defense	a) Low b) Moderate	a) Moderate b) Moderate	**a) Low** **b) Medium**
Cultural, spiritual or religious value	Cultural	• The seashore areas at Paradise, Jib, Andrews, and Bounty Hall are used for religious activities. • Residents of Westbury and Perth use the seashore in Dartmouth. • Burial ground at Jib.	Coastal	a) Local Hindu communities along coastal areas from Bounty Hall to Dartmouth b) Local communities for burial at Jib c) Local Hindu communities at Paradise	a) High b) Low c) High	a) High b) Low c) High	**a) Medium** **b) Low** **c) Medium**
Food: wild meat	Provisioning	• Residents of the NDC hunt iguanas in the La Resource area for sustenance or but sometimes for sale. The iguanas are sold in the NDC or at popular restaurants in the region. Shore birds are also caught for both sustenance and sale. Some persons hunt large lizards (salipenters) for meat. • Anacondas are also caught for sale to traders.	Mangroves	Local communities	Low	Moderate	**Low**
NDC 3 - Aberdeen/Zorg-en-Vlygt – Population estimate 6,000 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are approximately 15 boats and 40 families engaged in fishing in the NDC. These boats use landing sites at La Union, Three Friends and Capoey Koker depending on the accessibility of these sites. • An average of 2-3 fisherfolk work on each boat every 2-3 days.	a) Marine environment; beach; Kokers b) Coastal areas	a) Commercial fishing at Capoey Koker, including crabbers b) Fishing landing site in La Union c) Fishing landing site in Three Friends	a) High b) Low c) Low	a) Moderate b) Moderate c) Moderate	**a) High** **b) Low** **c) Low**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
	Provisioning	• Crabs are caught daily throughout the NDC for subsistence and commercial use. They are sold to persons both within and outside the NDC.	Mangroves	Crabbing for subsistence and commercial use	High	High	**Medium**
Livestock farming	Provisioning	• Along the sea defense walls, approximately 15-20 households utilize the land for grazing, primarily goats and cows, for livelihoods; • There is a cattle rearing camp at the seashore at Hoff-Van-Aurich and La Union.	Pasturelands	a) Local communities (general population) from Aberdeen to Affiance b) Local communities in/around Hoff-Van-Aurich and La Union	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Shoreline protection / Mangroves / River defense	Regulating	• Mangroves have been growing in the NDC naturally with the buildup of mud and silt over the last 1.5 years. Mangroves are also growing near Bacchus Park. The new growth has resulted in iguanas, crabs, and new species of birds in the area. However, mangroves are also being degraded in some areas.	Ocean, mud flat	a) Coastal Communities (general population) of the NDC b) Coastal communities near Bacchus Park	a) High b) Moderate	a) Moderate b) Low	**a) High** **b) High**
Shoreline protection / Mangroves / River defense	Regulating	• Government has installed bamboo groynes at Columbia, Aberdeen, and Affiance which are helping to protect the shoreline and reduce erosion along the coast of these areas.	Ocean, mud flat	Coastal communities	High	Moderate	**High**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the coastal areas but typically mudflats prevent significant usage in the area • Cremation site at La Union is the only sanctioned site in the Region	Coastal areas; ocean	a) Local Hindu population b) Hindu population throughout Region 2 use the Cremation Site	a) Low b) Critical	a) High b) Critical	**a) Low** **b) Critical**
Recreation	Cultural	• Bacchus Park and the seawall both provide recreation on a daily basis for over 100 people; more active on weekends and holidays. • Many persons use the sea walls in Queenstown for recreation purposes.	Seawall	a) Local communities utilizing the seawall at Bacchus Park b) Local communities using the seawalls in Queenstown	a) Moderate b) Moderate	a) Low b) Moderate	**a) High** **b) Medium**
Food (wild meat)	Provisioning	• Iguanas are hunted in the fish pond areas by a small group of men who sell the meat on the market • Approximately 60–70 persons hunt iguanas daily for sale at prices ranging from GYD$3,000–5,000. Currently, there is no hunting of wild birds.	Biodiversity Mangroves	a) Local community in Zorg-en-Vlygt b) Local communities through the NDC	a) Low b) High	a) Low b) Moderate	**a) Medium** **b) High**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 4 - Anna Regina Town Council – Population estimate 19,000 people							
Mangroves & Carbon Sequestration	Regulating	• The mangroves grow naturally on the newly deposited mudflats, regulating man natural factors; they contribute to pollination of crops and add to carbon sequestration; they also cause nuisance such as bird singing at night, mosquitoes and sand flies (for first time in 20 years); • NAREI program in Reliance started a few years ago has been welcome and in some areas (near Lima Port) the importance to stakeholders is expected to grow over time.	Mangroves	a) Local community b) Local communities near new plantings **ES Linkages:** Fishing, Crabbing, biodiversity	a) High b) Low	a) High a) High	**a) Medium** **b) Low**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are several fishing landing sites in the municipality, including Anna Regina (15 boats); Windsor Castle (3 owners); Lima (6 owners); Walton Hall (10–12 boats); Lima (10–12 boats); Hampton Court (20 boats); Sparta (15 boats). • There is subsistence fishing at other locations, but on a small scale.	Marine environment; beach; mooring locations	Commercial fishing at coastal areas	High	Moderate	**High**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the coastal areas where they can get access	Coastal areas; ocean	Hindu population mainly	Low	High	**Low**
Tourism and recreation	Cultural	• Approximately 10 to 20 users per day are at the seawall for recreation • More than 50 persons visit the Henrietta Hotel on a daily basis for recreation. Softball cricket matches are also played on the beach behind the hotel.	Coastal	Local communities **ES Linkages:** Sea Defense	High	Moderate	**High**
Agriculture Cultivated Crops	Provisioning	• Farmers utilize land along the river defense wall for subsistence farming at Lima, Walton Hall, Anna Regina, and Devonshire Castle. Crops include coconuts, bananas, plantains, and cash crops are planted. • Areas near Lima Port are popular for rice paddies.	Cultivated lands	a) Local communities (general population) b) Local community near Lima Port	a) High b) Low	a) Low b) High	**a) Critical** **b) Low**
Livestock Farming	Provisioning	• Areas near Lima Port are popular for grazing.		Local community near Lima Port	Low	High	**Low**
NDC 5 - Annandale/Riverstown – Population estimate 9,400 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are fishing landing sites at: Golden Fleece (2 boats), Zorg (5 boats), Adventure (2 boats), Riverstown (1 boat), and Abrams Zuil with 20 boats including 2 new anchor seine boats.	Marine environment; beach; mooring locations	a) Commercial fishing at Adventure b) Commercial fishing at Golden Fleece c) Commercial fishing at Zorg d) Commercial fishing at Riverstown e) Commercial fishing and anchor seine fishing at Abraham Zuil	a) Low b) Low c) Moderate d) Low e) Essential	a) High b) High c) High d) High e) Moderate	**a) Low** **b) Low** **c) Low** **d) Low** **e) Critical**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Livestock farming	Provisioning	• Along the sea defense walls at Golden Fleece, some households utilize the land for grazing, cows goats and sheep	Pasturelands	Local communities (general population)	High	Moderate	**Medium**
Cultural, religious, or spiritual value	Cultural	• Hindus conduct religious activities along beach primarily at Golden Fleece where there is also a temple nearby; • Cullen Beach also very popular	Coastal areas; ocean	a) Hindu population throughout the NDC b) Hindu population at Cullen Beach	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Tourism and Recreation	Cultural	• More than 50 persons used seawalls for recreation purposes at Perseverance, Golden Fleece, Cullen Beach, and Suddie where there are cricket matches, football matches, and bar-be-ques on weekends.	Coastal areas	General population	High	Moderate	**High**
Aquatic transportation/ports	Provisioning	• Main port is essential for access to other areas, including the islands; the ferry used to dock here but it is now used for businesses and trade. • Big Pier, located in Abrams Zuil, is another commercial port where fuel, goods, cattle, etc., are transported.	Commercial areas at Port	a) Residents, local businessmen and islanders, farmers, fisherfolk, tourists who utilize the main port b) Residents, local businessmen, farmers, fisherfolk who utilize the Big Pier area	a) Essential b) High	a) Moderate b) Low	**a) Critical** **b) Critical**
NDC 6 - Good Hope/Pomona – Population estimate 1,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are fishing landing sites at: Pomona with 10–12 boats, Riverside Creek with 10–12 boats, Riverstown with 6 boats, and Vilvoordeen with 15 boats. Fishing boats also occasionally land at the Supenaam port. • Families who live close to the seashore often engage in near shore fishing and have their own small boats to conduct fishing activities. There are two boats at Good Hope which are used for this type of fishing. • Fishing is popular along the coasts at Tiger Island and in the Essequibo River using hooks, seines, and gillnets for catching high water; catfish; shrimp. Riverside fishing is also popular due to wharves.	Marine environment; wharf; mooring locations	a) Commercial fishing at Riverside b) Commercial fishing at Vilvoordeen c) Commercial fishing at Pomona and Riverstown d) Fishing at Tiger Island and Essequibo River	a) Moderate b) High c) Essential d) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Medium** **b) High** **c) High** **d) Medium**
		• Crabbing is popular during the July to September crabbing season.	Marine habitats and Mangrove Forests	Crabbing along the coasts of the NDC	Low	High	**Low**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Aquatic transportation/ports	Provisioning	• There are several wharfs in the NDC: three wharfs in Fairfield, one wharf in Good Hope, one wharf in Spring Garden, one wharf in Vilvoordeen and one wharf in Riverstown. These are essential to commercial business and livelihoods; cargo unloading area for fertilizer; gas plant equipment; quarry material; rice; cattle • Supenaam port is a major area for passenger transport and shipment with over 100 boats	Commercial areas on wharf	Residents, local businessmen and islanders, farmers, fisherfolk, tourists at: a) Fairfield b) Vilvoordeen c) Supenaam	a) Essential b) Essential c) Essential	a) Moderate b) Moderate c) Low	**a) Critical** **b) Critical** **c) Critical**
Social/Economic Commercial activity	Provisioning	• Sawmills utilize river defense area to transport logs to the mill	Commercial areas	Residents, local businessmen	Moderate	Moderate	**Medium**
Erosion Regulation	Regulating	• Tiger Island is a critical sea defense from the NDC to erosion and flooding since there is no manmade or natural mangroves protecting the coast	Coastal vegetation	Local businesses at Sawmill and Aurora	Essential	Low	**Critical**
Historical landmark	Cultural	• Dutch Chimney is an important landmark in Supenaam	Tourism	Tourists, Residents	Low	Low	**Medium**
Livestock farming	Provisioning	• There is grazing of animals along the seashore from Riverstown Creek throughout the NDC in vacant areas.	Pasturelands	Local communities (general population)	Moderate	High	**Low**
Cultivated Crops	Provisioning	• Large scale cash crop farming on Tiger Island.	Cultivated lands	Local communities	Essential	Low	**Critical**
Food (wild meat)	Provisioning	• Iguanas are hunted on Tiger Island as well as on the southern coast of the NDC within and outside the NDC area.	Biodiversity	Local community	Low	Low	**Medium**
Tourism and Recreation	Cultural	• Beaches are used for recreation purposes at Vilvoordeen, Aurora, Spring Garden, Good Hope, and Tiger Island.	Beaches	a) Local communities on Essequibo Coast b) Visitors to Tiger Island	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Cultural, Religious of Spiritual Value	Cultural	• There are religious activities on the seashore through the NDC. • The Spring Garden temple is located close to the shoreline.	Beaches, shoreline	Local communities who utilize the seashore and temple	Moderate	Moderate	**Medium**

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APPENDIX D

Identified Ecosystem Services and Priority Ratings: Region 3 Coastal

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TABLE D-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 3 COASTAL

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 07 – Wakenaam - Population 3,200 – on the decrease due to migration							
Food - aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fishing is done on both sides of the Island. Some boats are owned by persons from the Island while others come from the West Coast of Demerara. The fishing area is also shared with residents of Leguan. Approximately 20-30 boats and 40-60 commercial fisherfolk operate on the island fishing a few days per week. Many families on the island depend on fishing for sustenance and livelihoods. • Shrimp is dried on the sea defense by fisherfolk in the shrimp season occurring during the months of April to September. Shrimp mainly caught between Leguan and Wakenaam • Crabs are caught during the July to September period by many residents and by approximately 5 persons all year round in the mangroves abundant on the island.	Marine habitat, river habitat, mangrove forests and sea defense	a) Commercial fishing at mouth of Essequibo River b) Commercial and subsistence fishing along the coast and in mangroves c) Commercial fishing in the Essequibo River d) Crabbing in mangroves e) Drying of shrimp on sea defenses	a) Essential b) High c) High d) Moderate e) Moderate	a) Moderate b) Moderate c) Low d) High e) High	**a) Critical** **b) High** **c) Critical** **d) Low** **e) Low**
Agriculture - Cultivated Crops	Provisioning	• There is some planting on the sea defense reserves mainly by persons who have done their own empoldering and consider the lands their responsibility to maintain and farm. Islanders also farm on the other islands in the Essequibo River including Tiger Island, Hogg Island, Truli Island, and Karia. • The dominant crop on Wakenaam is plantains. • Rice is also farmed for both commercial and subsistence use. • There are more than 100 families who farm along the river dam bordering their land.	Cultivated lands	Local communities (general population)	Essential	Moderate	**Critical**
Livestock Grazing	Provisioning	• Along the river defense, households utilize the land for grazing of cows, goats, and sheep for livelihood. Animals are tied in the farming areas or graze freely in Palmyra, Zeelandia, or New Friendship.	River defense and mangroves	Local communities (general population)	Medium	Medium	**Medium**
Transportation - Ports, Wharf, Ferry Stelling	Provisioning	• Ports, wharfs, and shipyards, inclusive of boat building, on the river dam. Over 22 ships seen in dock at the wharfs. Farmers have their own boats to carry supplies and produce. • Wharf essential for access to the island. • Sawmill utilize river defense area to transport logs to the mill.	Commercial areas on river dam	Residents, local businessmen and islanders, farmers, fisherfolk, tourists	Essential	Medium	**Critical**
Religious/Ritual	Cultural	• Areas with good access to the river used by the Hindu population for daily and seasonal worship. There are many locations for use with a few more established sites, including a temple.	River, river defense	Hindu population	Moderate	Low	**High**
Food: wild meat and Materials	Provisioning	• Within certain mangrove areas, there are a few men who hunt birds and iguanas, “labba” and crabs to sell on the island or over at Parika. • In the July to September period while it is dry, iguanas are out and are caught for fun or meat. • Bamboo growing along the river defense is harvested for a variety of uses such as religious, construction material for sheds, fishing poles and in farming.	Mangroves coconuts and bamboo	Local communities (general population) near Charity	Low	High	**Low**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Freshwater – Household use	Provisioning	• Households use the freshwater for many household purposes including animal husbandry and gardening.	Freshwater	Local communities on the island	High	Moderate	**High**
Freshwater – Crop irrigation and other agricultural uses	Provisioning	• The entire island depends on freshwater from the Essequibo River for its irrigation of rice paddies and other crops during the dry season. • Animals also drink the water that flows in the irrigation channels. • Freshwater intake contributes to inland fishery whereby tilapia and hassar are caught in the wild for sale and subsistence use.	Freshwater	Island farming community	Essential	Moderate	**Critical**
Recreational	Cultural	• Beaches to the north of the island are utilized for recreational purpose by residents and visitors	Beaches and mangroves	a) Beach at Maria's Pleasure b) Beach at Wakenaam Point	a) Medium b) Moderate	a) Medium b) High	**a) Medium** **b) Low**
Mangroves & Carbon Sequestration	Regulating	• The mangroves grow naturally on the island, regulating many natural factors, contributing to pollination of crops and adding to carbon sequestration.	Mangroves	Local community **ES Linkages**: Fishing, Crabbing, Biodiversity	Moderate	High	**Low**
Aquatic transportation/ports	Provisioning	• Commercial wharf at San Sousi for transport of fuels, rice, and other products that are shipped or imported to the island. Ferry also lands at San Sousi. • Speedboat landing site at Maria's Pleasure. Speed boats to Parika and Leguan operate from this location. Six boats operate this route charging 1000 for a trip per passenger.	Sea shore, shoreline	a) Wharf at San Sousi b) Speedboat landing at Maria's Pleasure	a) Essential b) High	a)Low b) Moderate	**a)Critical** **b) High**
NDC 08 – Leguan - Population 2,500 – decreasing due to migration to Region 3 and North America.							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Approximately 25 fishing boats catch fish and shrimp using areas such as Waterloo, Success, Canefield, and other areas where they can dock their boats. • Shrimp mainly caught between Leguan and Wakenaam. • Crab fishing is common during the summer crab season with 2-3 people making a daily catch for sale.	Marine environment; beaches; kokers and mangroves	a) Commercial fishing at Waterloo, Success and Canefield b) Commercial and subsistence fishing in Essequibo River c) Commercial and subsistence crabbing in mangroves	a) High b) High c) Low	a) Moderate b) Moderate c) High	**a) High** **b) High** **c) Low**
Transportation and Commercial Services	Provisioning	• Approximately 20 boats offer transportation services to Parika and other areas. Most islanders have their own boat. The ferry at Enterprise offers three services daily to Parika. • Commercial wharfs and loading sites are used for shipping fuel and produce. • A new wharf was constructed at Belfield which facilitates shipping of construction materials.	River & river defense dam	a) Transportation Services b) Commercial wharfs on the island	a) Essential b) High	a) Moderate b) Low	**a) Critical** **b) Critical**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the river and on the river defense. Areas with good access to the river are preferred. There are many locations for use, with a few more established sites. • Cremation at Uniform is conducted on one of the beaches on the island.	River & river dam	a) Hindu population using the cremation site at Uniform b) Hindu religious activities along the river and river defense at Blenheim	a) Essential b) Essential	a) Moderate b) Moderate	**a) Critical** **b) Critical**
Cultivated Crops	Provisioning	• Farmers utilize land along the river defense wall for crops and subsistence farming. Coconuts, bananas, plantains, and cash crops are planted.	Cultivated lands	Local communities (general population) cultivating crops at: a) Richmond Hill b) Success	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Irrigation Water	Provisioning	• The entire island depends on freshwater from the Essequibo River for its irrigation of rice paddies and other crops during the dry season. • Animals also drink the water that flows in the irrigation channels.	Essequibo River	Crops and livestock farmers	Essential	High	**High**
Livestock Grazing	Provisioning	• Households utilize the land Better Hope to La Resource for grazing of cows, goats, and sheep for livelihood • Grazing has been constrained by the river defense works at Maryville, Success, and Thieres.	River defense and Mangroves	Local communities (general population)	Medium	Medium	**Medium**
Tourism and Recreation	Cultural	• Locals utilize Canefield Beach, Success Beach (approximately 10-15 people a day at each location) for recreation, swimming, etc. • Organized tours are done to Leguan to tour its historic sites including St. Peters Church	River, Coastal and Marine	Local communities in northern portion of NDC and tourists: a) Beach at Uniform b) Heritage Site at St. Peter's Church c) Beach at Canefield	a) Moderate b) Essential c) Moderate	a) Moderate b) Low c) Moderate	**a) Medium** **b) Critical** **c) Medium**
Habitat provision, coastal protection	Supporting	• The island has a large area covered by mangroves with rich biodiversity of birds and crabs.	Coastal Mangroves	Local communities	Low	High	**Low**
Food (wild meat)	Provisioning	• Iguanas, capybara, labba, and wild hogs are hunted in the cultivated areas. Wild ducks will visit this area in the planting season to feed on the rice paddies.	Biodiversity	Local residents, Region 3, wild meat tourism	Low	Moderate	**Low**
Cultural Practices	Cultural	• Hunting, harvesting and fishing continue to be practiced in some traditional fashion including the local craft made to hunt or fish.	Cultural Heritage	Local communities **ES Linkages:** Possibility for sport tourism	Low	Moderate	**Low**
Erosion Regulation	Regulating	• The island is at risk to erosion and much of the shore is not protected by manmade concrete defense. The mangroves and other vegetation help to defend the island against erosion.	Coastal vegetation	Local communities **ES Linkages:** Biodiversity, Fishing, hunting, socioeconomic	Essential	Low	**Critical**
NDC 09 - Mora/Parika - Population 10,000, growing due to migration to the NDC							
Transportation and Commercial Services	Provisioning	• Parika stelling has transportation services by ferry to Supenaam, Leguan, Bartica, and Wakenaam. Hundreds of people travel daily. • Over 100 passenger boats leave for various destinations daily to other parts of the country. • Ten private wharves facilitate transportation services daily. • There are seven boat houses in the NDC with two parking lots for vehicles. • Ship terminal serving as a hub for timber, stone, fuel and river transportation at the Parika koker. • This NDC is significantly reliant on marine transport services and related economic activities.	River	a) Parika Stelling users by ferry and boats from Regions 2, 3 and Essequibo Islands b) Local users of private wharfs c) Private docking and landing sites for passenger travel d) Parika Koker **ES Linkages:** Tourism, recreation and socioeconomic	a) Essential b) Essential c) Essential d) Essential	a) Low b) Moderate c) Moderate d) Low	**a) Critical** **b) Critical** **c) Critical** **d) Critical**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fisheries wharf, where more than 20 boats load, refuel, and discharge catch. • Outfall area, where more than 10 boats operate • Big Kiss wharf, where more than 10 deep water vessels operate	River	Fisherfolk using landing sites at: a) Parika Stelling b) Parika Outfall c) Big Kiss Wharf	a) Essential b) Essential c) High	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) Critical** **c) High**
Religious/ Ritual	Cultural	• Big Kiss has a temple on the river dam for worship activities for the general public.	River dam	a) Local Hindu Community using Big Kiss	a) Essential b) Moderate	a) High b) Moderate	**a) High** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Religious activities along the river defense. • The religious activities are about the same with the Hanuman Murti being a new feature at the riverside of the NDC		b) Local Hindu community using other sites			
Cultivated Crops	Provisioning	• Crops cultivated along the sea dam including, bananas, coconuts and fruits	River dam, mangroves and bamboos	Local Community	Low	High	**Low**
Livestock Farming	Provisioning	• Grazing of goats and cows in the Namryk – Hyde Park area of > 100 animals	River dam, mangroves and bamboos	Local communities	Medium	Medium	**Medium**
Social/Economics	Provisioning	• 10 saw mills in the NDC with access to the river dam where logs are discharged and processed • Boat building, boat docking and landing area	River dam	a) Local sawmillers and forest sector stakeholders using the river dam b) Local boat builders	a) Essential b) Essential	a) Moderate b) High	**a) Critical** **b) High**
Biodiversity Reserve	Supporting	• Locals protect two small islands that are roosting areas for hundreds of birds including scarlet ibis and wild ducks in the Essequibo River. The birds are not hunted due to the actions of the community.	Biodiversity, Culture	Biodiversity, local community **ES Linkages:** Tourism	Essential	Moderate	**Critical**
Freshwater – Household use	Provisioning	• Hundreds of residents squat in more than 200 buildings on the shore and along the sea defense reserves. They use the fresh water from the river for household purposes.	Freshwater	Local communities	Essential	High	**High**
Social/Housing	Provisioning	• Approximately 50 houses are squeezed into the sea defense and shore area.	Shoreline, beach, river defense reserves	Local communities **ES Linkages:** Freshwater, fishing	High	Moderate	**High**
Tourism and Recreation	Cultural	• Recreation for residents of the NDC and the region. Private developer charges a user fee for entrance to the area.	Shoreline	Local communities	Moderate	Moderate	**Medium**
NDC 10 - Hydronie/Good Hope - Population 4,000 and increasing.							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing at Ruby Koker with 10-15 boats daily with 2/3 mainly focusing on fish. • A few fishing boats also operate from the Orangestein Shore • Fishing along the shore line by nets, seine, lines	River, Ocean	a) Local communities and fisherfolk at Ruby Koker b) Fisherfolk along Orangestein Shore and other fisherfolk fishing along the shoreline	a) Essential b) Moderate	a) High b) Moderate	**a) High** **b) Medium**
Recreation	Cultural	• The Bushy Park Beach is a popular tourist attraction for locals and people from other parts of the country, with approximately 50 people visiting daily and hundreds on weekends and special occasions. • Orangestein Beach where people living in close proximity frequent.	River, Beach	Local communities, Regions 3 and 4 at Bushy Park and Orangestein beach	Essential	Low	**Critical**
Agriculture: Grazing and Crops	Provisioning	• Cattle and goats graze in the Ledestein–Good Hope area. • People in Orangestein graze cows on the sea dam.	Sea Dam, Vegetation	a) Local communities at Ledesteine-Good Hope b) Local communities at Orangestein	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Religious	Cultural	• Religious activities at Ruby Koker and Bushy Park. Mosque at Ruby Koker. • People living along the river dam use the beach for Hindu religious activities • Burial Ground at Farm	Sea dam, beach	a) Local communities at Ruby Koker and Bushy Park and Hindu communities using the sea dam b) Burial Ground	a) Essential b) High	a) High b) Low	**a) High** **b) Critical**
Social/Economic Commercial activity	Provisioning	• Industrial activity at Bushy Park by KARES Engineering	Sea Dam, beach	Commercial activity for Region 3 and 4 and local businesses at:	a) High b) Essential	a) High b) Low	**a) High** **b) Critical**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Two new wharves were established at Orangestein. Wharf supporting sea going vessels at Bushy Park, including ship repairs • Boat building and repairs on the seadam		a) Kares Engineering b) Wharf users c) Boat builders	c) Moderate	c) High	**c) Low**
Food (Wild Meat)	Provisioning	• A few people catch iguanas on a regular basis for sale in the area.	Sea dam vegetation	Local communities	Low	Moderate	**Low**
Biomass for Livestock	Provisioning	• Animals grazing on the sea dam, mangrove blossoms, bamboo shoots, grass, etc.	Sea dam vegetation	Local residents in proximity to vegetation	Moderate	Moderate	**Medium**
NDC 11 – Greenwich Park/Vergenoegen – Population – 2,500 people							
Food: Fishing, shrimp, crabs	Provisioning	• Vergenoegen Outfall and Philadelphia Koker, with more than 20 boats • Greenwich Park, with seven boats • Shrimp drying along concreted sea defense • 10–15 persons in the NDC dry fish for sale on a large scale of whom four have permission from the NDC • Some fisherfolk use the fishing grounds at Barnwell	Seashore, river, ocean, mangroves River defense	Local communities, Region 3 using: a) Vergenoegen Outfall and Philadelphia Koker b) Greenwich Park c) Shrimp and fish drying on the seawall d) Fishing grounds in Barnwell	a) Essential b) High c) High d) Low	a) Low b) Moderate c) High d) Moderate	**a) Critical** **b) High** **c) Medium** **d) Low**
Recreation	Provisioning	• Vergenoegen Seawall, which 10-20 people use daily to exercise, relax or socialize • Philadelphia Seawall, which 10-20 people use daily for recreation • Low tide beach at Philadelphia utilized for games such as cricket.	River defense	Local Communities using Vergenoegen and Philadelphia Seawalls	a) High	a) Moderate	**a) High**
Religious	Cultural	• Barnwell with access to the river. • Philadelphia with access and temple next to the river. • Religious activities also conducted at Greenwich Park	River bank	Mainly local Hindu community using Barnwell access, and Philadelphia access and temple	High	Moderate	**High**
Cultivated Crops	Provisioning	• Cash crops and fruits planted along the river defense reserves. Some gardens are fenced off.	River defense reserves	Local communities	Essential	High	**High**
Squatting	Provisioning	• Informal housing at Barnwell with over a dozen houses with 30-50 people in total.	Sea defense	Local communities	High	High	**High**
Biomass for livestock	Provisioning	• Grazing occurs on the natural vegetation by a reported >200 animals in the NDC. At Greenwich Park and Barnwell the dam is completely blocked off by the residents.	Natural vegetation	Local residents in proximity to grazing	Moderate	Moderate	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the river and its bank, are highly valued by local communities and visitors.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
NDC 12 – Tuschen/Uitvlugt - Population in excess of 30,000 due to the growing Tuschen Housing Scheme							
Food: Fishing, shrimp, crabs	Provisioning	• Zeeburg Seawall, with 30-50 fish/shrimp boats • Boeraserie Koker, with 20 boats • Uitvlugt Seawall, with 15-20 boats • Zeelugt Seawall, 25 boats • In addition, large scale shrimp processing occurs at Zeeburg with large scale fish processing occurring in Zeelugt, all on the sea walls or sea defense reserves.	Seashore, river & ocean	Fisherfolk, Region 3 using: a) Zeeburg seawall b) Boeraserie Koker c) Uitvlugt Seawall d) Zeelugt Seawall	a) Essential b) Essential c) Essential d) Essential	a) Moderate b) Moderate c) High d) Moderate	**a) Critical** **b) Critical** **c) High** **d) Critical**
Tourism and Recreation	Cultural	• Cinderella Park at Zeelugt is used by 10-20 people daily and >100 on weekends • Ocean View, Uitvlugt has approximately 20 people daily	Seawall, sea defense reserves	Local communities, Region 3 using: a) Cinderella Park b) Ocean View	a) High b) Moderate c) Low	a) Moderate b) Moderate c) High	**a) High** **b) Medium** **c) Low**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Kastev has about 10 people visiting daily		c) Kastev			
Religious/Ritual	Cultural	• Temple on the sea defense reserves at Uitvlugt. In addition, religious activities are held at the sea throughout the NDC	Seawall reserves, shore, beach	Local Communities, Region 3, 4 using the Uitvlugt Temple and coastal areas	Essential	High	**High**
Crop Cultivation	Provisioning	• Crops and fruits planted in Zeelugt and in Uitvlugt	Seawall reserves	Local Communities planting	Moderate	High	**Low**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC. The open areas are limited due to cash crop farming on the sea defense reserves in Zeelugt, Meten-meer-zorg, and De Willem. It is also affected by the shrimp and fish processers.	Seashore	Local communities grazing animals	High	Moderate	**High**
Social/Economic	Provisioning	• Fish Processing at Zeelugt and Uitvlugt • Shrimp Processing at Zeeburg and Uitvlugt, with 1kg selling for GYD$1,600	Seawall & reserves	a) Fish processors b) Shrimp processors	a) Moderate b) Essential	a) High b) Moderate	**a) Low** **b) Critical**
Coastal Protection	Supporting	• The concrete sea defense is supported by natural vegetation including mangroves, coconuts, fruits, and some cash crop plots.	Sea defense & reserves	Coastal region	High	Low	**Critical**
Social/ Housing	Provisioning	• Informal housing of about on the sea dam and beyond on the sea defense reserves. The persons use the sea water and also dump their refuse in the sea.	Sea defense & reserves	Coastal region	High	High	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore, are highly valued by local communities and visitors.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
NDC 13 - Stewartville/Cornelia Ida – Population – 30,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing boat landing area at Leonora used by 15 boats that catch fish and shrimp. • Fishing area at Anna Catherina used by 8 boats. • Landing site at Corneila Ida with 3 boats.	Seashore and ocean	Fisherfolk using landing sites at: a) Leonara b) Anna Catherina c) Cornelia Ida	a) Essential b) High c) Moderate	a) Low b) Moderate c) High	**a) Critical** **b) High** **c) Low**
Recreation	Cultural	• Stewartville seawalls are used by almost 20 people daily. • Leonora seawall is used by 10-20 people daily. • Anna Catherina seawall is used by more than 20 people daily, with >100 on weekends.	Seawall, beach	Local communities using seawalls: a) Stewartville and Leonora; b) Anna Catherina c) Groenveldt	a) Moderate b) High c) Moderate	a) High b) Moderate c) Moderate	**a) Low** **b) High** **c) Medium**
Religious	Cultural	• Stewartville seawalls are used by < 10 people daily. • Leonora seawall is used by < 10 people daily. • Anna Catherina seawall is used by more than 10 people daily. • Cornelia Ida Seawall and reserves are used by >20 people daily. A temple is located at this site.	Seawall, beach, reserves	Local Communities, Region 3 using seawalls for religious practices at: a) Stewartville, Leonora, Anna Catherina; b) Cornelia Ida	a) Moderate b) High	a) High b) Moderate	**a) Low** **b) High**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC with cows, goats, and sheep numbering 200-300. • Some people keep ducks and pigs on the sea defense reserves using the fish for food.	Sea defense reserves	Local communities: a) Stewartville b) Anna Catherina b) Leonora	a) Moderate b) Moderate c) High	a) High b) Moderate c) High	**a) Low** **b) Medium** **c) Medium**
Crop Cultivation	Provisioning	• A few people plant on the sea defense reserves at Leonora. Squatters plant fruits and crops at Anna Catherina.	Sea defense reserves	Local communities	Low	High	**Low**
Social/Housing	Provisioning	• Squatting at Anna Catherina sea defense reserves by 15-20 families.	Sea defense and reserves	Local Communities	High	High	**High**
Social/Economic (Shrimp Processing)	Provisioning	• Large scale fish and shrimp processing occurs at Leonora with large scale shrimp processing occurring in Anna	Sea wall	Local communities	Essential	Moderate	**Critical**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		Catherina, all on the sea walls or sea defense reserves. Some persons have built their own drying floors and storage facility on the sea defense reserves.					
Coastal Protection	Supporting	• The concrete seawall/defense is supported by natural vegetation including mangroves, coconuts, fruits, and some cash crop plots.	Sea defense and reserves	Coastal region	High	Low	**Critical**
Biodiversity	Regulating	• A small area on the shore with mangroves is occupied by birds for roosting. Fishes and crabs are found in the water below where people fish.	Sea defense and reserves	Local communities **ES Linkages:** Tourism	Low	Moderate	**Low**
NDC 14 - Hague/Blankenburg - Population - 4,200 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing boat landing area at Hague seawall used by 10-12 boats. There is a reduction in the number of boats due to the ban on catfish in the USA and also fears of piracy. • About 10-20 persons use hooks, lines, seines, cast nets, or use fishing rods to catch fish and shrimp on a daily basis at Den Amstel and Blankenburg.	Seawall, seashore	a) Local communities, Region 3 b) Landing site at Hague and fishing by hooks, lines, seines and caste nets at Den Amstel and Blankenburg	a) High b) Moderate	a)Low b) Moderate	**a) Critical** **b) Medium**
Recreation	Cultural	• Den Amstel seawall with > 20 people using the area on a daily basis to swim, relax, exercise, and socialize and about 200 persons on weekends. • Hague seawall is used by <10 people daily. • A small beach which is utilized for sports such as cricke.t	Seawall, beach, shore	Local communities using the seawall at: a) Den Amstel b) Blankenburg **ES Linkages:** Tourism	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Religious	Cultural	• Religious activities at Hague seashore. • Religious activities at Blankenburg sea dam. • Cemetery at Blankenburg with historical significance.	Beach, sea shore	Local communities	a) Moderate b) Essential Moderate	b)High b) Moderate c) Moderate	**a) Low** **b) Critical** **c) Medium**
Agriculture/Grazing	Provisioning	• Grazing at Hague of cows, horses, and goats. • Grazing of > 100 goats at Blankenburg. • Grazing of cows and goats at Den Amstel.	Sea dam, reserves, mangroves	Local communities: a) Grazing at Hague and Den Amstel; b) Grazing at Blankenburg	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
NDC 15 - La Jalousie/Nouvelle Flanders - Population - 4,480 people							
Food: Fishing, shrimp, crabs	Provisioning	• Twenty boats use the Windsor Forest Koker to dock and some fisherfolk sell their fish in that area. • There are three fish mongers selling the prized catfish (gillbacker) by the Windsor Forest koker on a daily basis.	Seashore, ocean and rivers	Local Communities	Essential	Moderate	**Critical**
Recreation	Cultural	• Windsor Forest seawall frequented by approximately 30 people daily and 100 on weekends. The previously existing beach is now completely eroded. • Recreation area and bar on the sea dam in La Jalousie has more than 20 visitors daily	Seawall, beach	Local Communities using: a) The Windsor Forest Seawall b) Recreation area and bar at La Jalousie sea dam	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Religious	Cultural	• Religious activity at La Jalousie with tent in place for worshipers. • Religious activities at Windsor Forest • Cremation site at Ruimzeigt utilized daily	Sea shore, sea dam, reserves	Local Communities, Region 3, 4 using religious sites at: a) La Jalouise b) Windsor Forest c) Ruimzeigt	a) High b) Low c) Essential	a) Moderate b) High c) Moderate	**a) High** **b) Low** **c) Critical**
Agriculture/Grazing	Provisioning	• Grazing occurs along the sea defense reserve from La Jalousie – Waller's Delight and Crane. However, it is not a significant activity.	Sea defense reserves	Local Communities in: a) La Jalousie to Waller's Delight b) Crane	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Tourism and Recreation/ Religious	Cultural	• New beach forming at Harlem	Sea shore	Local community	Low	Moderate	**Low**
NDC 16 - Best Klien/Pouderoyen – Population - 20,300 people							
Social/Economic: Transportation, Wharfs	Provisioning	• Transport Wharf, GPL Wharf, Sawmill • Speedboat stelling, with 75 speed boats registered to work at the crossing between Georgetown and Vreed en Hoop with fifty three (53) working on a daily basis.	River, river dam, reserves	Local Communities, Regions 3,4	Essential	Moderate	**Critical**
Food: Fishing, shrimp, crabs	Provisioning	• There are 11 fishing boats working in the NDC docking at Vreed en Hoop, Phoenix Park and the Jetty. • Mainly near shore fishing done in both the Demerara River and Atlantic Ocean. • Approximately five people catch crabs on a weekly basis for sale in the community. More persons join in the crab season.	Seashore, river and ocean	Fisherfolk operating from: a) Vreed-en-Hoop b) Phoenix Park c) Nearshore	a) Moderate b) High b) Low	a) High b) High b) Moderate	**a) Low** **b) Medium** **b) Low**
Mangroves	Provisioning	• Mangrove growth at Crane, Best Village, Vreed-en-Hoop, and Pouderoyen. Mangrove spread is increasing. • Lots of wildlife within mangroves including several species of birds, monkeys, raccoons, wild ducks, etc.	Mangroves	Local Communities: a) Plastic City b) Pouderoyen	a) Essential b) Low	a) Low b) Moderate	**a) Critical** **b) Low**
Grazing	Provisioning	• Grazing at Crane, Pouderoyen, and Best Villages by locals and squatters. Cows are tied and goats and sheep allowed to roam freely on the sea dam.	Sea dam, mangroves	Local Communities: a) Phoenix Park; Pouderoyen b) Best Village, Vreed-en-Hoop	a) Moderate b) High	a) Moderate b) High	**a) Medium** **b) Medium**
Social/Housing	Provisioning	• Squatting at Phoenix Park and Best Village. • Squatting in the mangroves at Plastic City.	Sea defense, mangroves	Squatters at: a) Phoenix Park b) Mangroves in Plastic City c) Best Village	a) Essential b) Essential c) High	a) High b) High c) High	**a) High** **b) High** **c) Medium**
Religious	Cultural	• Crane jetty and Cogland Dam Koker permits religious activities.	Sea, river, beach, reserve	Local Communities	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• A small number of people catch iguana for sale. • Shore birds such as “plawads” and “curry” are hunted. River turtles are caught but this is on a decline.	Mangroves forests	Local communities (general population)	Low	Moderate	**Low**
Aquatic transport	Provisioning	• Waterway is used by boat builders for access to launch boats built on the riverbank.	Drainage channel	Local communities	High	Moderate	**High**
Tourism	Cultural	• Bird watching is sometimes done in the mangrove area. • Historical sites along river bank including a monument and 1700’s Dutch koker serve as attractions	Coastal mangroves and shoreline	Local communities and tourists	Medium	Medium	**Medium**
Erosion Regulation	Regulating	• Mangrove vegetation assists in regulating erosion of the riverbanks. River bank is being built up naturally.	Mangrove Forest	Local communities **ES Linkages:** River defense	High	High	**Medium**
Pollination	Regulating	• Pollinators are abundant in the mangroves and increase crop productivity on the coastland farms.	Mangrove forests, biodiversity	Local communities, famers, national economy	High	High	**Medium**
Timber and wood products/ Non-wood fibers and resins	Provisioning	• A small percentage of households harvest mangroves, primarily for construction of fences and other structures in the squatting area.	Forests	Local communities (general population)	Low	High	**Low**

APPENDIX E

Identified Ecosystem Services and Priority Ratings: Region 4 Coastal

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TABLE E-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 4 COASTAL

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Georgetown City, Population 132,000, with increases in suburban housing areas							
Social/Commercial – Port & Wharfs	Provisioning	• The Port Georgetown is used by >30 ocean-going vessels daily, with others anchored in the river. • The wharfs are used by > 50 fishing vessels including trawlers for deep sea fishing • Thousands of passengers use the ferry stelling on a daily basis.	River & Sea	a) Regions 3, 4 and other communities using Port of Georgetown and ferry stelling b) fisherfolk at wharfs **ES Linkages:** Food, Tourism, Employment	a) Essential b) Essential	a) Low/ Moderate b) High	**a) Critical** **b) High**
Tourism/Hotels	Cultural	• Two of the main hotels in Guyana are located on the seashore, with hundreds of guests per week and >200 employees.	Seashore	Guyana	High	Moderate	**High**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• >20 fishing vessels use the seashore to fish or to access their fishing grounds in deeper waters. • Individuals use the area to fish with lines.	Ocean/ River	a) Commercial fisherfolk b) Recreational or subsistence fishing	a) Essential b) Low	a) Moderate b) Moderate	**a) Critical** **b) Low**
Recreation	Cultural	• >100 individuals use the stretch of Seawall from Kingstown – UG road daily. >1000 frequent the bandstand area on weekends and holidays.	Sea/river defense, beach	Georgetown, Guyana **ES Linkage:** Tourism	Essential	Low	**Critical**
Biodiversity	Provisioning	• Thousands of birds roost in the mangroves close to the Demerara Harbour Bridge. Birds feed on the mudflats of the river.	Sea/ River, Mangroves	Georgetown, Region 3, Guyana, International **ES Linkage:** Tourism	High	Moderate	**High**
Religious/Ritual	Cultural	• Religious activities at the Kingston shore/beach, with > 20 people daily • Religious activities at the UG Road seawall, with > 10 people daily	Seawall, shore, beach	Local communities using religious areas at: a) Kingston shore b) UG Road	a) High b) Moderate	a) Moderate b) High	**a) High** **b) Low**
Mangroves	Provisioning	• Mangroves grow on the banks of the Demerara River and on the Georgetown seashore	Sea/ River, Mangroves	Georgetown, Guyana	High	Moderate	**High**
Erosion Regulation	Regulating	• The coastland is at risk to erosion, although protected by concrete defense. The mangroves and other vegetation help to defend the coast against erosion. Beaches forming along the seawall are contributing to this effort.	Coastal vegetation	Local communities **ES Linkages:** Biodiversity, Fishing, hunting, socioeconomic	Essential	Low	**Critical**
NDC 17 – Industry/Plaisance - Population – 25,000 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fishing, including shrimp, caught by >20 boats for commercial purposes. • Pin seine fishing by a few people on the shore. Hand line and cast net fishing by a few people for sustenance. Most boats dock at the Ogle Koker.	Marine habitat, river habitat and mangrove forests	a) Commercial fishing in the ocean b) Pin seine fishing at Industry and Plaisance	a) Essential b) Moderate	a) Moderate b) High	**a) Critical** **b) Low**
Recreation	Cultural	• 40-50 people visit the Cummings Lodge–Ogle Road area for daily exercise. Some people walk/jog from Kingston to this area as part of their exercise routine. • 20-40 persons can visit the Turkeyen to Cummings Lodge seawall daily to relax, exercise and socialize	Sea wall, reserves	Local communities using seawalls in: a) Cummings Lodge to Ogle b) Turkeyen to Cummings Lodge c) Plaisance to Betterhope	a) High b) High c) Moderate	a) Moderate b) High c) Moderate	**a) High** **b) Medium** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Religious/Ritual	Cultural	• Cummings Lodge shore and sea defense is used for religious activities by >10 people daily. • Plaisance Koker is used for religious activities. • The Ogle Koker is used by Jordanites to conduct baptism and twice per year there are African Libation Ceremonies.	Sea defense, reserves	Local communities: a) Cummings Lodge to Ogle b) Plaisance	a) Essential b) Moderate	a) Moderate b) Moderate	**a) Critical** **b) Medium**
Food: Wild Meat	Provisioning	• Wild ducks and birds caught in summer season as they feed in the area. Birds hunted including the Scarlet Ibises in the summer months when the birds are plentiful in the area.	Seashore, mangroves	Local communities (especially boys)	Moderate	High	**Low**
Agriculture - Cultivated Crops	Provisioning	• A few people planted trees and cash crops (squatters) along the sea defense reserves. The dominant crop is coconuts.	Cultivated lands	Local communities (general population)	Low	High	**Low**
Mangroves & Carbon Sequestration	Regulating	• The mangroves grow naturally on the newly deposited mudflats, regulating many natural factors, contributing to pollination of crops and adding to carbon sequestration. New mangrove growth has covered shoreline between Ogle and Plaisance.	Mangroves	Local community. **ES Linkages:** Fishing, Crabbing, biodiversity	High	High	**Medium**
Shoreline Protection	Regulating	• Mangroves and coastal vegetation play a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms in Plaisance. Mangroves also offer shoreline protection helping the shells and mud to accumulate and build and further buffer the sea defense,	Mangroves Beaches	Coastal Communities **ES Linkages:** Tourism, biodiversity	High	High	**Medium**
Social/Cultural	Squatting	• Squatting occurring in close proximity to the sea defense at Plaisance	Shoreline, sea defense	Coastal Communities	Moderate	High	**Low**
NDC 18 – Better Hope/La Bonne Intention - Population - 50,000 – is increasing due to natural population growth							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Approximately 35 fishing boats catch fish and shrimp from Montrose, Success, and Better Hope. New mangrove growth are blocking of access to the sea which is affecting the fisherfolk. • Crab fishing is common during the summer crab season with about 12 people making a regular catch for sale. • There is salt fish drying along the seashore at Montrose.	a,b) Marine environment; beach; mangroves	a) Commercial fisherfolk at LBI and Chateau Margot b) Commercial fisherfolk at Montrose c) Salt Fish Drying at Montrose d) Crabbers	a) High b) High c) Essential d) Low	a) Moderate b) Moderate c) High d) Moderate	**a) High** **b) High** **c) Critical** **d) Low**
Shoreline protection / Mangroves / River defense	Regulating	• The coastland is at risk of erosion and much of the shore is protected by concrete defense. The mangroves and other vegetation helps to defend the coast against erosion. Mangrove is growing naturally at the seashore due to the increases in mud/silt deposits. • The NDC monitors the growth of the mangroves within the area and has observed that mangroves growth along the shoreline continues to increase.	Coastal vegetation	Local communities. **ES Linkages:** Biodiversity, Fishing, hunting , socioeconomic, tourism	Low	Moderate	**Low**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the sea and on the sea defense reserves at Ogle or Mon Repos	Sea & sea defense reserves	Local communities	Moderate	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Livestock Farming	Provisioning	• Locals utilize land along the sea wall for grazing of goats at Better Hope to Montrose. • Along the sea defense in the NDC, households utilize the land for grazing of cows and goats for livelihood. The animal pens are built on the reserves and also includes ducks and chickens.	Sea defense reserves, mangroves	Local communities (general population) in: a) Better Hope to Montrose b) LBI	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Primary production, biodiversity	Supporting	• The NDC has a large area covered by new growth mangroves with rich biodiversity of birds and crabs. People use this area for crabbing in season and out of season.	Coastal Mangroves	Local communities	Low	Moderate	**Low**
Food: wild meat	Provisioning	• Lulu, egrets, plover birds are caught by a few people in the NDC on the seashore.	Biodiversity	Local communities, NDC **ES Linkages:** Wild meat tourism	Low	Moderate	**Low**
Tourism and Recreation	Cultural	• 10–20 persons relax and exercise on the seawalls at Le Ressouvenir, LBI, and Chateau Margot. • More than 20 persons use the Montrose seawall daily for recreation including playing dominoes and exercise.		Local communities using the seawalls in: a) Le Ressouvenir, LBI and Chateau Margot b) Montrose	a) Moderate b) High	a) Moderate b) High	**a) Medium** **b) Medium**
NDC 19 – Beterverwagting/Triumph - Population - 7,000 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fisheries landing area in Triumph where 15-20 boats load, refuel and discharge catch. • Mudflat where 10-15 catamarans operate using pin seine to fish.	Ocean, Mudflats, mangroves	a) Local Fisherfolk b) Local Communities	a) Essential b) High	a) Moderate b) High	**a) Critical** **b) Medium**
Recreation	Cultural	• >20 people use the Triumph end of the NDC to exercise, recreate, or socialize. Many people used to frequent the area before the mangroves began to increase. On weekends and holidays, there are a few families recreating in the area.	Sea wall, reserves	Local communities	Moderate	Moderate	**Medium**
Religious/ Ritual	Cultural	• Religious activities along the sea defense and at the koker at Triumph > 10 people daily.	Sea defense reserves, shore	Local Communities	Moderate	High	**Low**
Agriculture/Grazing	Provisioning	• Grazing of goats and cows in the NDC is limited as there is not much unoccupied or reserve land. • There has been a reduction of grazing along the shoreline. The NDC places high fines for stray cattle and many farmers have moved their animals to the backlands which is being developed by the Rural Agricultural Infrastructural Development Project for agriculture purposes.	Sea dam, Mangroves, reserves	Local communities	Low	Moderate	**Low**
Shoreline Protection	Regulating	• Mangroves and coastal vegetation at Beterverwagting play a critical role to maintain coastal stability and protect inland areas from waves, wind, and flooding from storms.	Mangroves Beaches	Coastal Communities **ES Linkages:** Tourism, biodiversity	Low	Moderate	**Low**
Coastal Protection	Supporting	• Mudflats are being built on the coast in the NDC that protect the sea defense structures. Mangroves has been growing in the NDC naturally with the buildup of mud and silt	Ocean, sea defense	Coastal communities	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: Wild Meat	Provisioning	• Wild ducks and shore birds are caught and eaten by few families in the summer when birds are plentiful in the area.	Seashore, mangroves	Local communities	Low	Moderate	**Low**
Social/Housing	Provisioning	• A housing scheme of 22 lots for residents is being developed Triumph North.		Residents in Triumph North	High	Low	**Critical**
NDC 20 – Mon Repos/La Reconnaissance - Population - 40,000 and increasing							
Food: Fishing, shrimp, crabs	Provisioning	• There are more than 100 fishing boats landing at Mon Repos Koker, Lusignan Koker and Annandale. Approximately 400–500 persons mainly from the villages of Mon Repos and Annandale. Mangroves have made it difficult for fisherfolk to access their landing areas. • < 10 people catch crab on a weekly basis for sale in the area.	Ocean & River ecosystems	a) Local fisherfolk at Mon Repos Koker and Lusignan Koker b) Annandale c) Local crabbers **ES Linkages:** Mangroves	a) Essential b) Essential b) Low	a) Low b) Low b) Moderate	**a) Critical** **b) Critical** **c) Low**
Recreation	Cultural	• Recreation at Lusignan and Annandale where people living in close proximity and others frequent. • The NDC has an abandoned play park in Annandale for recreational activities that is overgrown by vegetation. The NDC plans to refurbish the park for recreation and tourism purposes.	Sea wall, Beach	Local Communities using: a) Lusignan and Annandale b) community playground at Annandale	a) Moderate b) Low	a) High b) High	**a) Low** **b) Low**
Livestock Farming	Provisioning	• Cattle, sheep, and goats graze on the shoreline in the Lusignan area. Grazing is reduced due to stealing of animals.	Sea Dam, Vegetation	Local Communities	Moderate	Moderate	**Medium**
Religious	Cultural	• Religious activities with shrine built on the sea dam at Mon Repos • People living along the sea defense use the areas; accessible for religious activities at Annandale and Lusignan	Sea dam, beach	Local community using accessible areas at: a) Mon Repos b) Lusignan and Annandale	a) High b) Low	a) Moderate b) Moderate	**a) High** **b) Low**
Social/Economic Boat Building	Provisioning	• Boat building & repairs	Sea dam, beach	Local Community, Region 4	Essential	Moderate	**Critical**
Social/Economic - Tannery	Provisioning	• Mangrove barks are being utilized by three tanneries to color leather	Mangroves	Local leather tanner	High	High	**Medium**
Food: Wild Meat	Provisioning	• Wild ducks and shore birds are caught and eaten by few families in the summer when birds are plentiful in the area.	Sea shore, Mangroves	Local communities	Low	Moderate	**Low**
Social/Economic	Provisioning	• A heliport and a hotel are proposed for sea defense area at Lusignan, with the site already cleared for the construction to commence.	Sea Defenses	Private developers	Moderate	Moderate	**Medium**
Social/Economic	Provisioning	• A coconut processing center will be developed in close proximity to the shoreline at Annandale.	Sea shore	Private developers, Local communities	Moderate	High	**Low**
Social/Housing	Provisioning	• A new private housing scheme consisting of seventeen houses is being constructed close to the sea defense at Good Hope.	Sea dam	Private developers; Local communities	Moderate	Moderate	**Medium**
Shoreline protection / Mangroves / River defense	Regulating	• Mangroves cover the sea shore in Mon Repos and Annandale. In Mon Repos mangrove cover is increasing.	Mangroves	Local communities	High	Moderate	**High**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 21 – Buxton/Foulis – Population – 7,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing with six boats landing at Non Pariel as mud accumulation along the shoreline at Stratsphey made the landing site inaccessible • Fishing boats at Melanie and Paradise with pin seine • Some also catch shrimp	River, Ocean, mangroves	Local fisherfolk at: a) Non Pariel b) Melanie and Paradise	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Recreation	Provisioning	• Buxton/Friendship Seawall, which 10-20 people use daily to exercise, relax or socialize • Melanie/Non Pariel Seawall, which 10-20 people use daily for recreation	Sea defense, shore,	Local Communities at: a) Buxton / Friendship Seawall b) Melanie/Non Pariel Seawall	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Religious	Cultural	• Religious activity at Melanie with access to the sea. On Sundays, 20-30 families visit the area for religious activities.	Sea shore, sea dam	Local communities	Essential	Moderate	**Critical**
Livestock Farming	Provisioning	• Grazing of goats, sheep and cattle occurs on the natural vegetation by a reported few animals in the NDC	Natural vegetation	Local residents in proximity to grazing	Low	Moderate	**Low**
Habitat provision, coastal protection	Supporting	• Birds, insects, and some small mammals pollinate certain flora species, including some agricultural crops grown along the coast. The area has some tracts of mangrove and mixed vegetation that allows for such services.	Cultivated lands	Local communities **ES Linkages:** Crop cultivation	Low	Low	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore, are highly valued by local communities and visitors.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
Food: Wild Meat	Provisioning	• Wild ducks and shore birds are caught and eaten by few families in the summer when birds are plentiful in the area.	Sea shore, Mangroves	Local communities	Low	High	**Low**
Shoreline protection / Mangroves / River defense	Regulating	• NAREI plots at Mon Repos and Vigilance for mangroves. The growth of mangroves has created security issues for recreational users who are now avoiding these areas.	Sea shore, Mangroves	Local communities	High	Moderate	**High**
NDC 22 – Unity/Vereeniging - Population in excess of 9,000							
Food: Fishing, shrimp, crabs	Provisioning	• Unity shoreline has fewer than 20 fish/shrimp boats. • Riverview landing site at Unity at the Mahaica River mouth has approximately 50 boats. • Helena Koker, with approximately 25 boats. • There are over 150 fishing boats in the NDC of different types employing over 500 persons directly in fishing and an additional 500 persons in supporting services. • Crab catching done a lot, but seasonal.	River &sea	Local fisherfolk Region 4 a) Riverview landing site b) Unity Shoreline c) Landing sites at Beehive and Lowland d) Crabbing	a) Essential b) Moderate c) High d) Low	a) Low b) Moderate c) Moderate d) Moderate	**a) Critical** **b) Medium** **c) High** **d) Low**
Agriculture/Grazing	Provisioning	• Grazing at Unity shore for cows, horses, and goats. >200 animals graze in the pasture. Over 15 persons graze animals in the area.	Beach mangroves, vegetation; fishing	Local communities	Essential	Moderate	**Critical**
Recreation	Cultural	• Unity beach is frequented for swimming, exercise, recreation and socializing by 20-30 people daily.	Seawall, sea defense reserves	Local communities, Region 4	High	Moderate	**High**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Religious/Ritual	Cultural	• Religious activities held at the sea with access from the road throughout the NDC. • Unity Beach is the main area in the NDC for religious activity. 10-20 persons use this area daily for religious activities. Over 300 persons can be found on Sundays and thousands on Hindu religious days. • Crematorium at Unity Foreshore utilized regularly.	Seawall reserves, shore, beach	Local Communities, Region 4 using: a) Along coastal access areas b) Unity Beach and Crematorium	a) Essential b) Moderate	a) Moderate b) Moderate	**a) Critical** **b) Medium**
Ecotourism: Bird Tours	Cultural	• Daily bird tours in the Mahaica River to spot numerous bird species including the Canjie Pheasant	River ecosystem , Biodiversity	Local Guides, Tourists	High	Low	**Critical**
Cultivate Crops	Provisioning	• Crops and fruits planted on the sea and river defense reserves. • Coconut estates encroach on the reserves along with some cash crops.	Seawall reserves	a) Local Communities planting crops and fruits b) Coconut estate owners and workers	a) Moderate b) High	a) High b) Moderate	**a) Low** **b) High**
Food: Wild Meat	Provisioning	• Iguanas and some birds are increasingly caught in the shore and among the mangroves on a weekly basis for sale to wild meat enthusiasts.	Mangroves, Biodiversity	Local Boys	Moderate	Moderate	**Medium**
Social/Economic	Provisioning	• Wharfs in the Mahaica River supporting trade and the local economy. Numerous boats carry farm produce, goods, and passengers in the river.	Seawall & reserves	Local Communities	Moderate	Low	**High**
Coastal Protection	Supporting	• The concrete sea defense is supported by natural vegetation including mangroves, coconuts, fruits, and some cash crop plots.	Sea defense & reserves	Coastal region	High	Low	**Critical**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore, are highly valued by local communities and visitors. The Canjie Pheasant is highly valued and attracts daily tours to the area.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	Low	**High**
Habitat provision, coastal protection	Supporting	• Birds, insects, and some small mammals pollinate certain flora species, including some agricultural crops grown along the coast. The area has some tracts of mangrove and mixed vegetation that allow for such services.	Cultivated lands	Local communities **ES Linkages:** Crop cultivation	High	High	**Medium**
Mangrove Materials	Provisioning	• Some harvesting of mangroves for firewood and poles, but this is limited.	Mangrove	Few local individuals	Moderate	High	**Low**
NDC 23 Haslington/Grove - Population - 22,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing boat landing area at Greenfield >15 boats, mainly for fishing • Fishing boats landing area at Hope, with 10 boats. Fish are sold in the area. • Fishing boat landing area at Haslington, with 5 boats, and Victoria, with 3 boats • Fishing boat landing area with approximately 5 boats at Cove and John • Fishing done along the shoreline using seines and at kokers using cast net and lines. Catamarans used to access seine and lines via the mudflats.	Ocean, Mudflats, shore	Local fisherfolk , Region 4 at: a) Greenfield, b) Hope c) Cove and John d) Haslington e) Along other kokers; catamaran operators and users of cast nets and lines	a) Essential b) Essential c) High d) Moderate) e) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate e) Moderate	**a) Critical** **b) Critical** **c) High** **d) Medium** **e) Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• The locals catch much fishes in the swamps beyond the sea dam that is offered for sale in and out of the NDC.					
Primary production, biodiversity	Supporting	• This NDC has a Mangrove Reserve that facilitates mangrove conservation, apiculture, bird watching tours, and mangrove tours.	Mangrove Forest	a) Local Beekeeper, b) Coastal Communities c) Tourists	Essential	Moderate	**Critical**
Ecotourism	Cultural	• The mangrove reserve has over 70 species of birds that attract three tours daily in the school tour season and monthly tours from other markets including internationals.	Biodiversity, Mangroves	a) Local communities, b) Tour operators **ES Linkages:** Biodiversity	Essential	Moderate	**Critical**
Coastal Protection	Supporting	• Mudflats are naturally being built on the coast in the NDC that protects the sea defense structures and promotes the growth of mangroves. • Mangroves are monitored by 3 rangers; as such, there is no hunting of wildlife or harvesting on mangroves. • Mangroves on the increase due to planting and natural growth. • Previously Hope Beach was popular but now overgrown with mangrove. • Lots of awareness to protect mangroves	Ocean, sea defense	Coastal communities	Low	Moderate	**Low**
Recreation	Cultural	• Cove & John – Victoria seawalls is frequented by 20-40 people daily. • Haslington –Nootenzuil is used by 50 people daily to exercise, relax, or socialize. • Recreational area being constructed at Bel Field Seawall. • The NDC is in process of developing the beach at Victoria/Haslington for recreation and tourism purposes. There is a Regional Tourism Committee which is spearheading tourism development within the Region. • Weekend activities such as parties have increased along the seawall area.	Seawall, beach, shore	Local communities using: a) Cove and John Seawall b) Haslington –Nootenzuil **ES Linkages:** Tourism	a) Moderate b) Essential	a) Moderate b) Moderate	**a) Medium** **b) Critical**
Religious	Cultural	• Religious activities at Cove & John attracts thousands for the special religious days • Religious activities at Hope and Greenfield <10 people.	Beach, seashore	Local communities Guyana using: a) Cove & John b) Hope and Greenfield	a) Essential b) Moderate	a) Moderate b) High	**a) Critical** **b) Low**
Apiculture	Provisioning	• Beekeeping is done in the mangrove area, with about 4 liters of honey sold daily. Two persons are involved in Golden Grove.	Mangrove	Local beekeepers	High	Medium	**Medium**
Livestock Farming	Provisioning	• Grazing of cows at Hope sea dam and shore. • Grazing of cows at Hope – Golden Grove.	Sea dam, reserves, mangroves	Local communities	Moderate	Moderate	**Medium**
Food: Wild meat	Provisioning	• Iguanas are caught by a few people for own use. Tilapia is caught in the mangroves that grow in the flood basin.	Mangroves	Local communities **ES Linkages:** Biodiversity	Moderate	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Squatting	Provisioning	• Informal housing at Golden Grove and Nabaclis.	Sea defense, mangroves	Local communities	High	High	**Medium**
Cultivated Crops	Provisioning	• Crops and fruits planted on the sea and river defense reserves at Golden Grove and Nabaclis. • Coconut estate in Greenfield.	Sea defense reserves	a) Local farmers planting on sea and river defense reserves b) Coconut estate	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Habitat provision, coastal protection	Supporting	• Birds, insects, and some small mammals pollinate certain flora species, including some agricultural crops grown along the coast. The area has some tracts of mangrove and mixed vegetation that allow for such services.	Cultivated lands	Local communities **ES Linkages:** Crop cultivation	High	High	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore is highly valued by local communities and visitors.	Mangrove area	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
NDC 24 Enmore/Hope – Population – 2,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Twenty boats use the Enmore Koker to dock. People fish with line and nets in the area. • Pin seine fishing is also practices by 2 to 3 persons using catamaran to access to fishing grounds. • Shrimp is caught by persons dragging seine along the shoreline. • Tilapia is caught in the flood reservoir within mangroves • The area is under much economic depression due to the closure of the sugar estates. There is more demand on the fishing resources offshore and in the canals and wetlands within mangroves. • The fisherfolk have good access to their landing area as the access was upgraded by the National Drainage and Irrigation Authority. The improved access is also used by the pin seine fisherfolk.	Ocean, reservoir	a) Local commercial fisherfolk b) Pin seine fishing and shrimping along the shoreline c) Fishing in mangroves	a) Essential b) Moderate c) Moderate	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) Medium** **c) Medium**
Recreation	Cultural	• Enmore seawall was a popular spot but now is only frequented by >10 people daily. Most people use the community center.	Seawall, beach	Local Communities	Moderate	High	**Low**
Religious	Cultural	• Enmore shoreline is a popular place for worshipers.	Seashore, sea dam, reserves	Local Communities	High	Moderate	**High**
Livestock Farming	Provisioning	• Grazing occurs along the sea defense reserve from Enmore – Hope. The amount is decreasing due to stealing of animals.	Sea defense reserves	Local Communities	Moderate	Moderate	**Medium**
Cultivate Crops	Provisioning	• Crops and fruits planted on the sea and river defense reserves at Haslington by one person.	Sea defense reserves	Local farmers	Low	Moderate	**Low**
Ecosystem, Mangroves	Provisioning	• The NDC has an area covered by mangroves with rich biodiversity of birds, fishes, and crabs. New mangrove growth on the shore is increasing and contributing to carbon sequestration. Mangroves are increasing within the NDC shoreline, which has resulted in less persons exercising due to security fears.	Coastal Mangroves	Local communities **ES Linkages:** Carbon Sequestration	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Coastal Protection	Supporting	• Mudflats are being built on the coast in the NDC that protect the sea defense structures and promote the growth of mangroves	Ocean, sea defense	Coastal communities	High	High	**Medium**
Food: wild meat	Provisioning	• Some birds such as the plover birds are caught using wire along the shoreline.	Mangroves	Local communities	Low	High	**Low**

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APPENDIX F

Meeting Schedule

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REGION 1 VCs/CDCs/TCs

Name of VC/CDC/TC	Date and Time (2018)		Date and Time (2019)	
Father's Beach	Wed, April 4	9:30 AM	Mon, June 10	8:30 AM
Manawarin	Thur, April 5	9:00 AM	Mon, June 10	1:00 PM
Haimakabra	Thur, April 5	2:00 PM	Tues, June 11	8:30 AM
Waramuri	Fri, April 6	9:00 AM	Tues, June 11	8:30 AM
Santa Rosa	Fri, April 6	2:00 PM	Tue, June 11	2:00 PM
Assakata	Sat, April 7	9:00 AM	Wed, June 12	1:00 PM
Warapoka	Sat, April 7	2:00 PM	Thu, June 13	8:30 AM
Three Brothers	Mon, April 9	11:00 AM	Thu, June 13*	1:00 PM
Mabaruma Town Council	Tue, April 10	9:00 AM	Fri, June 14	8:30 AM
Aruka Mouth	Tue, April 10	2:00 PM	Fri, June 14	11:00 AM
Morawhanna	Wed, April 11	9:00 AM	Fri, June 14	1:00 PM
Smith's Creek	Wed, April 11	11:00 AM	Fri, June 14	3:00 PM
Imbotero	Wed, April 11	2:30 PM	Sat, June 15	9:00 AM
Almond Beach	Thur, April 12	9:00 AM	Sat, June 15	2:00 PM

* Meeting not held due to unavailability of village.

REGION 2 NDCs

Name of NDC	Date and Time (2017)		Date and Time (2019)	
Charity/Urasara	Wed, Nov. 15	10:00 AM	Tue, May 28	8:30 AM
Evergreen/Paradise	Thu, Nov. 16	9:00 AM	Tue, May 28	11:00 AM
Aberdeen/Zorg-en-Vlygt	Thu, Nov. 16	1:00 PM	Wed, May 29	8:30 AM
Anna Regina Town Council	Fri, Nov. 17	8:00 AM	Tue, May 28	2:00 PM
Annandale/Riverstown	Fri, Nov. 17	10:00 AM	Wed, May 29	11:00 AM
Good Hope/Pomona	Fri, Nov. 17	1:00 PM	Wed, May 29	2:00 PM

REGION 3 NDCs

Name of NDC (Coastal)	Date and Time (2017)		Date and Time (2019)	
Wakenaam (island)	Mon, Nov. 20	9:00 AM	Tues, July 9	9:00 AM
Leguan	Tue, Nov.21	9:00 AM	Tues, July 9	2:00 PM
Mora/Parika	Wed, Nov.22	9:00 AM	Wed, July 10	8:30 AM
Hydronie/Good Hope	Wed, Nov.22	1:00 PM	Wed, July 10	11:00 AM
Greenwich Park/ Vergenoegen	Thu, Nov. 23	9:00 AM	Wed, July 10	2:00 PM
Tuschen/Uitvlugt	Thu, Nov.23	1:00 PM	Thur, July 11	8:30 AM
Stewartville/Cornelia Ida	Fri, Nov. 24	9:00 AM	Thur, July 11	11:00 AM
Hague/Blankenburg	Fri, Nov. 24	1:00 PM	Thur, July 11	2:00 PM
La Jalousie/Nouvelle Flanders	Mon, Nov. 27	9:00 AM	Fri, July 12	8:30 AM

Name of NDC (Coastal)	Date and Time (2017)		Date and Time (2019)	
Best/Klien/ Pouderoyen	Mon, Nov. 27	1:00 PM	Fri, July 12	11:00 AM

REGION 4 NDCs

Name of NDC (Coastal)	Date and Time (2017)		Date and Time (2019)	
Georgetown City	Tue, Dec. 5	9:00 AM	---	---
Industry/Plaisance	Tue, Nov. 28	9:00 AM	Wed, May 8	8:30 AM
Better Hope/ LBI	Tue, Nov. 28	1:00 PM	Wed, May 8	11:00 AM
Beterverwagting/Triumph	Wed, Nov. 29	9:00 AM	Wed, May 8	2:00 PM
Mon Repos/ La Reconnaissance	Wed, Nov. 29	1:00 PM	Thu, May 9	8:30 AM
Buxton/Foulis	Thu, Nov. 30	9:00 AM	Thu, May 9	11:00 AM
Enmore/Hope	Mon, Dec. 4	1:00 PM	Thu, May 9	2:00 PM
Unity/Vereeniging	Thu, Nov. 30	1:00 PM	Fri, May 10	11:00 AM
Haslington/Grove	Mon, Dec. 4	9:00 AM	Fri, May 10	8:30 AM

--- Location not revisited during validation exercise.

APPENDIX G

Validation Data Summary

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ACRONYMS

CDC	Community Development Councils
EEPGL	Esso Exploration and Production Guyana Limited
GIS	Geographic Information System
NAREI	National Agricultural Research and Extension Institute
NDC	Neighbourhood Democratic Council
NGO	non-governmental organization
NTC	National Toshaos Council
SBPA	Shell Beach Protected Area
TC	Town Council
VC	Village Council

1. INTRODUCTION

As detailed in Section 1.2, after documenting the findings and analysis, the final phase in the process was to validate the compiled data and verify that the associated detailed mapping was accurate. An ecosystem services validation exercise commenced in May 2019 and concluded in July 2019. As described in Section 2.4, in addition to validating previously recorded information, the validation exercise allows for the collection of any new data relating to ecosystem services functions and values since the previous engagements, while also providing the opportunity to collect updated socioeconomic data at the community level.

The information presented in this Validation Data Summary appendix is limited to the feedback obtained from stakeholders during the validation stage whereby the socioeconomic and biodiversity experts presented the findings of the ecosystem services study and the coastal sensitivity maps on which the results of the ecosystem services study were displayed. These were presented to 62 of the original 64 Neighbourhood Democratic Councils (NDCs), Town Councils (TCs), Village Councils (VCs), and Community Development Councils (CDCs) in the coastal area of Regions 1, 2, 3, 4, 5, and 6.

The responses received during the validation exercise are detailed below, presented by region and stakeholder group. Feedback regarding additional or changed ecosystem services data is reflected under the “Ecosystem Services Survey” heading. Issues not directly related to ecosystem services functions or values, but related generally to socioeconomic status, are also noted under “Other data collected” headings for the purpose of documentation. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time which has lapsed since the 2017/2018 original data were collected and the 2019 validation exercise. In some cases, there are specific notes regarding changes that will be made within the Liza Project Geographic Information System (GIS) database. These are captured within the responses in order to maintain accuracy in the reporting and subsequent mapping efforts. The findings outlined in this appendix are provided in detail within the Detailed Findings Sections of the report.

Some minor changes and updates were recommended as indicated by individual focus groups. These minor updates relate mainly to adjustments in the quantitative data for some ecosystem services presented, as well as location of some activities. In a few instances, additional uses/services in some areas were recommended to be included. The spatial adjustments of locations and inclusion of new uses have been updated in the Liza GIS Database.

Additional socioeconomic data at the NDC, CDC, VC, and TC level were also collected, including updated population figures.

The NDCs, CDCs, VCs, and TCs generally expressed gratitude for the information shared and the opportunity to participate in the original screening and scoping process, and subsequent validation exercise. At their request, finalized maps of their area depicting the ecosystems services within their area as well as the summarized analysis was provided to each of the participating NDCs, CDCs, VCs, and TCs and Regional Councils in December 2019.

1.1. Region 1

This section presents the feedback from the ecosystem services validation exercise within Region 1. Engagements with the following CDCs, VCs, and TC within Region 1 were conducted during the period June 10 to June 15, 2019:

- Father's Beach
- Manawarin
- Waramuri
- Santa Rosa
- Assakata
- Warapoka
- Three Brothers
- Mabaruma Town Council
- Aruka Mouth
- Smith's Creek
- Morawhanna
- Almond Beach
- Imbotero

As noted above, Haimokabra and Waramuri in Region 1, which were visited separately in 2017/2018, were visited simultaneously during the validation exercise since Haimokabra is considered a satellite village of and shares leadership with Waramuri. A representative from the National Toshaos Council (NTC) participated in the entire Region 1 exercise. The NTC participation was to ensure all the engagements were fair and impartial and the concerns of the Indigenous communities were raised and addressed. The participation of the NTC was beneficial to the exercise, since communities were more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, had more confidence in the process and participated freely in the discussions. A representative from the non-governmental organization (NGO) Guyana Marine Conservation Society, who is also affiliated with the University of Guyana, attended the meetings in Region 1 to verify that engagement with Indigenous communities was performed in a matter that meets community expectations. Two of Esso Exploration and Production Guyana Limited's (EEPGL's) community and socioeconomic experts also attended the engagements at Father's Beach, Manwarin, and Waramuri.

1.1.1. Father's Beach Village Council

Ecosystem Services Survey

- Coconut palms on the shore, which are protected by the mangroves and earthen barriers, also function as dams. Cassava, fruits, vegetables, and other crops are planted on the farms with some of the produce sold in Pomeroon or at Charity. Coconut cockles are currently affecting the coconut grove. Coconut cockles attack the heart of the coconut palm, which eventually leads to the death of the tree. This is not isolated to Region 1 and is a known pest to coconut plantations in other parts of the coast of Guyana.

- Plants with medicinal and spiritual values are abundant on the beach and almost all plants found in the area are used for medicinal and other purposes.
- Mangroves, in addition to offering protection from erosion, also serve as a buffer between crops and the ocean, preventing the salt water spray from reaching the crops. In some areas there are mature mangroves and in others there is mangrove regrowth.
- There has been significant beach erosion over the years. Shells are being used for construction in place of stone and also used for landfill and to provide nutrients for plants (e.g., fruit trees).
- Fuel and boat repair services are provided onshore and offshore. Persons in need of fuel or repairs offshore can call and service is provided by residents. (Note: This service was added as 50_130 to the GIS dataset.)
- Hunting of wild animals or birds is limited in the area, and hunting by outsiders is banned. Some persons do catch iguanas but not on a regular basis. There are small animals caught for meat that can be found in the swamp beyond the farms.
- Crab meat is an important source of food for the households. Persons from other areas also catch crabs at Father's Beach. Crabs damage the dams and cassava crops.

Other Data Collected

- The village population is declining and currently stands at 23 persons. When there were significant activities on the beach, the population was in excess of 300 persons. Some have signaled their intention to return but have not done so.
- Father's Beach was well occupied with large cultivated farms some 60 years ago. From that time onwards, the beach has been slowly eroding with many of the farms washed away and the people migrating inland or to the Pomeroon River. On long stretches of the beach, the mangroves have completely eroded.
- The school was closed and most children now attend school at Waramuri. The medical center no longer functions and medical services are sought at Charity.
- The local people are prohibited by law from using turtle shells, which is important in one of their traditional religious practices. They claim that the village did not agree to these restrictions during the Shell Beach Protected Area (SBPA) consultation process. The community is awaiting the revision of the rules of the SBPA by the Government of Guyana to better reflect Indigenous people's culture.
- The community is not willing to discuss its spiritual practices with outsiders.
- Savannah burning is still a concern since it burns the dams that protect the community.

1.1.2. Manawarin Village Council

Ecosystem Services Survey

- Fishing along the sea coast has decreased because residents do not have the necessary boats and engines.

- Crabbing is an important cultural activity that the entire community participates in at some level.
- The Manawarin River is not the only form of access to the village. There are numerous tracks and dirt roads that provide access to the community from various points.
- Many species of animals are trapped for trading at Charity, including the emerald boa, rainbow boa, anaconda, and parrots. Seabirds are rarely caught, as people do not frequent the shore apart from during the crab season.
- The community cuts wood for internal construction and for sale commercially. The current dispute with the village of Wakapoa (an adjacent Amerindian village in Region 2 but not located within the coastal area) over the ownership of the resources has reduced the level of this activity.
- People have increasingly planted small-scale, cash-crop farms (e.g., vegetables, cassava) but the market for the produce is lacking and the costs for transport to Charity or Kumaka are prohibitive.
- A giant river otter feeding area was observed during the exercise. (Note: This service was added as 50_131 to the map dataset.)

Other Data Collected

- The population is in excess of 2,000 and is increasing.
- The area referred to as Rockstone is disputed but it is a spiritual site and has the potential to be a tourist attraction. It belongs to Manawarin since they previously occupied it. Trees planted by residents exist there today.

1.1.3. Waramuri Village Council

Ecosystem Services Survey

- According to the village Toshao, Waramuri houses the world's 27th shell mound to be discovered (although this has yet to be internationally verified). The expectation is for this site to be developed into a leading tourist attraction in the future as part of the village's plan to enhance ecotourism activities.
- The number of people involved in fishing is the same with most living in Haimokabra. Iron Punt area is used for fishing camps. Fish are caught and dried along the beach since ice is not available.
- Shorebirds are not hunted by the fisherfolk visiting the shore, but are sometimes used as bait for fishing.
- Wildlife is hunted on the shore with the assistance of dogs. Ducks, iguanas, deer, labba, agouti, and alligator are caught onshore. Snakes are caught and sold to trappers visiting the village or sold in Charity. Duck eggs are also collected.
- The shoreline area is preferred for farming since it is more fertile. However, large cultivated areas were washed away, as well as the fisherfolks' camp. Significant stands of mangroves and other lands are also eroded from Shell Beach.

- The village has deposits of stone that are used in construction. Stone is mined and sold locally and to contractors in Santa Rosa.
- Coconut cultivation is increasing within the community. Coconuts are sold at Pomeroon. Copra is also made and sold at Pomeroon.
- Lumbering is performed mainly for domestic construction. This activity is managed by the VC. However, no inventory of the forest within the community has been completed. SBPA management has indicated that it will assist the village in completing its forest resources inventory. Once completed, the village will use this information when developing its own management plan.
- The ite palm (an indigenous type of palm) is recognized by the village as the tree of life. The palm provides tibisiri[8], food, roof material, fruit for drink making, other construction material, and the tacoma worm[9].
- In addition to the river network, there is land access to the village from different onshore areas.

Other Data Collected

- The population is approximately 2,500 and is increasing.
- Economic activities within the community are also on the rise.
- Boats from Charity selling various commodities visit the community on a regular basis.
- The community plans to pursue tourism development. Some of the possible attractions/activities include crab catching, nature trails, historical remnants (such as Dutch bottles), the Shell Mound, and a nature creek. There are also plans to construct a guest house.
- Mangroves along the river banks sometimes fall into the river, which affects navigation. The village, given its location, often receives requests to remove the fallen trees.
- There has been a notable decrease in fishing within the Moruca River in recent years.
- The village has changed its construction methods and materials with the new designs being more modern and better for the households.

1.1.4. Santa Rosa Village Council

Ecosystem Services Survey

- Ite palms are found throughout the community, and residents can easily access and gather forest materials for multiple purpose use. People have chosen to build with modern materials but tibisiri is still used for many crafts.

[8] Tibisiri is made from the fiber from the leaves of the palm and is used to make hammocks, thatch roof, furniture, baskets, and carpets.
[9] Tacoma worm, also known as the beetle larvae (Rhynchophorus palmarum), feeds on old ite trees that have fallen to the ground. These beetles are full of fat and are considered a delicacy and a good source of nutrients by the indigenous communities that consume them.

- The Moruca River and its numerous waterways are used for swimming, cultural acts, fishing, recreation, sports, and some spiritual practices. (Note: This service was added as point 50_132 to the GIS dataset in order to identify cultural uses of the rivers.)
- Turtle shells are used by persons in their homes for spiritual practices.
- Some hunting/trapping of wildlife still occurs even though there is zero tolerance of this activity within the community. Deer are scarce in the savannas due to overhunting but iguanas are plentiful. Recently, many saki monkeys were trapped by a wildlife trader.
- The mangroves at the mouth of the Moruca River are part of the cultural heritage of Santa Rosa and should be carefully preserved while cleared to accommodate the safe movement of boats. The Moruca River mouth is part of the ancestral lands of the Amerindian people of Santa Rosa.
- The village has more than 100 fisherfolk who fish in both freshwater rivers and in the ocean. Fishing areas include Manawarin River, Moruca River, Baramanni River, Biara River, Dog Creek, Luri Creek, Baramanni Lake, Waini River, Waini Point, Iron Punt, and Father's Beach.
- Plants are gathered from the beach and throughout the community for medicinal and other purposes.

Other Data Collected

- The population is approximately 10,500 and is increasing. There are many returning Guyanese from Venezuela who have ties to the community.
- Economic activities are increasing. There is a new shopping mall under construction near the community that will be opened in the near future.

1.1.5. Assakata Village Council

Ecosystem Services Survey

- Lumbering is performed for domestic use and community projects.
- The village has no boats that fish in the ocean. The popular fishing areas include Baramanni Lake, Luri Creek, and Dog Creek.
- Crabs are caught in season, as the fisherfolk do not venture into the crab breeding area on a regular basis.
- The community plans to develop the Village Lake into a tourist attraction and combine it with the shell mound also found in their village. The community will develop an ecotourism plan and seek funding from the government as well as private sources.
- Members of the community are not involved in the trapping of animals for trade. Wild dogs are hunted. Occasionally, iguanas are also hunted for their meat. Conservation efforts have paid off with a reduction in wildlife trapping and trade within the community.
- About 30 persons are involved in the cutting of cabbage sticks for sale.

Other Data Collected

- The village population is 473 and increasing.
- Most persons from the community engage in farming.

1.1.6. Warapoka Village Council

Ecosystem Services Survey

- Warapoka is making strategic investments to become a major ecotourism destination, with visitor counts on the rise over the past several years due in part to government-sponsored ecotourism programs. The guest house has been renovated and plans to bridge the wetland leading to harpy eagle nests are being considered for the dry season. The community is also developing its sport fishing product at Luri Creek with help from Rewa village (North Rupununi). About 20 people are employed in tourism activities, an increase from 10 in 2018. Visitors, primarily consisting of local tourists, have increased over the past year as well. Attractions and activities include village tours, bird watching, cave visits, visits to harpy eagle nesting sites, cultural presentations and sport fishing. [Note: Two points were added to the GIS dataset: 50_133 identifying the Shell mound at Warapoka, and 50_134 for the sports fishing at Luri Creek.]
- The community does not fish in the Atlantic Ocean at this time, but sometimes fishing occurs along the beach, which is accessed through Luri Creek and Baramanni River. The fisherfolk currently fish in the rivers as far as Waini Point.
- Crabs are caught at Waini Point and Moruca River Mouth during the crabbing season.
- The community rarely traps animals for trade, but some community members hunt meat for food. The community gathers eggs from the tiger birds seasonally. Ducks and cranes that lay eggs by the thousands are found in the ite palm forest.
- Approximately 80 men cut cabbage (heart of palm) for sale commercially on a weekly basis during the dry periods of the year.
- Some persons within the community are engaged in craft making.

Other Data Collected

- The population is 650 and is increasing. Guyanese persons from Venezuela with ties to the community are returning. Forty such people have returned to date. However, there are also about 40 other Venezuelan migrants without any ties to the community who have also moved into the community.

1.1.7. Three Brothers Village Council

Ecosystem Services Survey

- Fishing remains the main sustenance and economic activity.
- Some villagers are still involved in the cutting of cabbage palm.

- There are a few commercial-scale farms in the area, but farming is generally in decline despite successes with ginger and other root crops.
- The village dogs continue to be attacked by jaguars, which is affecting hunting activities.

Other Data Collected

- The village population is 120 and is in decline as people continue to migrate to more populated areas like Mabaruma.
- The economic situation is declining more rapidly due to the fuel crisis, which has driven up the price of fuel that villagers depend on to travel in the Waini River and to Mabaruma.
- The villagers expressed discontent with the SBPA management and regulations.

1.1.8. Mabaruma Town Council

Ecosystem Services Survey

- The resource use in the township generally remains the same from the last year. There is a small increase in fishing from the migrant community, but the quantity remains unknown. The migrants also hunt for crabs for their sustenance, mainly in the areas close to their temporary homes.
- There is a small growth in the tourism sector, although there was significant growth in the number of people flying to Mabaruma.
- The township has three sawmills that provide dressed lumber for the town and other communities. The owners have timber concessions and also purchase timber from the Amerindian communities. There is a current boost in the building sector that sustains the three sawmills. These are not affected by the shortage of gasoline. [Note: A new point 50_134 was added to the GIS dataset to show the sawmill and lumber yard that supplies dressed lumber to the town and other communities.]
- The township has embraced the Green State Development Strategy and has built a “Green Park” at Hosororo and planted more than a thousand trees in the town. It also has a solar farm that generates power for the electric grid. There are plans to install a wind farm as well.

Other Data Collected

- The current population is estimated at 8,000.
- There has been in excess of 4,000 migrants (the vast majority Venezuelan and the rest Guyanese people with links to these communities) passing through the community recently, with more than 1,000 remaining. Most of these are residing in an area referred to as Khan’s Hill.
- The local people of the town are not responding in a positive manner to the presence of the migrants who are suspected of taking jobs, spreading diseases, conducting unsanitary practices, and occupying open spaces. There are also numerous cases of migrants being taken advantage

of by local people, which are not reported or given legal consideration due to lack of enforcement.

- There is a small increase in economic activities due to the presence of the migrants.
- The town needs a dedicated site for the disposal of garbage. The current site is not adequate and the migrants at Khan's Hill are seen rummaging through the garbage.

1.1.9. Aruka Mouth Community Development Council

Ecosystem Services Survey

- The community has about 60 men who fish on a regular basis, mainly in the Waini River Mouth.
- In addition to the fisherfolk who also have farms, there are approximately 20 farmers who rely mainly on farming as a means of sustenance. Produce is sold at Kumaka market on Tuesdays and Saturdays.
- Approximately 15 persons catch crabs and sell them on Tuesdays and Saturdays at the Kumaka market. Crabs are purchased by traders and taken to Georgetown.
- The community has about ten persons who hunt. The meat is used domestically and sold at the market. A few people hunt seabirds when they are plentiful.

Other Data Collected

- The population is approximately 300 and is increasing.
- The Warraus from Venezuela visit the community on the way to the Kumaka market and trade with a few willing people. Hammocks, craft, and dried fish are the main items that are in demand in Aruka Mouth.

1.1.10. Smith's Creek Community Development Council

Ecosystem Services Survey

- More than 100 people fish in the Waini River and at Waini Point heading further west along the Venezuelan Coast.
- Approximately 40 people cut cabbage palm during the dry season. A crew of ten men average 1,500 sticks, which occurs twice a month.
- Some men hunt for food but few trap any animals for sale. Land turtles are a favorite.
- There are many mangroves being cut and cleared to construct new houses for the migrants along the Barima River.
- Crab catching remains a significant activity. A crab processing facility is being established within the community with the support of the government.

Other Data Collected

- The population is 248 and increasing.
- There are migrants present within the community, mainly comprising of the same Warrau tribe of the community. At one time there were as many as 80 migrants present. Currently there are ten migrant families who have established dwellings within the community.
- Commercial activities relating to the fuel trade have increased at nearby Morawhanna on the opposite bank of the river. Fuel spills and leaks in the waterways are affecting the community as fuel washes up on the shore. Also, there has been a decline in fish caught within the river.
- The community needs an alternative source of water since the river is often contaminated by fuel, and during the dry season the creek that provides water is usually dry.

1.1.11. Morawhanna Community Development Council

Ecosystem Services Survey

- There has been an increase in economic activity due to the fuel trade. Boats from Venezuela bring fuel to sell to local vessels. There can be as many as 40 vessels docking in the Barima River in proximity to Morawhanna.
- The ice plant is now operational and numerous fishing boats come to purchase fuel.
- The area is mainly a commercial hub with the community taking advantage of its wharf and the increased trading. Food and other supplies are provided daily to the crews of the numerous ships.
- The community floods regularly so people have given up on planting crops.
- There are no hunters in the area who trap animals for trade or meat.
- Everyone fishes in the river for fresh fish on nearly a daily basis. The presence of numerous fish affirms for the villagers that their waters are not polluted due to fuel spills.
- There is now a water well within the community, which has significantly reduced the use of the river as a water source.

Other Data Collected

- The current population is approximately 100 persons.
- The community houses the Coast Guard, the Guyana Revenue Authority, and Immigration authorities.

1.1.12. Almond Beach Community Development Council

Ecosystem Services Survey

- Coconut is the main crop on the beach. Copra, dried coconuts, and water coconuts are sold at Kumaka market. Erosion is still taking away mature and young trees as it washes the shells away during high tide.
- Farming has been reduced due to the prolonged dry spell.
- Salt water has taken over the swamp, driving the freshwater fish away, including the hassar that was recently caught by the thousands.
- Fishing in the Atlantic Ocean is the same with small variations, positive and negative, depending on the catch, price, and cost of fuel. Current gasoline prices have reduced fishing activities.
- Ecotourism is nonexistent, as the community has had no recent visitors due to the lengthy and burdensome process prescribed by the SBPA authority. The SBPA authority also forbids visitors to walk on the beach in order to observe turtles. There have been fewer turtles observed on the beach since 2016, but the reduction in sightings may be as a result of reduced monitoring.
- Rain water is harvested for drinking and shell ponds are constructed to provide water for bathing and domestic chores.
- [Note: A new point 50_135 was added to the GIS dataset to show the SBPA Field Station on Almond Beach.]

Other Data Collected

- The village population is 51 persons.
- There are seven students currently attending the school on the beach.
- Erosion continues to affect the beach and livelihood activities. A comprehensive approach from the community, the Regional Democratic Council, and the Protected Area Commission is needed to address this issue.
- The community may need to be relocated further inland. This was previously proposed for an area inland but there has been no feedback on this plan.
- The community would like to re-introduce ecotourism but the SBPA authority restrictions are affecting this and other activities. There were previous awareness activities being conducted in relation to the sea turtle program, targeting schools, etc., but these are no longer being done.

1.1.13. Imbotero Community Development Council

Ecosystem Services Survey

- Almost everyone fishes in the Imbotero Creek and Barima River for daily catch. The community fisherfolk are not currently venturing out to Waini Point to fish, as they are afraid of having their outboard engine stolen by pirates.

- All hunting and fishing is done in proximity to the community, which has abundant resources. Building materials are also abundant in close proximity including mangroves for house building.
- Some villagers trap birds, reptiles, and small animals for sale to the wildlife traders or at Kumaka market. Some animals are caught for their meat especially in the dry season.
- The community now has a significant migrant population from Venezuela that has settled along the Barima River banks. [Note: Point 50_136 was added to the GIS dataset to show the Warraus settlement.] The migrants have been given temporary status to live and use the village resources. As such, there has been an increased use of the community's resources.

Other Data Collected

- The community currently has a population of 353 persons.
- The community currently has 153 Warraus migrants from Venezuela and is trying to cope with the influx of the migrants who are arriving with very little resources and materials.
- The government is currently providing some assistance to the migrants but this is not properly coordinated with the community. Also, this is causing tensions within the community since no assistance is being provided to the residents.
- The Warraus bring fish, hammocks, crafts, and household items for sale in the village and at Kumaka market.

1.2. Region 2

This section presents the feedback from the ecosystem services validation exercise within Region 2. Engagements with the following NDCs and TC within Region 2 were conducted during the period 28 May to 29 May 2019:

- Charity/Usara
- Evergreen/Paradise
- Aberdeen/Zorg-en-Vlygt
- Anna Regina Town Council
- Annandale/Riverstown
- Good Hope/Pomona

1.2.1. Charity/Usara NDC

Ecosystem Services Survey

- Approximately ten families in the NDC area are engaged in daily crabbing for their livelihoods. Some of these people travel to the Pomeroon River Mouth for crabbing. Crabs are in-season from July through September. During this time, there is an increase in the number of people crabbing.

- There has never been much hunting of wild animals in the area. However, hunting of wild birds has declined. In addition, some people catch iguanas, but not on a regular basis.
- The Big Bird Fish Complex at Charity is a major processing facility that processes large amounts of catch for export.
- There is significant erosion of the sea dam, mudflats, and mangroves along the shoreline of the NDC, which reduces the habitats for wildlife, birds, and crabs. This is especially prevalent along the coast of the NDC and in the Pomeroon River. Additional manmade sea defense structures like groins can be constructed to assist in capturing sediments by reducing the power of the washing waves.
- There is cash-crop farming and grazing on the sea dam and the sea defenses. There is more grazing when the rice lands are under cultivation. The cultivated areas are not adequately irrigated and need urgent investment in order for the land to reach its full potential for agricultural production.

Other Data Collected

- The population within the NDC area is 7,800 and has been stable.
- There is large-scale rice cultivation, which is water intensive in the NDC area. However, the Tapacuma Reservoir was not designed to provide irrigation for rice cultivation but for farming cash crops only. Incomes are higher in rice cultivation and this incentivizes farmers to cultivate rice in the NDC area. As a consequence, farmers have a shortage of fresh water for all crops particularly during the dry seasons.

1.2.2. Evergreen/Paradise NDC

Ecosystem Services Survey

- More than ten people from the NDC hunt crabs in the Summerset and Berks mangroves on a weekly basis for commercial purposes.
- Residents of the NDC hunt iguanas in the La Resource area for sustenance, and occasionally for commercial purposes. The iguanas are sold in the NDC for popular restaurants in the region. Shorebirds are also caught for both sustenance and sale. Some people hunt large lizards (salipenters) for meat and anacondas to sell to traders.
- There is an increase in fishing activity in the NDC mainly due to decreased rice cultivation. There are more fisherfolk at the Andrews Koker than previously reported. In addition, there are five boats in Evergreen and six at Perth. Castle is not located in the NDC area.
- Many cows graze in the Perth, Dartmouth, and Andrews areas. In addition, cows, sheep, and goats are grazed in the Better Hope to La Resource areas.
- The seashore areas at Paradise, Jib, Andrews, and Bounty Hall are used for religious activities. Residents of Westbury and Perth use the seashore in Dartmouth.

- Recreation activities are found at the Dartmouth Seawall, especially on Sundays when dominoes are played.
- Trees along the sea dam from Evergreen to Better Hope are being cut down, which is contributing to erosion.

Other Data Collected

- The population in the NDC area is 7,500.
- There has been a decline in rice cultivation in the NDC area due to lower rainfall and saline intrusion into the drainage and irrigation system. This has led to more mixed farming with multiple crops being grown, including an increase in red peas in Dartmouth.
- Grazing of animals in the NDC area has increased.

1.2.3. Aberdeen/ Zorg-en-Vlygt NDC

Ecosystem Services Survey

- There are approximately 15 boats and 40 families engaged in fishing in the NDC. These boats use landing sites at La Union, Three Friends, and Capoey Koker depending on the accessibility of these sites.
- There is a new growth of mangroves in the NDC, which has resulted in iguanas, crabs, and new species of birds in the area. Crabs are caught and sold daily from persons both within and outside the NDC. In addition, approximately 60 to 70 persons hunt iguanas daily for sale at prices ranging from $3,000 to $5,000 GYD (approximately $14.35 to $23.92 USD). Currently, there is no hunting of wild birds.
- Mangroves are washing away at Columbia. At this locale, the government has installed bamboo groins at Columbia, Aberdeen, and Affiance, which help to protect the shoreline and reduce erosion along the coast of the NDC.
- There is a rearing camp for cattle at the seashore at Hoff-Van-Aurich and La Union.
- Many persons graze their animals on the sea dam and over the seashore. There has been a small increase in the amount of cattle present in the NDC.
- There is a cremation site at La Union that is used by the entire Essequibo coast.
- Many persons use the sea wall in Queenstown for recreation purposes.

Other Data Collected

- There are significantly more mosquitoes in the NDC area due to the regrowth of mangroves.
- Coconuts have been growing wildly along the seashore beyond the rip raps, particularly in Queenstown. This is aided by the accretion of mud in the NDC area. However, there is no large-scale cultivation of coconuts in the NDC.

1.2.4. Anna Regina Town Council

Ecosystem Services Survey

- There has been significant regrowth of mangroves in the municipality and mangrove growth continues to increase. This has resulted in negative impacts for residents including:
  - Increasing mosquitoes that deter people from visiting the seawall. There are also more mosquitoes in residential areas within the municipality.
  - The accumulation of mud and sediments on the seashore that blocks the channel. In some instances, grazing animals become stuck in the mud and die. In addition, sometimes fishing boats become stuck in the mud and dead fish are dumped into the mud. These create odors and also act as breeding grounds for mosquitoes.
  - The beach at Anna Regina has been lost due to the accretion of mud. At Easter, which is the biggest day for recreation activities at the seawall and beach, there was a lower turnout than in previous years and those that visited left early. In addition, people can no longer access the seashore to conduct religious activities.
- There are landing sites at Sparta with 15 boats, Hampton Court with 20 boats, Anna Regina with 15 boats, Walton Hall with 10 to 12 boats, and Lima with 10 to 12 boats. Overall, fishing activities have declined in the municipality; this is partly attributed to the ban on exports of the gillbacker.
- More than 50 people visit the Henrietta seawall on a daily basis, particularly to access the open Wi-Fi hotspot supplied by the government. Softball cricket matches are also played on the beach.
- There is crop cultivation on the government reserves at Lima, Walton Hall, Anna Regina, and Devonshire Castle.

Other Data Collected

- There are approximately 22,000 persons in the municipality. In addition, the boundaries of the township were expanded since the last visit to include Lima Sands.
- There are approximately 5,000 persons from Venezuela scattered throughout the township comprising both returning Guyanese and native Venezuelans.
- Rice cultivation has declined in the municipality due to declining rainfall and a paddy bug infestation.
- There are two excavators on pontoons in the channel leading to the koker in Anna Regina that keep the channel clear due to the accretion of drift mud.

1.2.5. Annandale/Riverstown NDC

Ecosystem Services Survey

- There are fishing landing sites at: Golden Fleece with 2 boats, Zorg with 5 boats, Adventure with 2 boats, Riverstown with 1 boat, and Abraham Zuil with 20 boats, including 2 new anchor seine boats.
- Fishing activities have increased in the NDC area because other employment options are limited.
- Grazing of cows has increased on the seawall and sea dams.
- Religious activities are conducted throughout the NDC but mostly at Golden Fleece.
- There are recreational activities at the seawalls at Perseverance, Golden Fleece, and Suddie, where there are cricket matches, football matches, and barbecues on weekends.
- The beach at Cullen is popular but needs upgrading to facilitate tourism activities. The NDC is seeking to build stands and washroom facilities that will improve the services offered at the beach. Dumping of garbage on the seashore should also be reduced.

Other Data Collected

- There are 10,840 persons in the NDC. This count was completed in 2018 and includes Venezuelan migrants.
- The Venezuela migrants include returning Guyanese and native Venezuelans. It is alleged that many of the migrant women engage in prostitution, which causes significant, negative impacts to the local population.

1.2.6. Good Hope/Pomona NDC

Ecosystem Services Survey

- There are fishing landing sites at: Pomona with 10 to 12 boats, Riverside Creek with 10 to 12 boats, Riverstown with 6 boats, and Vilvoordeen with 15 boats. Fishing boats also occasionally land at Supenaam. There has been an increase in fishing in the NDC area due to declines in other economic sectors, such as rice and livestock.
- Families who live close to the seashore often engage in nearshore fishing and have their own small boats to conduct fishing activities. There are two boats at Good Hope which are used for this type of fishing.
- There are wharves to facilitate shipping of raw materials for construction, commercial products, and exports. There are three wharfs in Fairfield, one in Good Hope, one in Spring Garden, one in Vilvoordeen, and one in Riverstown.
- There is grazing of animals along the seashore starting from Riverstown Creek.
- Hunting of iguanas has increased and is done by persons from both within and outside the NDC area.

- There are beaches for recreation purposes at Vilvoordeen, Aurora, Spring Garden, and Good Hope.
- There are religious activities on the seashore throughout the NDC. The Spring Garden temple is located close to the shoreline.
- There is significant erosion along the coastline of the NDC. Tiger Island is helping to slow the rate of erosion. Currently, revetments are being installed at Aurora. Similar sea defense measures are needed at other locations in the NDC.
- The landing area at Supenaam is being enhanced.
- [Note: The GIS datasets should include the label "Itribisi Lake" at the point 6_15 as a portion of this lake falls within the NDC; remove "West Demerara" from the points at 6_10 and 6_11; clarify the Tiger Island is under management of Region 2.]

Other Data Collected

- There are approximately 10,000 persons in the NDC and the population is increasing. This includes previous residents returning to the NDC area, migrants from Venezuela, and Amerindians moving from inland areas of Region 2.
- There are several new houses in the NDC.

1.3. Region 3

This section presents the feedback from the ESS Validation Exercise within Region 3. Engagements with the following NDCs within Region 3 were conducted during the period of 9 to 12 July 2019:

- Wakenaam
- Leguan
- Mora/ Parika
- Hydronie/ Good Hope
- Greenwich Park/Vergenoegen
- Tuschen/ Uitvlugt
- Stewartville/Cornelia Ida
- Hague/ Blankenburg
- La Jalousie/Nouvelle Flanders
- Best/ Klien/Pouderoyen

1.3.1. Wakenaam NDC

Ecosystem Services Survey

- Fishing is done on both sides of the island. Some boats are owned by persons from the island, while other boats come from the West Coast of Demerara. The fishing area is shared with residents of Leguan and approximately 20 to 30 boats operate in the area.
- Many residents catch crabs from July to September, but a few residents catch crabs all year in the mangroves on the island.

- During April to September, fisherfolk catch shrimp during the shrimp season and dry it on the sea defense wall.
- During the dry season in July to September, residents catch iguanas for recreation and sustenance.
- By empoldering, some people plant/farm on the sea defense reserves and consider upkeep of farms along the Essequibo and on Tiger Island, Hogg Island, Truli Island, and Karia Karia their responsibility.
- Animal grazing is not a challenge—animals are either tied in the farming areas to graze or graze freely in Palmaria, Zeelandia, or New Friendship.
- The beach at Zeelandia has significantly eroded over the years.
- There are 46 kokers around the island, which provide drainage and irrigation.
- There is a pending proposal to construct and operate a solar farm on the island.

Other Data Collected

- At its peak, the population of the island was 18,000 but is now 3,300. This is likely due to the fact that there are not many jobs on the island and islanders seek employment elsewhere and the majority of current residents are self-employed.
- There is an increase in the presence of Amerindians from various areas of the country and many of these Amerindians are seeking employment.
- The plantain chip factory that was constructed in 2014 is not yet operational, but is expected to bring about 30 jobs to the island.
- Plantain production has been increasing recently. It is estimated that the island exports five boats, each with approximately 15,000 pounds of plantains, every day.
- The island does not have a landfill site or garbage collection system, which results in dumping in waterways.

1.3.2. Leguan NDC

Ecosystem Services Survey

- Residents hunt iguanas (which are plentiful on the island) for recreation, sustenance, and sale.
- Several residents from the island catch and sell crabs from the mangroves on a weekly basis.
- Fishing has increased in the NDC mainly due to the decreased rice cultivation. There are around 25 fish and shrimp boats on the island.
- There is significant grazing in the NDC, which is concentrated between Better Hope and La Resource. Grazing has been constrained by the river defense works at Maryville, Success, and Thieres.

- Shorebirds are rarely caught for their meat and only in the summer months. Grassland birds are caught and kept in cages to become pets, with some sold at Parika.
- Recreation activities often occur at Canefield and Success beaches, especially on weekends when many games are played.
- Guyana Energy Agency is looking to set up a wind farm at Dauntless Point on the island.
- The island is considered by residents to be rich in natural gas, with pockets reportedly visibly flowing out of the ground in Belfield and Richmond. One resident traps the gas and uses it for cooking.
- A new wharf was recently constructed at Belfield. It facilitates shipping of construction materials.
- Farming has declined along the shoreline as a result of construction of the sea defense.

Other Data Collected

- The population on the island was 10,000 at its peak, but is currently 2,700.
- There are not many jobs on the island and the majority of the residents are self-employed.
- Economic activities on the island fluctuate, depending on rice cultivation and price.
- There are about 20 speed boats providing transportation to Parika.
- The island is challenged by the absence of a landfill site or garbage collection system, which results in dumping along the shoreline and in trenches.

1.3.3. Mora/ Parika NDC

Ecosystem Services Survey

- Within the Essequibo River, Parika remains the hub of river transportation with speed boat services, shipping, ferry, etc.
- There are a few fishing boats operating in the NDC at Kent and Hyde Park. The boats move around the NDC tracking the catch. In general, the deep sea trawlers are found at Big Kiss and Shairaz wharfs.
- Grazing has significantly declined as a result of the sea defense works and theft.
- There are seven house boats in the NDC and two associated parking lots.
- There are five dockyards for ship repairs in the NDC.
- There are 10 wharves within the NDC—two being recently constructed.
- Squatting along the shoreline remains a big challenge for the NDC, with more persons migrating to the NDC and seeking low-cost housing.
- The religious activities are about the same, with the Hanuman Murti being a new feature at the riverside of the NDC.
- Residents of Bird Island are protecting the island as a safe haven for birds.

- Mangroves are sparse within the NDC, with mainly boulders as the sea defense. The sea defense is currently being rebuilt between Grove and Hyde Park.

Other Data Collected

- The population within the NDC is currently 12,000 and is increasing due to an influx of people from other areas of the country seeking employment.
- There is some squatting inland by Guyanese nationals who have recently returned from Venezuela.
- There has been an increase in economic activities related to small business and service providers.
- The NDC is a major hub for commercial activities within Region 3.

1.3.4. Good Hope/Hydronie NDC

Ecosystem Services Survey

- The sawmill at Bushy Park is now closed; however, there are other economic activities in place such as the pre-casting concrete plant.
- Crops are still being planted along the shoreline.
- In addition to Ruby Koker, there are a few fishing boats operating from the Orangestein Shore.
- The Orangestein beach is used a landing site for large vessels.
- Two new wharves were built at Orangestein.
- There are two burial grounds along the sea dam in the NDC at Good Hope and Ruby.

Other Data Collected

- The population within the NDC is currently 4,200.

1.3.5. Greenwich Park/ Vergenoegen

Ecosystem Services Survey

- There are seven fishing boats, although they are also used to catch shrimp, at Greenwich Park along the sea dam, while there are approximately 25 more fishing boats at the Vergenoegen Outfall.
- Approximately 10 to 15 NDC residents dry fish for sale on a large scale, only four of whom have permits to do so.
- There is an increase in recreational use of the seawall and, aligned with this, the government is interested in building up the seawall area at Vergenoegen for recreational use.
- There is grazing along the sea dam at Greenwich Park and Barnwell. This area is completely blocked off by the residents.

- Religious activities are also conducted mainly in Barnwell, Philadelphia, and Greenwich Park in the NDC.
- Residents continue to use the sea defense reserve for farming.
- There are some squatters on the sea defense reserve.
- Most of the mangroves from are now gone.

Other Data Collected

- The population within the NDC is currently 2,600.
- There are about 75 Venezuelan migrants within the NDC.
- There has been an increase in small businesses such as supermarkets and wash bays.
- Illegally dumping waste in public spaces is a common issue in the NDC.

1.3.6. Tuschen/ Uitvlugt NDC

Ecosystem Services Survey

- There are 25 fishing boats at each of the sites Zeelugt, Zeeburg, and Uitylugt, respectively.
- Large scale shrimp processing occurs at Zeeburg, while large scale fish processing occurs at Zeelugt. All of this occurs on the sea walls or sea defense reserves.
- Grazing occurs in open areas in Zeelugt, Uitvlugt, and Tuchen; however, these areas are limited because of cash crop farming on the sea defense reserves and the shrimp and fish processers.
- Residents utilize the seawall for exercise and recreation, although some residents are deterred from using this space because there is significant garbage along the shore that distracts from quality time along the seawall.
- The NDC has a number of schools and parks in close proximity to the sea defense.
- Squatting along the shoreline area has increased since the previous engagement. This is occurring at several areas in the NDC.

Other Data Collected

- The population within the NDC is currently 35,500. There are new housing accommodations at Zeelugt, Tuschen, De Williem, Zeeburg, and Uitvlugt. It is expected that the population will continue to increase as a result of these accommodations.
- There is a significant migrant population within the NDC, which includes Guyanese nationals returning from Venezuela.

1.3.7. Stewartville/ Cornelia Ida NDC

Ecosystem Services Survey

- There are 15 fishing boats at Leonora, 8 boats at Anna Catherina, and 3 boats at Cornelia Ida.
- Large scale fish and shrimp processing occurs at Leonora; large scale shrimp processing occurs in Anna Catherina. All of this processing occurs, on the seawalls or sea defense reserves. Some residents have built their own drying floors and storage facilities on the sea defense reserves.
- Ducks and pigs are reared on the sea defense reserves, being drawn by the fish disposed by the fisherfolk.
- Grazing occurs in open areas throughout the NDC; however, this area is limited by squatters in Anna Catherina and Stewartville.
- The sea walls at Stewartville, Leonora, and Anna Catherina are used for recreation and religious practices on a daily basis.

Other Data Collected

- The population within the NDC is currently 30,000.
- It is estimated that there are 200 to 300 Venezuelan migrants within the NDC, consisting primarily of returning Guyanese nationals.
- There has been an increase in small businesses within the NDC.

1.3.8. Hague/ Blankenburg NDC

Ecosystem Services Survey

- There are approximately 10 fishing boats operating at Hague in the NDC, which is less than previous counts. This is likely due to the US embargo on catfish and heightened fears of piracy.
- Grazing has increased on the sea defense and shore, as the owners avoid the public road where thieves monitor.
- Recreation activities have been reduced with the rehabilitation of the sea defense and the erosion of the beach; however, many residents—upwards of 200 on weekends—continue to visit the Den Amstel sea walls for recreation and exercise. Recreation activities have also likely been reduced as a result of the significant amount of garbage that washes up along the shoreline.
- Approximately 20 residents use hooks, lines, seines, cast nets, or fishing rods to catch fish and shrimp on a daily basis at Den Amstel and Blankenburg.
- There are mangroves beyond the sea defense where birds roost.
- The religious activities are about the same within the NDC as they were in 2017.
- Shrimp drying no longer occurs, as the seawall—which was historically used—has been updated as part of sea defense works.

Other Data Collected

- The NDC population remains 4,200.
- There has been an increase in small businesses within the NDC such as wash bays, taxi services, and supermarkets.

1.3.9. La Jalousie/ Nouvelle Flanders NDC

Ecosystem Services Survey

- The mangroves in the NDC have been completely eroded. The wildlife has migrated east to the mangroves in the neighboring NDC.
- There are approximately 20 fishing boats in the NDC. There are three fish mongers who sell prized catfish (gillbacker) daily by the Windsor Forest koker.
- The main areas for religious activities are at Blankenburg, Windsor Forest, and the Cremation Site.
- The Cremation Site continues to be one on the most used site in the country, with as many as three cremations per day.
- Grazing is not a significant activity on the reserves anymore. Some animal graze on the sea defense reserves or graze freely; however, more animals graze in the burial grounds inland, south of the shore.
- There is almost no hunting of shorebirds. There is no other biodiversity inhabiting the shoreline within the NDC.
- During the weekdays, approximately 30 residents exercise or recreationally use the Windsor Forest sea wall daily, while during the weekends more than 100 residents exercise or recreational use this area. The previously existing beach is now completely eroded.

Other Data Collected

- The population within the NDC is approximately 5,500 and is increasing due to three new housing accommodations. Guyanese nationals returning from Venezuela are also contributing to an increase in the NDC's population.
- There has been a small increase in small businesses within the NDC such as supermarkets.

1.3.10. Best/ Klien/ Pouderoyen NDC

Ecosystem Services Survey

- There are 75 speed boats registered to work at the crossing between Georgetown and Vreed en Hoop, with 53 working on a daily basis.
- There are 11 fishing boats docking at Vreed en Hoop, Phoenix Park, and the Jetty.

- Grazing mostly occurs in the Best Village and Pouderoyen area. Cows are tied and goats and sheep are allowed to roam freely.
- The NDC's mangroves are increasing, but are under threat from squatters who are clearing them and using the trees and shrubs for building materials.
- A few residents catch crabs on a daily basis as their livelihood, and more residents participate in the industry during crab season.
- Little hunting—mainly iguanas—occurs in the area.
- Tourists, primarily bird watchers, visit the NDC as part of tours organized by operators located in Georgetown.
- The shoreline is being actively considered for the development of shore-based facilities.

Other Data Collected

- The population within the NDC is approximately 25,000 and is increasing due to migration. Guyanese from the hinterlands and other rural areas move to the area, as well as Venezuelan migrants.
- There has been an increase in small businesses within the NDC.

1.4. Region 4

This section presents the feedback from the ecosystem services validation exercise within Region 4. Engagements with the following NDCs within Region 4 were conducted during the period 8 May to 10 May 2019:

- Industry/Plaisance
- Better Hope/La Bonne Intention
- Beterverwagting/Triumph
- Mon Repos/La Reconnaissance
- Buxton/ Foulis
- Enmore/Hope
- Haslington/Golden Grove
- Unity/Vereegining

1.4.1. Industry/Plaisance NDC

Ecosystem Services Survey

- The mangroves are now more prevalent along the shoreline within the NDC and are taking over parts of the shore completely, especially between Ogle and Plaisance. The mangroves offer shoreline protection by helping the shells and mud to accumulate and build, which further buffers the sea defense.

- The locals hunt sea birds, including the Scarlet Ibis on occasion, mainly in the summer months when the birds are plentiful in the area. The birds avoid the areas near the shore, feeding in shallow mud a few hundred meters from the seawall, thus making it additionally challenging for hunters to get close enough to catch them.
- In addition to worshipping at the seashore by Hindus, the Jordanites (a religious group within Guyana) conduct baptisms at the Ogle Koker and there are African Libation Ceremonies twice per year.
- There is squatting occurring in close proximity to the sea defense at Plaisance.
- [Note: Recreation areas should be changed in the GIS dataset from Cummings Lodge–UG Road to Cummings Lodge – Ogle.]

Other Data Collected

- The population within the NDC area is approximately 25,000 and should be increasing given that there are new housing schemes within the area.
- The NDC has seen the growth of small businesses in recent times, including an influx of migrants who work mainly in the bars.
- The major challenge in the NDC is the illegal dumping of garbage along the shore that ends up in the mangroves. A youth group in Plaisance is actively cleaning up the shoreline on a regular basis, but its efforts are not enough to address the garbage problem.
- The increasing use of the Ogle Koker by fisherfolk has decreased its aesthetics with the build-up of shacks and the odor of decaying fish.

1.4.2. Betterhope/LBI NDC

Ecosystem Services Survey

- The NDC monitors the growth of the mangroves within the area and has observed that mangrove growth along the shoreline continues to increase. This has resulted in:
  - An increase in mosquitos that has limited the use of the shoreline for recreation and religious practices. Religious activities have moved to Ogle or Mon Repos, where there is better access and less sand flies and mosquitoes.
  - An increase in garbage dumping within the mangrove area, which is challenging to clean.
  - Blocking access to the sea which affects the fisherfolk.
- There has been a reduction in grazing of animals on the shoreline and adjacent areas.
- There is salt fish drying along the seashore at Montrose.
- There was no new activity within the NDC along the seashore.

Other Data Collected

- The estimated population is 30,000; the population is increasing.
- There was a report of mangrove destruction at Pigeon Island.

1.4.3. Beterverwagting/Triumph NDC

Ecosystem Services Survey

- A new housing area is changing the land use. The NDC is building a housing scheme of 22 lots for residents at Triumph North. The project has reduced the area available for grazing animals.
- There has been a reduction of grazing along the shoreline. The NDC places high fines for stray cattle and many farmers have moved their animals to the back lands which are being developed by the Rural Agricultural Infrastructural Development Project for agriculture purposes.
- There is not much change in the mangrove cover despite the rapid growth in other NDCs.
- There are new businesses in the NDC over the last year, including Chinese supermarkets.

Other Data Collected

- The population is approximately 7,000.

1.4.4. Mon Repos/La Reconnaissance NDC

Ecosystem Services Survey

- A heliport and a hotel are proposed for the sea defense area at Lusignan, with the site already cleared for the construction to commence.
- An application for a coconut processing center in close proximity to the shoreline at Annandale is currently being reviewed by the NDC.
- A new private housing scheme consisting of 17 houses is being constructed close to the sea defense at Good Hope. Eight of the houses are already constructed.
- In Mon Repos, mangrove growth has increased. This has resulted in:
  - The fisherfolk experiencing difficulties in accessing the landing area along the shore.
  - An increase in mosquitoes. The NDC has a fogging machine to help with the mosquitoes, but has not used it due to the lack of knowledge in mixing the chemicals and operating the machine.
  - An increase in garbage within the mangroves.
- There are more than 100 fishing boats within the NDC employing approximately 400 to 500 people, mainly from the villages of Mon Repos and Annandale.
- The NDC has a mangrove plot with an abandoned play park for recreational activities that is overgrown by vegetation. The NDC plans to refurbish the park for recreation and tourism purposes.

Other Data Collected

- The population is approximately 40,000.
- The NDC has an influx of migrants (Guyanese returning from Venezuela as well as Venezuelan citizens), but they are mainly employed in various businesses and are not squatting on the NDC reserves.

1.4.5. Buxton/Foulis NDC

Ecosystem Services Survey

- There is no new mangrove growth within the NDC except for the National Agricultural Research and Extension Institute (NAREI) plots at Mon Repos and Vigilance. However, the growth of mangroves has created security issues for recreational users who are now avoiding these areas.
- There are some changes to the fish landing sites within the NDC as a result of mud accumulating along the shoreline. Boats are now landing at Non Pariel.
- There is less grazing in the NDC as more animals were lost to thieves preying on the animals in the bushes.
- The local squatters vacated the area at the Buxton sea dam on their own accord.
- There is seasonal hunting of the birds on the shore by a few individuals.

Other Data Collected

- The population is approximately 7,000.
- There are new businesses in the NDC, including three Chinese supermarkets.
- More people are involved in fishing as a means of supplementing their incomes since the closure of the Enmore Sugar Estate.
- A group of Venezuelan migrants with Guyanese family members is now squatting at Non Pariel.

1.4.6. Enmore/Hope NDC

Ecosystem Services Survey

- The area is under economic depression due to the closure of the sugar estates. There is more demand on the fishing resources offshore, in the canals and wetlands, and within the mangroves. The wetland is an important source of tilapia that is caught for sale by many residents of the NDC.
- The fisherfolk have good access to their landing area as the access was upgraded by the National Drainage and Irrigation Authority. The improved access is also used by the pin seine fisherfolk.
- There are two to three persons who conduct pin seine fishing using catamarans to access to fishing ground.

- Shrimp is caught by persons dragging seines along the shoreline.
- The mangroves are increasing within the NDC shoreline, which has reduced recreation in the area.
- Some birds, such as the plovers, are caught using wire along the shoreline.

Other Data Collected

- The population is approximately 8,000.

1.4.7. Haslington–Golden Grove NDC

Ecosystem Services Survey

- The NDC is developing the beach at Victoria/Haslington for recreation and tourism purposes. There is a Regional Tourism Committee that is spearheading tourism development within the Region.
- There is an increase in the number of fishing boats within the NDC, which is directly employing more local people. The number of catamaran fisherfolk has decreased as the mud flats have moved beyond the boundary of the NDC.
- The level of grazing within the NDC has decreased with many of the animals moved to the back lands where there are more grazing grounds.
- Two persons in the NDC engage in bee keeping at Golden Grove.
- The locals catch fish in the swamps beyond the sea dam. The catch is offered for sale in and out of the NDC.
- There is a minor increase in squatting near the sea defense.
- Weekend activities such as parties have increased along the seawall area.

Other Data Collected

- The population is approximately 27,000 and is increasing due to new housing schemes within the NDC.
- An old coconut estate is being cleared and prepared for rice cultivation.

1.4.8. Unity/Vereeniging NDC

Ecosystem Services Survey

- More boats are now docking on the Mahaica River due to security concerns arising from the previous docking areas, especially the Helena Landing Site, which now has about 25 boats. There are more than 150 fishing boats in the NDC of different types employing more than 500 people directly in fishing and an additional 500 people in supporting services.
- The fish landing site at the old Mahaica River Bridge falls within the Woodlands–Farm NDC and not within this NDC. This site has about 15 to 20 boats.

- The two landing sites at Unity should be separated, with the Riverview site at the Mahaica River mouth having about 50 boats, while the landing site at the Unity shoreline has fewer boats (less than 20 boats).
- Grazing within the NDC remains the same; however, the changing land use is detrimental to grazing animals.
- Mangrove growth remains the same and the wood is used by farmers and fisherfolk.
- There is an increasing number of people who hunt iguanas and wild birds on a weekly basis for sale to wild meat enthusiasts.
- The wharf facilities remain the same but there are plans to expand the wharf to facilitate additional development in the area.

Other Data Collected

- The population is approximately 13,000.

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ATTACHMENT A: REGISTRATION SHEET

Attachment A1: Region 1

Name	Designation	Contact Information
Father's Beach VC		
B. Boyer	Farmer	
Steve Goddette		
Romario James		
Celine Van Sluytman	Councillor	On file
Genevieve Van Sluytman	Toshao	On file
Manawarin VC		
Rekem Lyte		On file
Ameir Miller		
Tenessa Miller		
Conan John		
Roland Tobin		
Roxanne Henry		On file
Wanita Lyle		
Menelva Roberts		
Merona Fredericks		
Ian Singh	Teacher	On file
Anika James	Teacher	On file
Taren	Student	On file
Mazema	Student	
Meshella	Student	
Nicola	Student	
Selia	Student	
Lona	Student	
Maritta	Student	
Brinton	Student	
Simon	Student	
Charwayne	Student	
Lewis Miller		
Christopher James	Community Health Worker	On file
L. Lall		
Dwain Vieira		
Ted Fredreicks		

Name	Designation	Contact Information
Reuben Lyte	Farmer	On file
Roy Miller	Farmer	On file
Golin Shew	Teacher	On file
Heidi Martinez	Teacher	On file
Elisha George	Teacher	On file
George	Teacher	On file
Nedera George	Teacher	On file
Violet Samuels	Teacher	On file
Edna James	Cook	
Shermine John	Cook	
Genith Roberts	Teacher	On file
Louyann Henry	Teacher	On file
Melindia Henry	Teacher	On file
Phillip Williams	Teacher	On file
Lovern Williams	Shop Keeper	On file
Waramuri VC		
Learmond Emmanuel	Toshao	On file
Ivan Holmes	Villager	On file
Sharmayne De la Cruz	Councillor	On file
Ernest Boyal		
Derick Henry	Councillor	On file
Santa Rosa VC		
Mary De Silva	CDO	On file
Whanita Phillips	Toshao	On file
Michael Anthony	Councillor	On file
Alopius Daniels	Councillor	On file
Murphy Rodrigues	Councillor	On file
J. Shawn Atkinson	Councillor	On file
Mebach Atkinson	Resident	On file
Tracy Bhojedat- Hetsberger	Councillor	On file
Assakata VC		
Eugene Daniels	Farmer	On file
Henry	Teacher	On file
Margery Jacobs	Farmer	On file
Melissa Richards		On file
Canace Bloomhart		On file
Francine Domingo		On file
Eyon Lucas	Farmer	On file
Donna Charles		

Name	Designation	Contact Information
Mariette Henry		On file
Reno Williams	Logging	
Fazeela Joseph		
Levi Daniels		
Shermela Bloomhunt	Farmer	On file
Sharon Daniels	Farmer	
Rockesha Henry		
Terrence Henry	Farmer	
Mitzi Daniels	Health Worker	On file
Cynthia Conyers	Housewife	
Karen Daniels		On file
Clinton Anthony	Farmer	
Clifton Henry	Farmer	
Alban Cyroms	Farmer	
Cyri Joseph	Farmer	
William Henry	Farmer	
William Conyers		
Warapoka VC		
Nalini Wilson	Teacher	On file
Pamela Williams		
Deon Henry	Farmer	
Marcus Boyal	Farmer	
Duncan Henry	Farmer	On file
Michelle Welcome	Farmer	
Grace Henry	Farmer	
Dave		
Dolly Henry		
Neil Thornhill		
Leroy Henry		
Victor Welcome	Farmer	
Carlene Wilson	Manager	On file
Joseph Boyal	School Teacher	On file
Malini Pierre		
Vashty Rodrigues		On file
Terrence Welcome		
Levi Lucas		
Annika Lucas		

Name	Designation	Contact Information
Three Friends VC		
	Toshao	
Mabaruma Town Council		
Celestine Chacon	Secretary	On file
Maria Basheer	Town Clerk	On file
Egbert Dubrg	Supt. of Works	On file
Chris Phang	Mayor	On file
Aruka Mouth CDC		
Malissa Pritchand	CDC Chairperson	On file
Mario Mc Lennon	Farmer	On file
Elton O' Neil	Fisherman	On file
Shane Yipson	Fisherman	On file
Manuel Rodrigues	Fisherman	
Norris Joseph	Fisherman	On file
Elion Allicock	Fisherman	On file
Randy Webber	Fisherman	
Warell David	Fisherman	
Desmond Joseph	Fisherman	On file
Randolph Webber	Farmer	
Sharmin Joseph	HM (ag)	On file
Smith's Creek CDC		
Leolie Borin	Farmer	
Stanley Sam	Farmer	
Augustine Lockan	Fisherman	
Reynold Santiago	Fisherman	
Jousu Lakan	Fisherman	
Mario Williams	Fisherman	
Clemet Borin	Fisherman	
Wendy Borin	Farmer	
Elizabeth Sam	Crab Catcher	
Celia Lewis	Housewife	
Jermey Bumbury		
Junita Sam		
Elizabeth Lewis		
Lucy Williams		
Ingrid Williams		
Sherman Lewis	CDC	On file
Boodwah Sookdeo		On file

Name	Designation	Contact Information
Morawhanna CDC		
Marlon Smilther	Businessman	On file
Andre Roberts		
Rebecca Roberts		
Melrose Pritchard	Teacher	On file
Susanna Phillips	School Cook	On file
Terrence Rufino	CDC	On file
Sylvia Roberts	Health Worker	On file
Rianna Jaggernath		
Ruben Solomon		
Shanaaz Rufino	Teacher	
Akeem Marks		
Zaheer Khan		
Almond Beach CDC		
Ricardo Thomas	Farmer	On file
Arnold Benjamin	CDC Chair	On file
Alicia France	Teacher	On file
Kistow Augustus	Teacher	On file
Myles Pierre	PAC employee	On file
Ken Joseph	Monitor	On file
Timothy Andrews	Ranger/ Tour Guide	On file
A. Campbell	Ranger	On file
Violet James	Housewife	
Imbotero CDC		
Ashton Williams	Farming	
Patrick Sam	Farming	On file
Jeanette Jack	Poultry Farming	
Mary Anastacio	Housewife	
Indra Harris	Poultry Farming	
Georgia Marley Morphy		
Josephine Martin		
Dolores Anselmo		
Susan Raseo		
Morcoline Martin		
Julio Valenzuela		
Raul Marquez		
Miser Marquez		
Mariani Raseo		
Lisandra Raseo		

Name	Designation	Contact Information
Trecia Jerome		
Norma Santagio		

Attachment A2: Region 2

Name	Designation	Contact Information
Charity/Urasara NDC		
Rameez P. Baksh	Assistant Overseer	On file
Peter Pammoogan	Labourer	On file
Carita Perreira	Market Clerk	On file
Gregory Ryan Van Sluytman	Manager	On file
Tamesh Kishore	Chairman	On file
Samuel Sooklall	Overseer	On file
Deleep Singh	Businessman	On file
Evergreen/ Paradise NDC		
Edmund Price	Checker	On file
Keith Bellfield	Supervisor	On file
Gw eneth Mc Farlane		On file
Lionel Boodhram	Chairman	On file
Inez Grant		
Mohamed Ahmad		On file
Kissoonlall Jaw akoorlall		On file
Kira Sukhnandan	E.H.A	On file
Wazim Ramdin	E.H.A	On file
Savita Deochan	Overseer E/P NDC	On file
Aldrin Shepherd	Teacher	On file
Yvette Ramnaught	C.E.T.L	On file
Anna Regina Town Council NDC		
Jew an Persaud	Rice Farmer	On file
Rajendra Prabhulall	Mayor	On file
Esther Alves	Environmental Health Asst.	On file
Ravindra Persaud	Environmental Health Asst.	On file
Radika Narish Lall	Municipal Treasurer	On file
Muhammad Rafeeq	Security Guard	On file
Chandanie Kissoon	C/ Secretary	On file
Diane Critchlow	Tow n Clerk	On file
Bissoon Lalltoo	Ranger	On file

Name	Designation	Contact Information
Rajkumarie Deonarine	Finance Clerk	On file
Rudolph C.G Williams	Deputy Mayor	On file
Dew an Persaud	Councillor	On file
Wazeer Dhanraj	Market Clerk	On file
Aberdeen/ Zorg-en-Vlygt NDC		
Jayashree Persaud	Chairperson	On file
Stephon Vaughn	Councillor	On file
Cromw ell Mentis	Councillor	On file
Sharmen Henry	Councillor	On file
Danieram Singh	Overseer	On file
Hansranie Ow eri Jodhan	Councillor	On file
Kumar Rambo	Furniture Manufacturer	On file
Deodat Persaud	Ranger/ COR	On file
Ghansham Persaud	Councillor	On file
Safeek Mohamed	Councillor	On file
Annandale/ Riverstow n NDC		
Soorsattie Sankar		On file
Marva S. Chappelle		On file
Charran Sarabjeet	NDC Chairman	On file
Esther Connelly	Environmental Health Asst.	On file
Heamw ant Narine	Public Health Inspector	
Seerojanie Singh	Vice Chairperson	On file
Balw ant Singh	G. Fleece	On file
P. Rupnarayan	Market Clerk	On file
T. Daniels	Assistant Overseer	On file
Rockel Williams		On file
Ramkew an Dass		On file
Good Hope/ Pomona NDC		
Andy E. Ramnarine	Teaching (NDC Chair)	On file
Deona Dean	EHA	On file
Yograj Bhow an	CETL (CIIP)	On file
Purandai Rupnarayan	Environmental Health Officer	On file
Rovin Doolara	Ranger Ch/P NDC	On file
Misha Persaud	Overseer Ch/P NDC	On file
Arnold Adams	Vice Chairman	On file

Attachment A3: Region 3

Name	Designation	Contact Information
Wakenaam NDC		
Jeanette Harrylall	Vice Chairperson	On file
S. Saaed Ahmad	Chairman	On file
Yogita Thakur	Overseer	On file
Sabita Persaud	Typist Clerk	On file
Yuyul Chaula	Superintendent of work	On file
Luasieann Whyte	Student	On file
Afera Zafull	Student	On file
Ackbar Alli	Councillor	On file
Lynnell Graham	Environmental Health Asst.	On file
Leguan NDC		
Mahindra Ganpat		On file
Lachhman Dwarkha		On file
Sheik Ayube		On file
M. Phaghu		On file
E. Ayube		On file
E. Ramroop		On file
Fazia Ali		On file
Tuslie R. Singh	Overseer	On file
Jainarine Singh		On file
Balgobin Magon		On file
Mustapha Zaman	Field Foreman N.D&IA	On file
Mora/ Parika NDC		
Phillip France	Councillor	On file
Aleassa Peters	Overseer	On file
Siddique Jameil	Environmental Health Asst.	On file
Resay Rodrigues	Student	On file
Raywatti Outar	Vice Chairperson	On file
Y. Khan	Councillor	On file
Jaideo Sooklal	Farmer/ Cman	On file
Melita Chaitram	Student	On file
Donald Nauth	Councillor	On file
Hydronie/ Good Hope NDC		

Name	Designation	Contact Information
Viola Vaughn	Housewife	On file
Nafleem Phillips	Housewife	On file
Felisha Coleman	Housewife	On file
Yugisthir Hemrup	Farmer	On file
LP Ramotar	Farmer	On file
A. Ragnauth	Farmer	On file
S. Singh	Housewife	On file
Moses Ramjohn	Labourer	
Perasram Persaud	Contractor	On file
Bibi Khadija McLennan	Councillor	On file
Greenwich Park/Vergenoegen NDC		
Steaphen Ramdas	Self Employed	On file
Rameshwar Bajnauth	Asst. Overseer	On file
Mahendra Lall	Joiner/ Councillor	On file
Melecia Washington Wellington	Overseer	On file
Simone Osborne	Environmental Health Asst.	On file
Mickhel McKend	Work Study Student	On file
Michael Adams	Work Study Student	On file
Francis Wright	Councillor	On file
Shavon George		On file
Ann Zelena Ally		On file
Tuschen/Uitvlugt NDC		
Sheldon Alexander	Self Employed	On file
Uma Devi Gajraj	Assistant Overseer	On file
Bibi S. Ambedkar	Overseer	On file
Vishal Ambedkar	Chairman/ Teacher	On file
B. S Nath	Councillor	On file
Samuel Oudhoo	Work Study Student	On file
Karen Persaud	Work Study Student	On file
Revaldo Smith	Work Study Student	On file
Roopnarine Singh	Councillor/ Accountant	On file
Dinesh Prashad		On file
Sue Ann Melville	Environmental Health Asst.	On file

Name	Designation	Contact Information
Shameeza Azad	Environmental Health Asst.	On file
Salima Ali	Councillor	On file
Leotha Greene Watson	Councillor	On file
Stewartville/ Cornelia Ida NDC		
Noel Waithe	Councillor	On file
P. Hinds	Councillor	On file
Oneil A. Dayne	Councillor	On file
Rashree Premnath	Councillor	On file
Lionel Rasul	Councillor	On file
Savitri Gopaul	Overseer	On file
Jainarine Narine	Chairman	On file
Shaneeza Yacoob	Assistant Overseer	On file
Beesham Basdeo	Councillor	On file
Yassim Ali	Councillor	On file
Kocwrilia Persaud	Councillor	On file
Sheik Samad	Councillor	On file
Denesh Narine	Environmental Health Personnel	On file
Hague/ Blankenburg NDC		
John Crawford	Councillor	On file
Marjorie Eversley	Councillor	On file
Vincent Boucher	Councillor	On file
Sandrene McKend	Councillor	On file
Delon Grandison	Councillor	On file
Kamrul Hasan	Councillor	On file
Chaitram Surujpal	Councillor	On file
Ceceline Crighton	Overseer	On file
Deon Dublin	Health Officer	On file
George Langevine	Councillor	On file
Sakeria Henriques	Student	On file
Lois Dash	Assistant Overseer	On file
Kenton Hilliman	Chairman	On file
La Jalousie/ Nouvelle Flanders NDC		
Stacy Deoraj	Typist	On file
Karran Walter	Assistant Overseer	On file

Name	Designation	Contact Information
Rajish Kadarnauth	Chairman	On file
Latchman Khamraj	Overseer	On file
Best Klien/ Pouderoyen NDC		
M.R. Sudama	Farmer/ Councillor	On file
M. Ragnauth	Retired PR	On file
S. Chanballi	Housewife	On file
Rehon Bhair	Vice Chairman	On file
U. Balram	Chairman	On file
V. Yearwood	Housewife	On file
M. Lokhnauth	Housewife	On file
R. Archer	Councillor/ Pastor	On file
Chand	Councillor	On file
S. A. Churaman	Overseer	On file
Aisha Trim	Work Study Student	On file
La Cosy Mason	Work Study Student	On file
N. Subhan	Assistant Overseer	On file
S. Harripersaud	Typist Clerk/ Collector of Rates	On file
Kay Low Koon	Retiree	On file
Suraj Narine	Youth Community Development Officer	On file

Attachment A4: Region 4

Name	Designation	Contact Information
Industry/ Plaisance NDC		
Cloyde Abel	NDC Councillor	On file
R. Ramdass	NDC Councillor/Logistics Manager	On file
Rodwell Lewis	NDC Chairman	On file
Deborah McDowell	Overseer	On file
Monesa Hughes	Asst. Overseer	On file
Rev. Basil Roberts	Superintendent of Works	On file
Dawn Johnson	NDC Councillor	On file
Better Hope/ La Bonne Intention NDC		
Zaman Shaw	Medical Doctor/NDC Chairman	On file
Ramkaran Budhram	NDC Councillor	On file

Name	Designation	Contact Information
Abdool M Razack	NDC Councillor	On file
Leonie Ramnarine	NDC Councillor	On file
S Ramcharan	NDC Councillor	On file
Sheik Samsail	NDC Councillor/Businessman	On file
Beterverwagting/ Triumph NDC		
Nykeen Critchlow	Superintendent of Works	On file
Jimmaul Bagot	NDC Chairman	On file
Mon Repos/ La Reconnaissance NDC		
Ayube Mohammed	Businessman/Chairman	On file
Parisram Ramkisson	Overseer	On file
M.S Baksh	NDC Councillor/Construction Worker	On file
Bisrounai Persaud	NDC Councillor	On file
Sachin Shiwdas	NDC Councillor/Businessman	On file
Sherry Deos	NDC Councillor/Activist	On file
Buxton/ Foulis NDC		
Neirpaul Purai	NDC Chairman	On file
Chetram Dowlatram	NDC Councillor	On file
Chandrawattie Singh	NDC Councillor	On file
Petal Telford	NDC Vice Chairperson	On file
Jackdeep Singh	NDC Councillor	On file
Roger Evelyn	NDC Councillor	On file
Enmore/ Hope NDC		
Aarti Persaud Ugraj	NDC Councillor	On file
Somawattie Mahae	Typist/clerk	On file
Jaydesh Dumay	CIIP Foreman	On file
Ramnarase Tewari	NDC Chairman	On file
Anand Persaud	NDC Councillor	On file
C.B Singh	NDC Councillor	On file
Seogopaul Basdeo	NDC Councillor	On file
Mohadeo Panday	NDC Councillor	On file
H. Persaud	P.R	On file
Mahendra Sharma	NDC Councillor	On file
Haslington/ Grove NDC		
Ingrid Holder	NDC Councillor	On file
Charlotte De Jesus	NDC Councillor	On file
Akesha Layne	NDC Staff	On file
Sandra Sukhu	NDC Councillor	On file
Steve Martins	NDC Councillor	On file
Shaquille Adonis	NDC Councillor	On file

Name	Designation	Contact Information
R. Chanderpaul	NDC Councillor	On file
Maureen Philadelphia	NDC Chairw oman	On file
Avnel Woode	NDC Councillor	On file
Samuel Sandy	NDC Councillor	On file
Yonette Jervis	Overseer (Ag)	On file
Corw in Harry	NDC Councillor	On file
Joy Morgan-Lew is	NDC Councillor	On file
Unity/ Vereeniging NDC		
Atamdeo Persaud	NDC Chairman	On file
Lallbachand Debi	NDC Councillor	On file
Basmattie Singh	NDC Councillor	On file
Natasha Dhaniran	NDC Councillor	On file
Dw arka Roopnarain	NDC Councillor	On file
Rushana Walters	E.H.A	On file
Lemuel Lynch	E.H.A	On file
Diodat Haridat	Overseer	On file

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ATTACHMENT B: IMAGES

Attachment B1: Region 1

Father's Beach VC

Manawarin VC

Waramuri VC

Santa Rosa VC

Assakata VC

Warapoka VC

Mabaruma Town Council

Aruka Mouth CDC

Smith's Creek CDC

Morawhanna CDC

Almond Beach CDC

Imbotero CDC

Attachment B2: Region 2

Charity-Urasara NDC

Evergreen-Paradise NDC

Anna Regina Town Council

Aberdeen-Zorg-en-Vlygt NDC

Annandale-Riverstown NDC

Good Hope-Pomona NDC

Attachment B3: Region 3

Wakenaam NDC

Leguan NDC

Mora-Parika NDC

Hydronie-Good Hope NDC

Greenwich Park-Vergenoegen NDC

Tuschen-Uitvlugt NDC

Stewartville-Cornelia Ida NDC

Hague-Blankenburg NDC

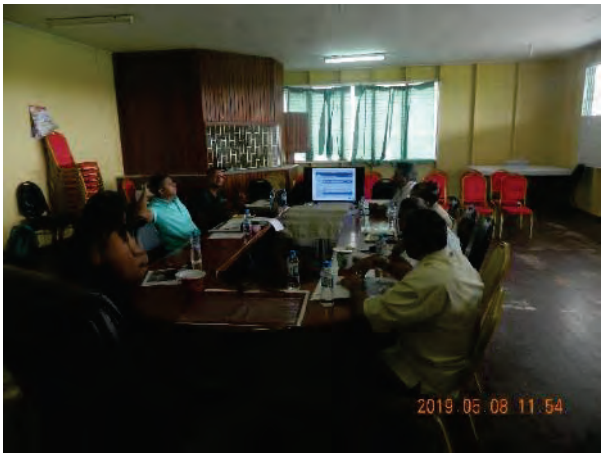
La Jalousie-Nouvelle Flanders NDC

Best-Klien-Pouderoyen NDC

Attachment B4: Region 4

Industry-Plaisance NDC

Better Hope-La Bonne Intention NDC



Beterverwagting-Triumph NDC

Mon Repos-La Reconnaissance NDC

Buxton-Foulis NDC

Enmore-Hope NDC

Haslington-Grove NDC

Unity-Vereeniging NDC

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Enhanced Coastal Sensitivity Mapping – Ecosystem Services (Regions 5 and 6) – FINAL REPORT

Esso Exploration and Production Guyana Limited

April 2020

The business of sustainability

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1. INTRODUCTION

1.1. Overview

This report provides an introduction to the concept and treatment of ecosystem services along the coastal communities in Regions 5 and 6 of Guyana. Ecosystem services are typically defined as the benefits that people obtain from the natural environment as further defined and described in Section 1.2. The report was prepared by Environmental Resources Management (ERM) and Environmental Management Consultants (EMC). The work described herein is supplemental to the Liza Phase 1 Post-Permit Studies for Regions 1-4 requested by the Guyana Environmental Protection Agency (EPA) in the Environmental Permit issued to Esso Exploration and Production Guyana Ltd. (EEPGL) for its Liza Phase 1 Development Project[1].

Along with the Enhanced Coastal Sensitivity Mapping – Biodiversity report and related geospatial mapping (submitted under separate cover), this report is a summary of field studies conducted to verify (i.e., ground truth) selected shoreline and coastal habitat classifications in Regions 5 and 6. The information presented in this report specifically provides for the screening and scoping of ecosystem services utilizing an internationally recognized ecosystem services methodology combined with geospatial analysis, as described in Section 2. The purpose is to provide specific details on coastal communities and their use of coastal resources to better inform EEPGL's oil spill response planning, as well as to provide information for use in future project Environmental Impact Assessments (EIAs).

The information presented in this report is limited to Regions 5 and 6. A similar report for Regions 1-4 has been prepared under separate cover for submission to the EPA as a regulatory requirement. This report covering Regions 5 and 6 is for EEPGL's internal use only.

1.2. Scope Development

ERM and EMC held a coordination and planning workshop in October 2017 in Georgetown, with key stakeholders including Government, non-governmental organizations (NGOs), academics, indigenous community representatives, and other expert entities to discuss the purpose of the Region 1-4 ecosystem services study, its applicability and the proposed methodology. It was determined that a Community Based Participatory Research (CBPR) approach with local communities would be utilized in order to conduct a screening and scoping of ecosystem services. The objective of the study was to provide data to establish a baseline of the relationship between coastal communities and the natural environment. The results of the study are captured in this report, as well as in the Liza Project Geographic Information System (GIS) database, and Liza Project Stakeholder Engagement Plan. The Study Area was defined as the immediate coastal area, up to a distance of 500 meters from the shoreline.

The first phase of the exercise was conducted in November and December 2017 in Regions 2, 3, and 4. The second phase of the exercise for Region 5 and 6 was conducted in January and

[1] Environmental Permit No. 20160705-EEDPF, dated June 1, 2017

February 2018. Local specialists from EMC accompanied by an ERM socioeconomic expert conducted stakeholder meetings with 24 coastal Neighborhood Democratic Councils (NDCs) in Regions 5 and 6 to learn first-hand about their activities related to ecosystem services. Over 168 local community members participated in the meetings, and many from each NDC accompanied the team into the field after each meeting to help visually observe and map the activities.

The team entered data at each meeting directly into handheld tablets linked to the Liza Project GIS database, and also took notes on general comments and observations. The results of these Region 5 and 6 meetings and field observations are described in this report, along with Ecosystem Service-specific maps for each NDC. Map books have been created from the GIS information contained in the database, and are appended to this report. Additionally, integrated map books (including both ecosystem service and biodiversity information) will be included in EEPGL's Oil Spill Response Plan, where necessary.

During May to July 2019, following the screening, scoping, and assessment exercise, the same team of socioeconomic experts conducted a validation effort of the ecosystem services baseline data collected during the previous assessment phase. The team visited the same coastal NDCs, CDCs, VCs, and TCs (the Black Bush Polder NDC in Region 6 was not revisited due to its distance from the coastal zone). This additional validation step enhances the accuracy of the original effort by allowing stakeholders to review and comment on the results of the screening, scoping, and assessment exercise. Any changes or additions to individual ecosystem services from the exercise were documented and larger trends that could have occurred over time as a result of specific ecosystem management interventions (e.g., mangrove programs) or extrinsic factors (e.g., population changes) were identified.

1.3. Collaboration with NAREI

The participation of four officers from the Mangrove Restoration and Management Department of the National Agriculture Research & Extension Institute (NAREI) Mangrove Department ("the Department") for a total of nine days in the ESS work was beneficial to both the ESS Team and the Department, as well as the Local Authorities (NDCs and Town Councils). The ESS Team was able to access information on activities occurring within the mangroves areas of these regions, as well as the concerns of the Department in relation to these activities. Information was also obtained on areas where the Department is/was involved in activities, including monitoring and restoration. The ESS engagement also provided an opportunity for the Local Authorities to identify and discuss issues and concerns relating to the mangroves within their districts. Other benefits included the following:

- The ESS engagements with the Local Authorities provided a forum for NAREI to discuss issues relating to mangroves within districts. For many of the NDCs/Town Councils this was their first direct engagement with NAREI.
- NAREI was able to collect information on mangroves within each district, including mangrove distribution, uses of the mangrove forest, activities being conducted within the mangrove forest, and issues and concerns regarding mangroves.

- The verification exercise provided the opportunity for NAREI to interact with some users of mangrove areas, especially persons involved in fishing and construction and operation of fish ponds within mangrove areas.
- NAREI was able to share information with the Local Authorities relating to mangrove management, including the importance of mangroves, the status of mangroves as protected species, activities which are allowed within mangrove forests, activities which are prohibited and are detrimental to mangroves, and potential economic activities which can be conducted within mangroves forest. Importantly, recommendations on addressing some of the current issues and concerns such as grazing within mangrove forest and clearing of mangrove vegetation were shared. There was good dialogue and sharing of ideas between the Department and the Local Authorities on these areas.
- NAREI was able to share its plans for improvement in mangrove management along coastal areas, especially through more public awareness and information sharing now that there is a dedicated Community Development Officer.
- The communities recognized the importance of mangroves and their legal status as a protected species. There was a call for a balance between enforcement and sustainable use issues for the rural people who have been historically utilizing its many ecosystem services.
- The shrimp farmers of Region 6 agreed to organize themselves into a formal group that could be better engaged by NAREI for the mangrove management and sustainable use of the coastal resources.

1.4. Definition of Ecosystem Services

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities and provide cultural fulfilment.

There are four standard categories of ecosystem services: *provisioning, regulating, cultural and supporting* services, defined as follows.[2]

- **Provisioning services:** The goods or products obtained from ecosystems such as food, freshwater, timber, fiber and other goods.
- **Regulating services:** The benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards.
- **Cultural services:** The non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment.
- **Supporting services:** The natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Additional details about the types of services under each category are provided in Appendix A.

[2] Millennium Ecosystem Assessment (MA). 2005. Synthesis Report. Island Press, Washington DC.

2. METHODOLOGY

2.1. Ecosystem Services Screening

A screening exercise was undertaken with the NDCs prior to field observations in order to identify a comprehensive list of the ecosystem services that are potentially present along coastal communities in Regions 5 and 6. This step does not attempt to consider the importance of the services to beneficiaries or the likelihood of the Project impacting them in the event of an unplanned oil spill; it simply asks whether a service is likely to be present or not in each costal area.

For a service to be considered present, it must meet two criteria:

1. Habitats present in the Study Area are believed to provide this service or are similar to habitats elsewhere that provide this service; and
2. People are believed to benefit from the service, either at the local, national, or global level, and/or the Project is expected to benefit from this service.

Appendix A provides the screening checklist that was used by the team when interviewing the NDCs. The table uses a standard list of ecosystem services adapted from internationally accredited sources.[3] All services identified as present or potentially present were then "screened in" to be considered when going into the field for observation, data collection, and mapping of the exact locations where such services exist.

PHOTO 1: INTERVIEWS WITH NDC MEMBERS AND LOCAL COMMUNITY

[3] World Resources Institute (WRI). 2013. Weaving Ecosystem Services into Impact Assessment: A Step-by-Step Method. WRI, Washington, DC.

2.2. Ecosystem Services Scoping

Following completion of the screening exercise, the team and members of the local community used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This step aimed to:

- Establish a complete list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify the habitats and resources that provide ecosystem services in the Study Area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The descriptions and examples of "scoped-in" services for the Study Area, based on stakeholder input and field verification information, are provided in the scoping tables and broken down by NDC. During the engagements, the team, where appropriate, also asked for baseline data at the NDC level, including population statistics, numbers of beneficiaries utilizing each service or partaking in various livelihoods, incomes generated from livelihoods, and other socioeconomic baseline data. These data, when available, are captured in the overview of each Region, as well as in the detailed scoping tables. This information can also be found in the Liza Project GIS Database.

PHOTO 2: FIELD OBSERVATIONS WITH NDC MEMBERS, NAREI TEAM, AND LOCAL COMMUNITY

2.3. Ecosystem Services Prioritization

The ecosystem services prioritization has been designed to be consistent with international best practice, using the 2012 International Finance Corporation (IFC) Performance Standards (PS) as guidance. The prioritization process focuses on identifying services which are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

a) **Importance of ecosystem services** to beneficiaries was assessed according to the following criteria and assigned a rating from low to essential based on:
   - Intensity of use – e.g., daily, weekly or seasonal use; quantitative data were used if available and relevant;
   - Scope of use – e.g., household versus community level, commercial use only, subsistence only or both;
   - Degree of dependence – e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community; and
   - The importance expressed by stakeholders and beneficiaries, including cultural and historical importance.

The weight given to each of these components varied slightly depending upon the service, but the importance to stakeholders and beneficiaries take precedence over other criteria where the rating is not clear. Where a service was of greater or lesser importance to different stakeholder groups, two (or more) ratings were assigned so that impacts on these groups can be assessed individually.

b) **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The 'replaceability' of a service was assessed according to the following criteria and assigned a rating from high (many alternatives) to low (few or no alternatives):
   - The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and man-made substitutes (e.g., availability of man-made items as an alternative to handicrafts);
   - The accessibility, cost and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
   - Preference / appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign a priority rating to the service (see Figure 2-1 below). **Ecosystem services *with high* or *critical* priority ratings are considered to be 'priority' ecosystem services.** As noted above, some services may have different importance ratings for different

beneficiary groups, and therefore may be rated 'priority' services for some beneficiaries but not for others.

FIGURE 2-1: ASSIGNING A PRIORITY RATING TO ECOSYSTEM SERVICES

		Replaceability of Service		
		High *(many spatial alternatives)*	**Moderate** *(some spatial alternatives)*	**Low or Not Replaceable** *(few to no spatial alternatives)*
Importance of Service to Beneficiaries	**Essential**	*High*	*Critical*	*Critical*
	High	*Medium*	*High*	*Critical*
	Moderate	*Low*	*Medium*	*High*
	Low	*Low*	*Low*	*Medium*

2.4. Ecosystem Services Validation

Following completion of the above described steps, it was decided to revisit each of the NDCs, VCs, CDCs, and TCs to:

- Validate that the information compiled was correct;
- Verify that the Coastal Resources Maps were accurate;
- Collect any new data relating to ecosystems benefits since the previous engagements; and
- Collect updated socioeconomic data.

During the validation exercises, the team presented the findings and maps and asked the stakeholders a series of questions, as detailed below:

- Is the information presented for your district (NDC/TC/CDC/VC) correct?
- If not, what do we need to change/adjust?
- Are the locations for the various services presented on the map correct?
- Are the main economic activities/livelihoods in the area the same as one year ago? If not, what has changed?
- Has there been any notable growth or decline in any particular sector? What sector? What has changed?
- Has there been any increase in coastal resources over the past year? What purpose and where?
- Has there been any new use of coastal resources within the area over the past year? What purpose and where?
- Has there been any change to previous mapped points?

- What is the general description of the change?
- What is the current population estimate or trend (increased or decreased over past year)? What is contributing to the trend?
- Are there any other notable socioeconomic data that you wish to have documented?

The responses received during the validation exercise are incorporated below, presented by region. Raw data as it was recorded can be found in Appendix E: Validation Data Summary. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time elapsed between the 2017/2018 original data collection and the 2019 validation exercise.

3. ECOSYSTEM SERVICES FINDINGS AND PRELIMINARY CONCLUSIONS

3.1. Overview of Findings

Based on the findings of the assessment, provisioning services were the primary service provided by the coastal ecosystem in Regions 5 and 6, accounting for 63.6 percent of the location-specific services identified in the two regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants; and
- Animals hunted primarily for food (recreational hunting is covered separately under cultural services).

Cultural services were the second most prevalent ecosystem service, representing approximately 23.3 percent of the location-specific services identified in the three regions. The most common cultural services identified include:

- Cultural value placed on traditional practices such as use of a location for prayer services; and
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing;

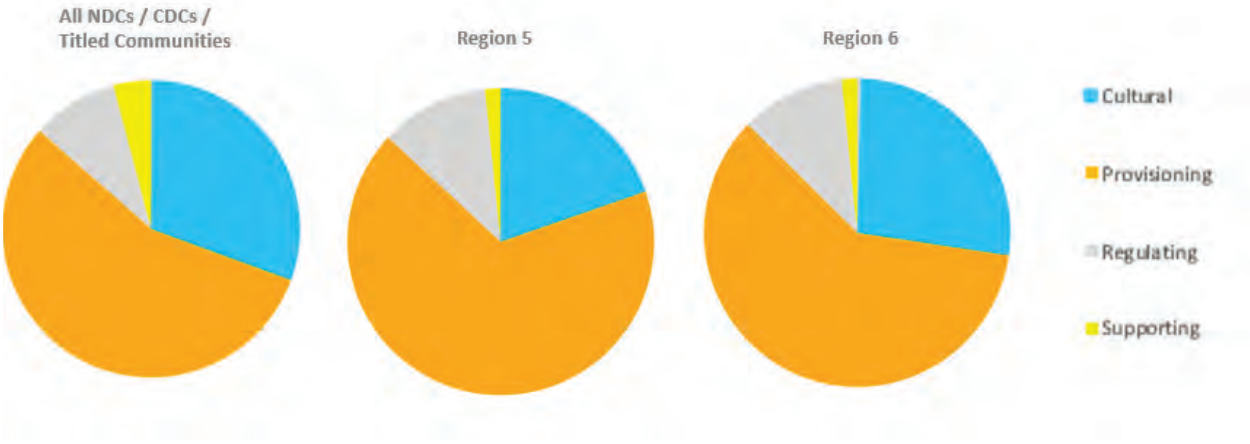
Regulating services were the least prevalent ecosystem services, representing approximately 11.3 percent of the location-specific services identified in the three regions. The most common regulating services identified include:

- Shoreline protection and the role of mangroves in protecting crops, buildings, recreation areas from waves, wind and flooding; and
- Shoreline protection along rivers.

Supporting services, which represented less than 2 percent, are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. The service “Habitat Provision” is typically an exception, which is sometimes valued as an “end-use” service by stakeholders in addition to its supporting role. Therefore, lack of identified supporting services is not atypical.

Figure 3-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories for Regions 5 and 6, as well as for all NDCs (including Regions 2 through 6).

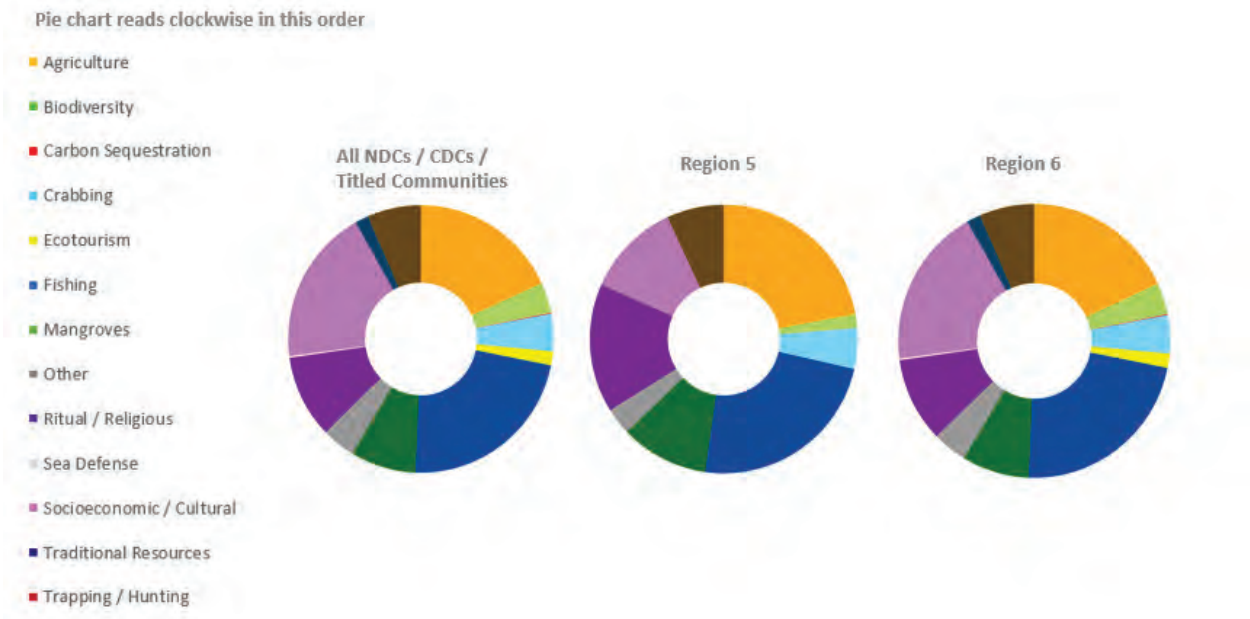
FIGURE 3-1: DISTRIBUTION OF ECOSYSTEM SERVICE CATEGORIES



NOTE: "All NDCs" pie chart includes Regions 1 through 6, which, when combined, indicates provisioning at 55.5 percent, cultural at 31 percent, regulating at 9.5 percent, and supporting at 4 percent.

Figure 3-2 summarizes the distribution of specific ecosystem service types across the categories. The service types match those used in the map books described herein.

FIGURE 3-2: DISTRIBUTION OF ECOSYSTEM SERVICE TYPES



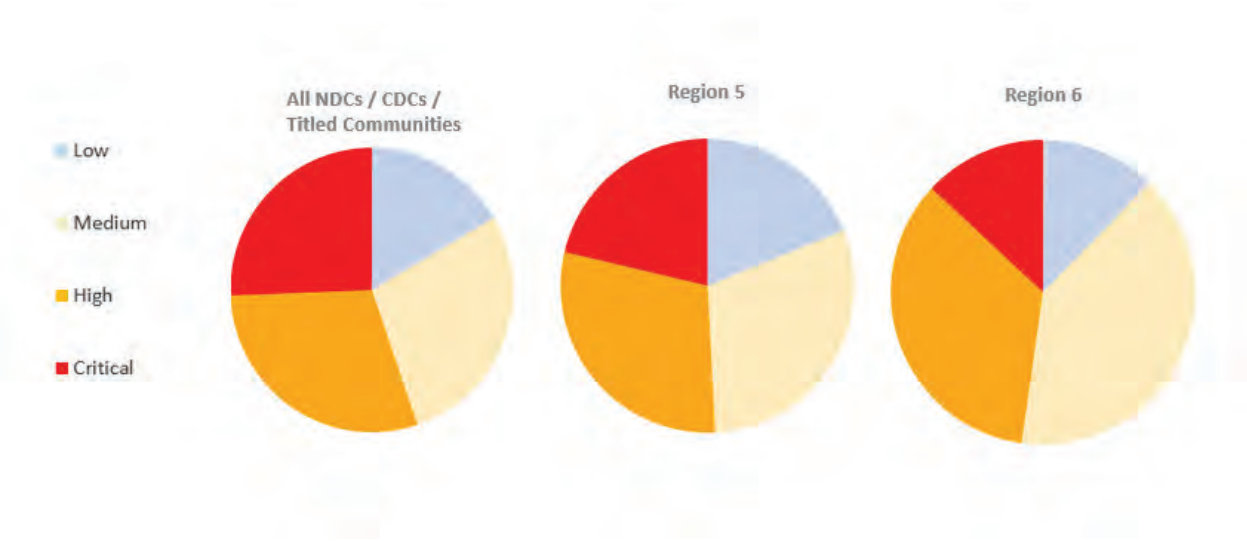
NOTE: "All NDCs" includes Regions 1 through 6, which, when combined, indicates fishing at 23 percent, socioeconomic/cultural at 19 percent, agriculture at 18 percent, ritual/religious at 10 percent, mangroves at 8 percent, trapping/hunting at 7 percent, crabbing at 5 percent, other at 4 percent, ecotourism and traditional resources each at 2 percent, and sea defense and carbon sequestration each at under 1 percent.

3.2. Summary of Findings by Region

Detailed findings for each identified ecosystem service, as well as priority ratings, are provided in Appendices B and C, and are summarized in Sections 4 and 5. As one of the primary goals of this study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 5 and 6, the ratings vary widely depending upon the responses from each NDC. For example, in one NDC in Region 6, livestock farming along the coastal wall was reported to be medium priority, whereas in the same NDC at another location, the same service was considered a critical priority. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figure 3-3 summarizes the distribution of priority ratings for the location-specific ecosystem services identified.

FIGURE 3-3: DISTRIBUTION OF ECOSYSTEM SERVICE PRIORITY RANKINGS



NOTE: "All NDCs" includes Regions 2 through 6, which, when combined, indicates critical at 26 percent, high at 28 percent, medium at 28 percent, and low at 18 percent.

For overview and general comparison purposes only, the **highest priority rating for each service in each region is included in the table below.** As described in the methodology, services with *high* or *critical* priority ratings are considered to be 'priority' ecosystem services and would be a primary focus in the event of oil spill response. The overview table also helps to visualize which services did not feature as having importance to beneficiaries across the regions.

Table 3-1 summarizes the highest priority rating assigned in each region for each ecosystem service and Figure 3-4 shows a map of where all of the 'priority' (i.e., critical or high rating) ecosystem services are located, regardless of type or region.

TABLE 3-1: HIGHEST ECOSYSTEM SERVICE PRIORITY RATINGS FOR EACH REGION

Ecosystem Service Type	Region 5	Region 6
Provisioning Services		
Marine aquaculture and wild-caught fish & shellfish (food)	Critical	Critical
Cultivated crops	High	High
Livestock farming	Critical	Critical
Food: wild plants and honey	Medium	Low
Food: wild meat	Medium	High
Biomass fuel	N/A	N/A
Timber and wood products	N/A	N/A
Non-wood fibers and resins	N/A	N/A
Traditional medicine	N/A	N/A
Freshwater for household use	N/A	N/A
Freshwater for irrigation use	N/A	Medium
Aquatic transportation/ports	Critical	Critical
Social/Economic Commercial activity	Critical	Critical
Social/Housing	Low	High
Regulating Services		
Global climate regulation	N/A	N/A
Regulation of water timing and flows	N/A	N/A
Flood regulation	Critical	High
Erosion regulation	N/A	N/A
Shoreline protection / Mangrove	Critical	High
Pest regulation	N/A	N/A
Pollination	N/A	N/A
Disease regulation	N/A	N/A
Cultural Services		
Cultural, religious, or spiritual value	Critical	Critical
Aesthetic value of natural landscapes, historical landmarks	N/A	N/A
Tourism and recreation	Critical	Critical
Non-use value of biodiversity	N/A	N/A
Supporting Services		
Habitat provision, coastal protection	N/A	High
Primary production, biodiversity	N/A	N/A
Nutrient cycling	N/A	N/A
Water cycling	N/A	N/A
Soil formation	N/A	N/A

N/A – Not applicable; service not identified in the region

FIGURE 3-4: IDENTIFIED LOCATIONS OF CRITICAL AND HIGH PRIORITY ECOSYSTEM SERVICES – REGIONS 5-6

3.3. Use of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) priority services within the NDCs are summarized below:

TABLE 3-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE NDCs—REGION 5

NDC Name	Type of Service	Brief Description
Woodlands/Farm	Provisioning	Commercial and subsistence fishing along the coast and in mangroves
	Provisioning	Grazing of livestock Fairfield to Bath, and High Dam to Drill
	Cultural	New beach at Taymouth Manor used for recreational purposes
Hamlet/Chance	Provisioning	Fishing and fisheries landing at the Mahaicony River (Old Bridge); shrimping and crabbing in the mangroves and swamps
	Provisioning	Cultivation of cash crops and fruits throughout the NDC
	Regulating	Shoreline protection with mangrove forest protecting from the impacts of the Mahaicony River
Mahaicony/Abary	Cultural	There is a large beach at Good Faith that is frequented by persons from throughout Region 5 for recreational and religious purposes.
	Provisioning	Commercial and subsistence fishing, shrimping, and crabbing along the coast and in mangroves with fishery landing site at Abary River Mouth
	Provisioning	Grazing of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands.
	Regulating	Extensive area of mangrove forest on the shoreline
Profit/Rising Sun	Cultural	Locals from throughout the West Berbice area utilize the Belladrum Beach to relax, swim, exercise, and socialize daily. More persons visit on weekends including Hindus for religious purposes.
	Cultural	A crematorium at Weldaad is used by the residents of the NDC and Region.
	Provisioning	Boat landings at Belladrum, Profit, and Foulis are used by many fisherfolk.
	Provisioning	Grazing of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands
	Regulating	Existing and new growth of mangroves protecting the shoreline from the impacts of the sea
Seafield/Tempie	Provisioning	Fisherfolk use the fishing landing sites at Jacoba and Seafield and local communities fishing and shrimping in mangroves and swamps
	Provisioning	Grazing of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands
Union/Naarstigheid	Cultural	Locals utilize Onverwagt, Bush Lot and Hopetown for recreational and religious purposes. Bush Lot has a horse racing track close to the shore that is

NDC Name	Type of Service	Brief Description
		used by thousands of persons at least each quarter.
	Provisioning	Commercial and subsistence fishing along the coast and in mangroves with fishery landing site at Bush Lot
	Regulating	Existing and new growth of mangroves protecting the shoreline from the impacts of the sea and drainage pump at Trafalgar aids in flood prevention
Bath/Woodley Park	Provisioning	Fishing and fisheries landing at the No. 12 Village outfall; fishing, shrimping, and crabbing in mangroves and swamps
	Provisioning	Cash crop cultivation in close proximity to the sea dam and on the façade throughout the NDC; animals are also grazed along the shoreline and in mangroves throughout the NDC
	Cultural	Local Hindu religious activities are practiced at Bath, Experiment, and No. 11 & 12
Woodlands/Bel Air	Provisioning	Cash crop cultivation in close proximity to the sea dam and on the façade throughout the NDC
	Provisioning	Cows, goats, and sheep on the shore in the mangroves and on adjacent lands
Zeelugt/Rosignol	Cultural	Religious activities held at three temples located at the shore at Rosignol and No. 2 Village
	Provisioning	Processing facility at Rosignol that processes Manicole Palm for export
	Provisioning	Commercial and subsistence fishing along the coast and in mangroves with fishery landing sites at Rosignol, De Edward, Victory Dam, and Bennet Dam
	Provisioning	Processing facility at Rosignol that processes much of the landed fish catch for export
	Provisioning	Boat building at Victory Dam and De Edward
	Provisioning	Cows, goats, donkeys, and sheep are grazed along the shoreline and in the mangroves
	Provisioning	River transportation wharf used by more than 1,000 persons daily and Berbice River Bridge used by thousands of Guyanese daily

3.3.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 5 is fishing in the sea and in the mangroves along the coast. The main commercial products from the sea include many types of catfish, snapper, bangamary, butterfish, mullet, snook, and trout. Some shrimping also occurs in selected areas, sometimes close to the shore. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. The natural ponds and drainage channels receive ocean water during the spring tide, which contains young shrimp and fish species that are looking to migrate into less salty water until they mature into adulthood. These are harvested by persons for both commercial and subsistence purposes.

Crab catching is also done in the mangrove areas. Crabs are caught in the period July to August during their spawning season in areas where they are available. Some persons catch crabs throughout the year by hunting them in the mangroves. The sea crabs are found in small puddles left on the mudflat when the water recedes. The system of rivers is also critical to the growth of the rich biodiversity of the sea. The Mahaica, Mahaicony, Abary, and Berbice rivers provide spawning grounds, shelter, and nutrients for aquatic life.

Housing is the main activity on the coastland, followed by agriculture. Communities along the coast engage in subsistence farming of vegetables and fruits. Commercial farms grow sugarcane, staple grains (including rice), coconuts, and cash crops. Some of the cash crop farming occurs along the sea defense area.

The scale of livestock farming ranges considerably across communities in Region 5, depending on the level of crop cultivation - since this restricts grazing grounds. Some households keep a few chickens, pigs, sheep, goats, and cattle for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be either dual purpose or specialize in dairy or beef. There is also large-scale rearing of sheep and goats, which primarily graze at the shoreline areas.

A limited number of residents in Region 5 are engaged in honey production. While mangroves provide the habitat for honey production, it is not common in Region 5 despite the fact that many people interviewed understood how honey production could be a major source of income. The bees provide a critical service of pollination for the cash crop farmers whose produce is highly valued in the economy. However, there is only one large producer and a few smaller ones who are making use of this service.

A small number of households utilize various types of meat (including iguana, etc.) for subsistence, whether they hunt it themselves or purchase it. Persons are engaged in hunting of wild animals which are sold throughout the region. Bird hunting is common by wire, shotgun, or nets and is a major source of food or income in the area, with birds sold openly in local markets.

Some wood and non-wood fibers, including mangrove trees and coconut husks, are used in handicrafts and household items in some of the coastal communities, although this is not extensive. Mangrove bark is used in a limited amount for tanning. The buttonwood tree of the mangrove forests is used by the cash crop farmers as a prop for vines and fence posts. Fisherfolk use the white mangrove for fish poles, which they refer to as “cedar.”

Potable water is available for communities from groundwater and many residents harvest rainwater. A few persons rely on the canals for household purposes. Transportation is mainly land-based along the coast, except for a few instances when the sea coast is used.

3.3.2. Regulating Services

The majority of the shoreline of Region 5 is a mixture of mud or sand/shells. This shoreline has a first line defense of mangroves to buffer the wave action of the sea. Mangroves play a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. Short tracks of riprap sea defense exist in a few of the NDCs.

The NAREI mangrove re-growth program has resulted in significant mangrove population in the Bel Air – Mon Choisi area. However, these have increased concerns over the nuisance of sand flies and mosquitoes. Residents are aware of the importance of mangrove in coastal protection and report that they have reduced activities that can negatively affect growth.

Natural shoreline protection services can be replaced by man-made engineering solutions, if needed. However, these are generally expensive to build and maintain over time.

3.3.3. Cultural Services

The Hindu population visits the shoreline for their traditional daily or weekly early morning prayers. More recently, daily visits have been reduced for the majority, with most persons conducting prayers on Fridays or Sundays at the places with beaches or access to the shoreline. The Hindu tradition of planting prayer flags at various points along the shoreline, typically associated with shore access, is a significant practice. On occasions, the beaches will be used by Christians for baptism services. These natural spaces with cultural, spiritual or religious importance are considered “living heritage,” particularly for Hindus.

There are a few areas along the shoreline which locals utilize for recreation, including walking, running, kite flying, and general recreation. Some persons will venture out of the NDC or will have visits from other NDCs, depending on the shoreline or beach in the area. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors.

3.3.4. Supporting Services

The natural processes such as soil formation, nutrient cycling, erosion control, and primary productivity are likely in the region. This is evidenced by the excessive expanse of natural sea defense supported by mangroves. The processes of soil formation and nutrition cycling are constant in the region, as areas are constantly being eroded or built up by sediments. The mangrove growth rapidly follows the buildup of sediments giving further protection to the natural shore. However, it should be noted that during the engagement, the existence of these supporting services was not reported.

3.4. Use of Findings

The findings of the ecosystem services assessment provide an improved understanding of the specific locations where priority ecosystem services are present along the coast, and this information can be used to support the update of EEPGL’s OSRP (i.e., with respect to prioritizing response activities in the event of an oil spill) to include Regions 5 and 6, if necessary. In addition, the data can be leveraged for future EIAs and for ethnographic analysis, where understanding how stakeholders view their relationship with the natural environmental may be required.

4. REGION 5 COASTAL ECOSYSTEM SERVICES FINDINGS

4.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 4-1: POPULATION ESTIMATES - REGION 5

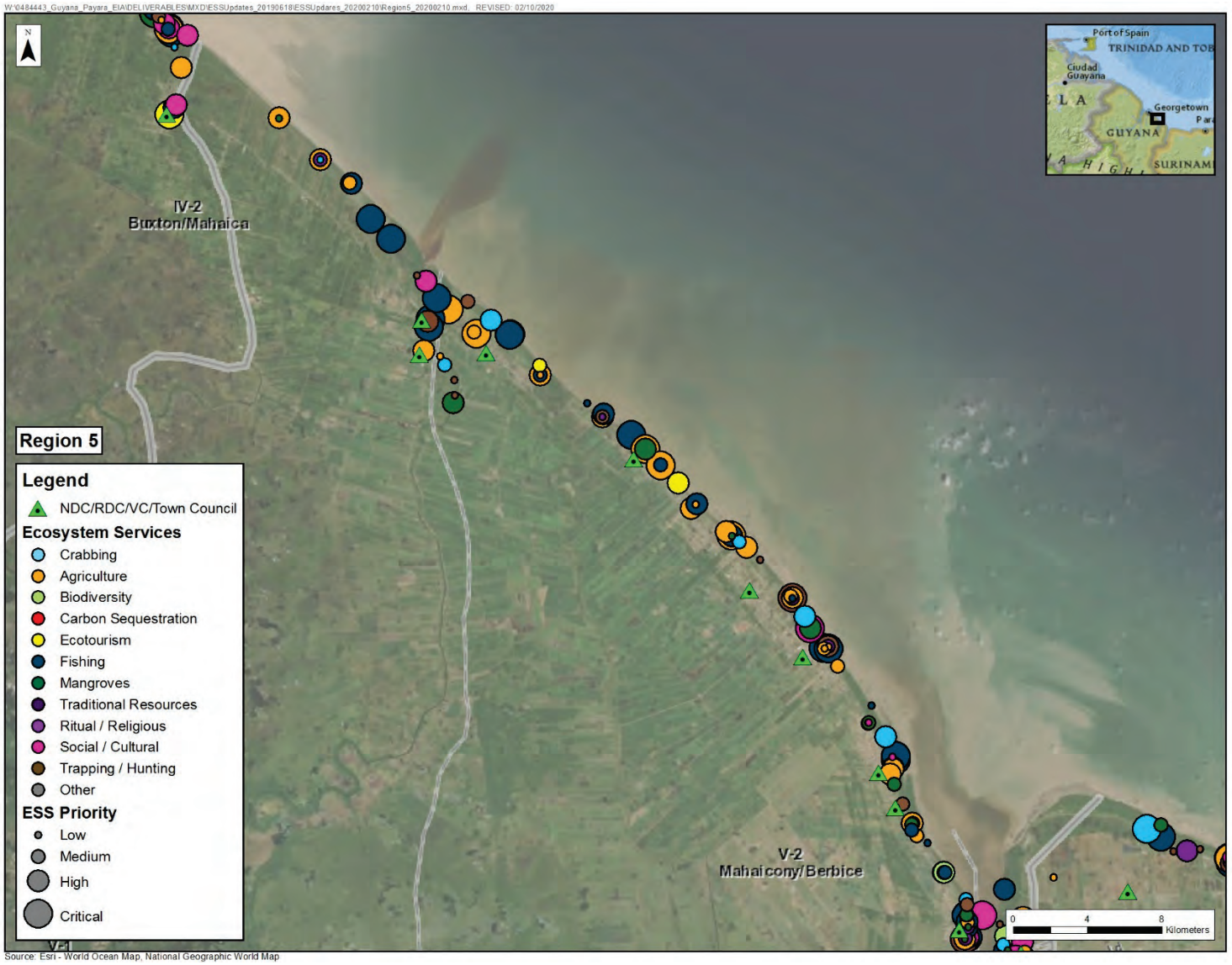
NDC Name	Population Estimate
Woodlands/Farm	20,000
Hamlet/Chance	1,500
Profit/Rising Sun	7,500
Mahaicony/Abary	8,000
Union/Naarstigheid	15,000
Seafield/Tempie	5,000
Bath/Woodley Park	18,000
Woodlands/Bel Air	1,200
Zeelugt/Rosignol	2,000

4.2. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix B.

Figure 4-1 shows the shows the ecosystem service locations identified by the Region 5 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 4-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 5



5. REGION 6 COASTAL ECOSYSTEM SERVICES FINDINGS

5.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 5-1: POPULATION ESTIMATES—REGION 6

NDC Name	Population Estimate
Ordinance/Fort Lands	8,500
Kintyre/No.37	1,000
Gibraltar/Fyrish	5,600
Kilcoy/Hampshire	25,000
Rose Hall Town Council	15,000
Port Mourant/John	16,000
Bloomfield/Whim	4,000
Lancaster/Hogstye	2,500
Black Bush Polder	4,500
Good Hope/No.51	2,354
Macedonia/Joppa	3,535
Bushlot/Adventure	6,000
Maida/Tarlogie	3,500
No. 52/No. 74	20,000
Corriverton Town Council	18,000

5.2. Summary of Findings

The services rated as “critical” or “high” priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 5-2: SERVICES RATED AS “CRITICAL” OR “HIGH” PRIORITY WITHIN THE NDCs—REGION 6

NDC Name	Type of Service	Brief Description
Ordinance/Fort Lands	Provisioning	Wharf at Canje Bridge facilitating transport of building supplies (stone, steel and sand) and boat repairs, sawmill at Sheet Anchor
	Provisioning	Fishing and fisheries landing at Sheet Anchor, Cumberland and Seawell
	Provisioning	Significant livestock population grazing along the shore area
	Provisioning	Informal housing at Sheet Anchor and Cumberland

NDC Name	Type of Service	Brief Description
	Supporting	Mangroves provide habitats for wild bees, birds, crabs, fish, and shrimp
Kintyre/No.37	Provisioning	Numerous ponds both natural and man-made being used for shrimp and fish including tilapia and mullet
	Provisioning	Significant crab catching throughout the year
	Provisioning	Significant grazing of livestock along the shore area
	Provisioning	CXG Shorebase in Seawall and Wharf on Crab Island
	Provisioning	Clay along shore area harvested for clay brick making
	Regulating	Extensive area of mangrove forest used as shoreline and coastal protection; drainage pumps are installed at Borlam Dam
	Cultural	Cemetery located in close proximity to the seashore
Gibraltar/Fyrish	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
	Provisioning	Animal grazing pastures in mangroves and in pasturelands in the NDC
Kilcoy/Hampshire	Provisioning	Significant crab catching throughout the year
	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC
	Provisioning	Large landing site at Albion for commercial artisanal fishing boats
	Provisioning	Large-scale poultry farms along the sea shore at Kilcoy and Chesney; cattle also grazed along the seashore and in mangroves
	Provisioning	Cultivation of cash crops and fruits along the shoreline
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
Rose Hall Town Council	Cultural	The Rose Hall beach is utilized for recreational and religious purposes by hundreds of persons on a daily basis
	Cultural	The religious activities of the Hindus are held at the beach, which provides space and privacy
	Provisioning	Beach used as landing site for fishing boats
	Provisioning	Pin seine fishing conducted along shoreline area by locals
Port Mourant/John	Provisioning	Significant livestock population grazing along the shore area
	Provisioning	A large poultry farm exists at John with over 5,000 chickens
	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC with

NDC Name	Type of Service	Brief Description
		a fishing landing site at the Port Mourant Outfall
	Cultural	Babu John Crematorium at Tain has national significance
Bloomfield/Whim	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC and boats dock along coast
	Provisioning	Cash crop cultivation in close proximity to the sea dam at Whim & Letter Kenny
	Provisioning	A Guyana Water Incorporated (GWI) water well and pump system is located in Letter Kenny in close proximity to the seashore
	Regulating	Mangrove forest covers most of the shore with new growth in some areas
	Cultural	Religious activities are held at Whim to Letter Kenny, including a cemetery
Lancaster/ Hogstye	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC and fishing boats use Hogstye/Adventure outfall
	Provisioning	Cash crop cultivation in close proximity to the sea dam throughout the NDC
Black Bush Polder	Regulating	Two drainage outlets at No. 43 and at Adventure
Good Hope/No.51	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC
	Provisioning	Catching of crabs, fish and shrimp in the mangrove forest on a weekly basis
	Provisioning	Hunting of iguanas in mangroves for meat and for sale by persons from the NDC and wider Region 6
	Regulating	Mangrove coverage is increasing throughout and is important to protecting the shoreline
Macedonia/Joppa	Provisioning	Significant boat building at No. 43
	Provisioning	Livestock grazing along the shore area throughout the NDC
	Provisioning	Fishing and fisheries landing at No. 43 and Eversham, and fishing and crabbing in mangroves and fish ponds
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
Bushlot/Adventure	Regulating	Two drainage outlets at No. 43 and at Adventure
	Provisioning	Cash crop cultivation in close proximity to the sea dam on private lands and on reserves at Bushlot–Friendship
	Provisioning	Fishing and crabbing in mangroves, swamps, and communal fish ponds; privately owned shrimp ponds and landing sites for commercial artisanal fishing boats at Adventure and Bushlot/Kildonan

NDC Name	Type of Service	Brief Description
	Cultural	Recreation and religious activities at the Bushlot beach by hundreds of persons on a weekly basis
Maida/Tarlogie	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC; crabbing in the mangroves for sustenance and recreation
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
	Provisioning	Grazing of more than 1,000 animals on the dam and in the mangroves at Ellington Park, Philippi and Kilmarnock; there are also small farms adjacent to the sea dam where cash crops and fruits are planted
	Provisioning	Boats landing at Tarlogie, Maida and Kilmarnock
No. 52/No. 74	Provisioning	Significant commercial fishing and fisheries landing at No. 66 and No. 65 and catching fish, shrimp, and crabs in mangroves and along the shoreline
	Provisioning	Construction of a fish processing plant approximately 10 meters from the No. 65 Outfall
	Provisioning	Cash crop cultivation along most areas of the shore and on sea dam on private lands with coconuts and other crops
	Provisioning	Significant boat building activities at No. 66
	Cultural	Significant recreational activities at the No. 63 beach—the most popular and widely used beach in the country—as well as at No. 69 and No. 70 beaches
	Cultural	Religious activities along the shoreline of the NDC, especially at No. 63 and No. 73 villages
Corriverton Town Council	Provisioning	Wharves facilitate the movement of people and cargo between Guyana and Suriname daily, as well as between the Region and other parts of Guyana
	Provisioning	Significant livestock population grazing along the shore area
	Provisioning	The shoreline at the central area of the Township (No. 78 Village) is utilized for recreational purposes.
	Provisioning	Significant fishing and fisheries landing, and boat building, at No. 79 and other areas
	Provisioning	Informal housing (squatting) along the shoreline of Line Path, Dukestown, Scottsburg, and No. 78 and No. 79 villages
	Cultural	Religious activities held in the area at Line Path, Scottsburg, and Spring Garden

NDC Name	Type of Service	Brief Description
	Cultural	Tour operators who provide trips along the Corentyne River with fishing options

5.2.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 6 is fishing in the sea and along the shore in close proximity to the coastal mangroves. The main commercial products from the sea include many types of catfish, snapper, bangamary, butterfish, mullet, snook, trout, and 'sardines'[4]. There are almost 1,000 fishing boats in the region, making the fishing occupation a critical one for the economy. The sardines are caught in the Corentyne River in seasons. The fisherfolk utilized the Chinese seine for shrimping in the Ocean. Coastal shrimping is done by the use of small seines pulled by two persons on the near shore where sandy beaches occur.

The abundant mangrove forest provides an important nursery function and habitat for a number of commercial fish and shellfish species including tilapia, mullet, shrimp, and the sherriga. A widespread practice is allowing seawater to flow into ponds, where it is kept for the growth of black belly shrimp and some fish species. Ponds are both natural and man-made and the species harvested are in much demand by the local people. This practice is dominant throughout the region.

Crab catching is also done in the mangrove areas. Crabs are caught in the period July to August during their spawning season in areas where they are available. Some persons catch crabs throughout the year by hunting them in the mangroves. The sea crabs are found in small puddles left on the mudflat when the water recedes. The system of rivers is also critical to the growth of the rich biodiversity of the sea. The Mahaica, Mahaicony, Abary, and Berbice Rivers provide spawning grounds, shelter, and nutrients for aquatic life.

Region 6 is a major agricultural production hub, with its farmlands extending to the shoreline with cultivation of cash crops, fruits, and coconuts. Agriculture plays a dominant role in the economy, with much of the produce taken to Georgetown. Many farmers also keep livestock including pigs, sheep, goats, chickens, and ducks. Some households keep a few of these animals in their yards for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be either dual purpose or specialize in dairy or beef. A lot of grazing occurs along the shoreline area, especially by sheep and goats. Some farmers graze their animals in the backlands during the out of crop period for rice, but once cultivation recommences, these are returned to the shore.

In this region, only a small group of people take advantage of the numerous benefits of the mangroves. Many persons are afraid of the bees and keep away from them. The bees provide a critical service of pollination for the cash crop farmers, whose produce is highly valued in the economy but undervalued in the community.

[4] The species is referred to as sardine by the locals but may not be the sardine species.

Many persons in the various NDCs hunt iguanas and other form of wildlife. In Corriverton, rabbits are hunted for their meat, along with other small mammals that move to the shoreline from the sugar cultivation areas. The hunting of shorebirds with nets, wire, and shotgun is a significant activity for locals. The bird meat is normally sold in the market and is in high demand, especially from overseas-based Guyanese returning home. However, this activity is treated as illegal in the No. 63 Beach area and hunters can be arrested. Bird hunting is more prevalent on remote mudflats where birds gather to feed. Some birds are also captured at the fish ponds, where they feed on the fish and shrimp.

5.2.2. Regulating Services

For most of the region, there is a naturally-built sea defense consisting of a mixture of clay or sand/shells. Most of this shoreline has as a first line of defense in the form of the mangroves - to buffer wave action. The large expanse of mangroves plays a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. The shoreline is being eroded in some areas while accretion is evident in others, bolstered by new mangrove growth. Short tracks of concrete and riprap sea defense exist in a few NDCs, where the wave action would have broken down the natural sea defense.

The NAREI mangrove re-growth programs are active in a few of the NDCS of Region 6, in areas such as Wellington Park. Some re-growth areas are being affected by erosion within this region. There are plans for extending mangrove restoration activities within the region and the mangrove restoration project has been well received by the NDCs and accepted by many locals; as such, activities which could be detrimental to mangroves have been drastically reduced.

5.2.3. Cultural Services

The region has the most popular beach in the country, the No. 63 Beach, which is utilized daily and especially on weekend for recreational purposes. It is frequented by thousands of persons from throughout the country on Easter and other holidays. It is also utilized by Hindus and Christians for various spiritual and recreational purposes. There are many other locations that are frequented by the Hindu population for their traditional daily early morning prayers and religious functions. Most persons frequent the sea or areas close to the sea on Fridays or Sundays. In a few of the NDCs, there are temples in close proximity to the sea that are frequented on a regular basis. These natural spaces with cultural, spiritual or religious importance are considered “living heritage,” particularly for Hindus. The most prominent of these is the Hindu tradition of planting prayer flags at various points along the shoreline – most typically associated with shore access.

The community recognizes the value of their beaches and shoreline areas within their NDCs which are used for recreation, including walking, running, kite flying, and general socialization. Many persons will visit areas outside of their NDC to locations that provide better access to the shoreline with beaches for their own purposes. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors. The Town Council of Rose Hall Town has plans to invest in its beach that is a popular spot for

recreational activities. The Town Council of Corriverton has plans to erect a boardwalk along a portion of its sea defense to promote tourism in the town. Further improvements to facilitate tourism are planned for the No. 63 Beach.

5.2.4. Supporting Services

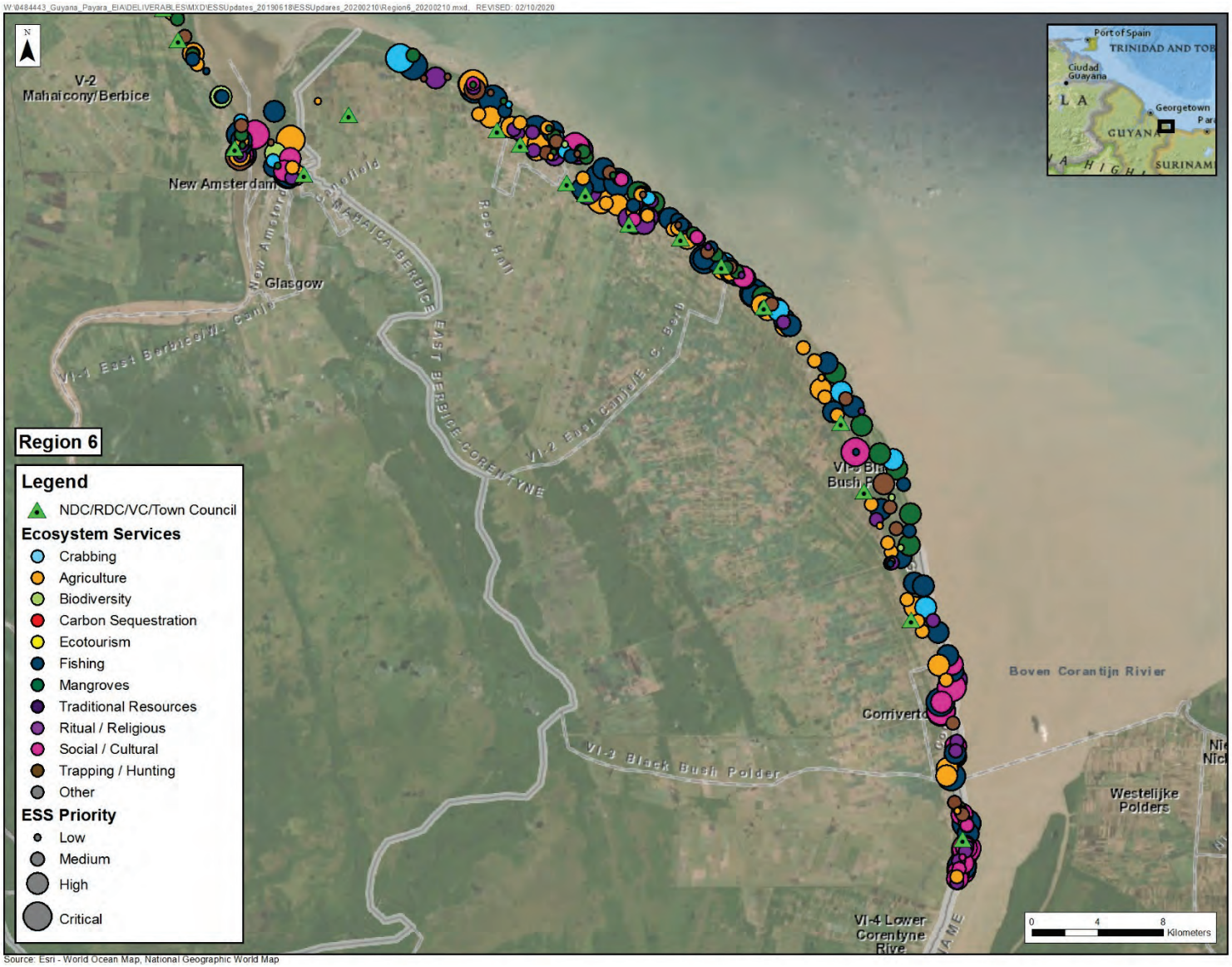
The natural processes such as soil formation, nutrient cycling, erosion control, and primary productivity are likely in the region. This is evident by the excessive expanse of natural sea defense supported by mangroves. The processes of soil formation and nutrition cycling are constant in the region, as areas are constantly being eroded or built up by sediments. The mangrove growth rapidly follows the buildup of sediments, giving further protection to the natural shore. However, it should be noted that during the engagement, the existence of these supporting services was not reported.

5.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix C.

Figure 5-1 shows the ecosystem service locations identified by the Region 6 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol) – critical, high, medium, or low – utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 5-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 6



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APPENDIX A

Screening Checklist

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Ecosystem Service	Description, Examples
Provisioning Services	
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for harvesting
Food: wild plants, nuts, mushrooms, fruit, honey	Fruit, nuts, wild plants, etc. collected in natural areas for consumption or sale
Food: wild meat	Animals hunted primarily for food (recreational hunting is covered separately under cultural services)
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale
Biomass for livestock production	Sedentary and nomadic livestock farming supported by native forage plants
Biomass fuel	Wood, dung and plant matter collected for charcoal or fuel
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp, paper – wood is used in house construction (importance varies by community)
Non-wood fibres and resins	For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber
Freshwater - household use	Freshwater for bathing, drinking, laundry, household use
Freshwater - irrigation & industry	Freshwater for irrigation or industrial use
Natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use
Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade
Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology
Regulating Services	
Regulation of air quality	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a “sink”) or emitting chemicals to the atmosphere (i.e., serving as a “source”)
Climate regulation: global	Vegetated areas sequester CO_2, with implications for global climate change
Climate regulation: local	Regulation of temperature, shade air, and quality by vegetated areas
Regulation of water timing and flows (including flood regulation)	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge
Water purification and waste treatment	Role played by vegetation in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds
Shoreline protection	Role of natural habitats (e.g., wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms
Fire regulation	Regulation of fire frequency and intensity (e.g., dense forest can provide firebreaks)

Ecosystem Service	Description, Examples
Pest regulation	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock
Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens
Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas
Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops
Cultural Services	
Spiritual or religious value	Natural spaces or species with spiritual or religious importance
Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources
Tourism and recreation	Use of natural spaces and resources for tourism or local recreation (e.g., swimming, boating, fishing)
Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value
Supporting Services[5]	
Habitat provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation
Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulphur, phosphorus, carbon) through ecosystems
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms.
Soil formation	Natural soil-forming processes throughout vegetated areas

[5] Supporting Services are intermediate ecological outcomes that are not directly used but rather support other ecosystem services. An exception is made for Habitat Provision, which is sometimes valued as an "end-use" service by stakeholders in addition to its supporting role.

APPENDIX B

Identified Ecosystem Services and Priority Ratings: Region 5 Coastal

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TABLE B-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 5 COASTAL

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 26 – Woodlands/Farm							
Shoreline Protection	Regulating	• Extensive area of mangrove forest on the shore line protecting the sea shore from the impacts of the sea. There are lots of birds, crabs, fish and shrimp in the mangroves with crabs and shrimp caught for commercial purposes at De Kindren to Drill area. Mangroves also protect the river defense in the Mahaica River. The sea defense is under threat, with erosion taking place in some sections, particularly Fairfield seashore. • There is beekeeping within the NDC, but not at the shoreline. However, the bees might be feeding within the mangroves at the shoreline.	Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves **ES Linkages:** Agriculture, sea defense	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• Less than 10 persons with over 200 heads of cattle in the area on lands beyond the sea dam and approximately 20 sheep at Fairfield/Bath. • Over 300 heads of cattle grazing at High Dam to Drill with a private farm at Drill.	Sea Dam, Pastures	Local communities, private cattle farmers Agriculture	High	Moderate	**High**
Cultivated Crops	Provisioning	• Rice cultivation close to the sea dam in a few areas. Other crop cultivation in close proximity to the sea dam on private lands and on reserves. Grazing is done on the lands in this area not under cultivation.	Sea dam, cultivated areas	Local farmers, residents Private developers	High	High	**Medium**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Swamp shrimp caught for commercial purposes between De Kindren to Drill area in the drainage canals and sold locally @ 10,000 per bucket. Tilapia, mullet, and other species caught in this area as well with approximately 50 persons weekly visiting the area to harvest. • There is much fishing within the Bellamy Canal that is behind the sea dam. More than 10 persons visit this canal daily during the dry season to catch fish and shrimp. • Fish Landing Site at Mahaica River at Old Bridge, with 10-15 boats. • Some persons also catch crabs in the mangroves.	Marine Habitat and Mangrove Forests	Fisherfolk engaged in: a) Commercial and subsistence fishing along the coast, canal, and in mangroves b) Fishing at the Mahaica River Old Bridge c) Crabbing	a) Essential b) High c) Low	a) Moderate b) Low c) High	**a) Critical** **b) Critical** **c) Low**
Cultural, Religious	Cultural	• Religious activity along the dams leading to the sea shore and on the sea shore where access is provided and the area is clear or with a beach.	Seashore; Sea Dam	Local Hindus	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Many persons hunt along the shoreline for iguanas, labba, and wild birds for subsistence use and sale.	Mangroves, seashore	Local communities	Moderate	High	**Low**
Tourism and Recreation	Cultural	• A new beach at Taymouth Manor is being used for recreational activities. Access to the area is currently a challenge but the NDC is hoping to put the necessary infrastructure in place.	Seashore	Local communities	Moderate	Low	**High**
NDC 27 – Hamlet/Chance							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 30 boats which dock at the Mahaicony River that do commercial fishing at sea. The area also has a few small boats that fish in the river. • Tilapia and mullet are caught in the mangroves by a few persons for sale in the community. • Crabs are caught in the July-August season.	Marine environment; Mangroves; River ecosystem	Local communities and fisherfolk who: a) Utilize the landing site and fishing in the Mahaicony River b) Fish in the mangroves	a) Essential b) Essential c) Moderate	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) Critical** **c) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Fish is caught by lines and nets in the Mahaicony River by more than ten persons daily for subsistence.		c) Crab in the mangroves			
Wildlife: wild meat and song birds	Provisioning	• Iguanas are caught on the seashore and along the banks of the Mahaicony River for sale with each adult going for GYD$3,000–5,000. • Sea birds including curi curi and storks are caught for meat. • Song birds are caught for trade. Birds caught along the shore and river banks include Twa Twa, Grasie, Canary, Red, and Love birds.	Mangroves	a) Local communities who hunt iguanas and sea birds for meat and for sale b) Local communities who catch song birds for trade	a) Low b) Low	a) Moderate b) Moderate	**a) Low** **b) Low**
Cultural, Religious	Cultural	• Religious activity mainly done outside of NDC or along the river with good access.	Seashore; sea dam	Local communities	Low	Moderate	**Low**
Shoreline Protection	Regulating	• Extensive area of mangrove forest protects the local communities from the impacts of the Mahaicony River.	Mangrove Forests	Local communities **ES Linkages:** River Defense	High	Moderate	**High**
Livestock Farming	Provisioning	• A few head of cattle are grazed within the NDC but the main stocks are kept at the backlands where there are pastures.	Pastureland	Local communities	Low	High	**Low**
Cultivated Crops	Provisioning	• Farming of household crops for consumption; banana trees, bora, etc., throughout the NDC	Cultivated Lands	Local communities	Moderate	Low	**High**
NDC 28 – Mahaicony/Abary							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 60 boats in the Abary River that commercially fish in the sea employing over 200 persons. Catch includes bangamary, butterfish, trout, and some shrimp. The number of boats fluctuates with the fish season with more persons putting their boats to work in the summer when the catch is plentiful. The sargassum is a constant bother to the fisherfolk, affecting their nets and their ability to catch fish. There are also numerous wrecks in the area that affect the fisherfolk when the nets get tangled in the wrecks. Drift mud also affects fishing activities • Pin seine fishing done by almost 50 persons on a daily basis along the shore in the NDC. • Hundreds of persons from Regions 4 & 5 catch shrimp and crabs in the mangroves and swamps when in season.	Marine environment; Mangroves; River Ecosystem	Local communities and fisherfolk who: a) Utilize the Abary landing site b) Fish using pin seines c) Shrimping and crabbing in the mangroves **ES Linkages:** Economic shrimping & Crabbing	a) Essential b) High c) High	a) Moderate b) High c) Moderate	**a) Critical** **b) Medium** **c) High**
Agriculture: Apiculture	Provisioning	• Beekeeping in the mangroves with three sets of active hives of about 20 in total observed in Huntley and Airy Hall.	Mangrove Forest	Local communities	High	High	**Medium**
Shoreline Protection	Regulating	• Extensive area of mangrove forest on the shoreline protecting the seashore from the impacts of the sea. Mangroves also protect the river defense along the Abary River. Mangroves are in the increase in the NDC due to natural growth.	Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves **ES Linkages:** Agriculture, Apiculture, Grazing Fishing Sea & River defense	Essential	Moderate	**Critical**
Tourism and Recreation	Cultural	• There is a large beach within the NDC at Good Faith that is frequented by persons from throughout Region 5 and is used by approximately 50-100 persons per	Coastal and Marine	Local communities in NDC and Region 5 using the beaches in:	a) Essential b) Moderate	a) Moderate b) Moderate	**a) Critical** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		day and more than 50 families on holidays and weekends. This beach is used increasingly as beaches in other NDCs are being covered by mud and taken over by mangroves. • There is a small beach at Abary that is used by several persons in the area.		a) Good Faith b) Abary **ES Linkages:** Religious activity, Fishing			
Religious Activities	Cultural	• More than 10 persons daily and 100 on weekends and religious days used the Good Faith Beach for worshipping. There is also a cremation site at the beach.	Coastal	Local Hindu communities	High	Low	**Critical**
Livestock Farming	Provisioning	• Approximately fifty people graze over 1,000 heads of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands.	Coastal, Pasturelands	Local communities grazing cattle in: a) Abary b) Huntley c) Good Faith	a) High b) Essential c) Essential	a) Moderate b) Moderate c) Moderate	**a) High** **b) Critical** **c) Critical**
Cultivated Crops	Provisioning	• There are a few persons who farm on the sea m and on adjacent lands with mainly cash crops and fruits in Abary.	Coastal, Pasturelands	Local communities	Low	Moderate	**Low**
Wildlife: wild meat and song birds	Provisioning	• Sea birds including curi curi, plover and egrets are caught for meat • Songbirds are caught during the summer months when they are plentiful on the shore and river banks.	Mangroves	Local people	Moderate	Moderate	**Medium**
NDC 29 - Profit/Rising Sun							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 12 boats landing at Belladrum, Profit, and Foulis employing approximately almost 40 persons. Catch includes catfish, bangamary, butterfish, trout, mullet, and some shrimp. The fishing boats move according to the migration of the fish to different fishing grounds. • Fishing and shrimping with 3-5 boats at Weldaad. • Pin seine fishing done by 6 persons on a daily basis along the shore in the NDC.	Marine environment; Mangroves; river ecosystem	Fisherfolk who: a) Utilize the fishing landing site in the Belladrum, b) Utilize the landing site in Profit Foulis c) Utilize the landing site in Weldaad d) Practice pin seine fishing along the shoreline	a) Essential b) High c) High d) Moderate	a) Moderate b) Moderate c) High d) High	**a) Critical** **b) High** **c) Medium** **d) Low**
Food: wild meat	Provisioning	• Iguanas are caught on the seashore along with sea birds including curi curi and wild ducks for meat on a limited basis by a few persons.	Mangroves, shoreline	Local people	High	High	**Medium**
Cultural: Religious	Cultural	• The NDC has a few sites throughout used for religious purposes. A crematorium at Weldaad is used by the residents of the NDC and Region.	Coastal	Hindu rituals at: a) Sea dam in Profit/Foulis b) Sea dam in Weldaad	a) Low b) Moderate	a) Moderate b) Moderate	**a) Low** **b) Medium**
Livestock Farming	Provisioning	• There are more than 100 persons who graze more than 2,000 animals on the shore, in the mangroves, and on adjacent lands with a growing population due to natural increase. • However, there is a reported high rate of thievery of livestock.	Coastal, Pasturelands	Local Communities grazing animals in: a) Profit/Foulis b) Belladrum c) Weldaad	a) High b) Essential c) Essential	a) Moderate b) Moderate c) Moderate	**a) High** **b) Critical** **c) Critical**
Tourism and Recreation	Cultural	• Locals utilize Belladrum Beach with approximately 50 persons per day to relax, swim, exercise, and socialize. More persons visit on weekends including Hindus for religious purposes. The beach is used by many persons and expected to be used by more as a bridge and a new road will be built to access the beach.	Coastal and Marine	a) Local communities using the sea front at Belladrum b) Birdwatching by locals and tourists	a) High b) Moderate	a) Moderate b) Low	**a) High** **b) High**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• There is an increase in bird watching in the area by tourists promoted by the Georgetown-based bird watching groups. Species include curi curi, pellew, and duckla. There are thousands of duckla in the area in the afternoons when the tide is low.					
Shoreline Protection	Regulating	• Extensive area of Mangrove forest at Weldaad shore protecting the sea shore from the impacts of the sea. New mangrove growth is noted in the area. Grazing of animals occurs in the mangroves and may affect the new plants.	Mangrove Forests	Local communities **ES Linkages:** Agriculture, fishing, grazing	High	Moderate	**High**
NDC 30 – Seafield/Tempie							
Food: wild meat	Provisioning	• A few mammals and iguanas are caught on the seashore. Many plover birds are caught using wire along with curi curi and wild ducks for meat.	Mangroves, shoreline	Local people	Low	Moderate	**Low**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are landing sites for fishing boats at Jacoba and Seafield. Catch includes catfish, bangamary, butterfish, trout, mullet, and some shrimp. The mangroves have reduced at Jacoba and more fishing boats are now in the area as the mud is washing away. • In addition, approximately 10 persons catch shrimp, tilapia, coo coo belly, and cufum in the swamp ponds or drainage canals. • Crabs are caught in the season by a numerous persons locally.	Marine environment; Mangroves ecosystem	Local people using the: a) Fishing landing site at Jacoba b) Fishing and shrimping in swamp ponds, mangroves and drainage canals c) Fishing landing site in Seafield d) Mangroves and shoreline area for crabbing	a) High b) Moderate c) High d) High	a) Moderate b) Low c) Moderate d) High	**a) High** **b) High** **c) High** **d) Moderate**
Cultivated Crops	Provisioning	• There are approximately 20 persons in Seafield-Litchfield with cash crop farms on the sea dam and on adjacent lands with mainly cash crops and fruits. Cash crop cultivation is increasing along the sea defense. • Coconut plantations are found beyond the sea dam.	Coastal lands	Local communities	Moderate	High	**Low**
Shoreline Protection	Regulating	• Erosion has significantly reduced the shoreline within the NDC over the years. The area has old sluices that are in the sea approximately 1 km from the present shoreline. • The farmers are fearful of the salt water intruding onto their farms as some persons are cutting the mangroves for their own purposes in No. 42 and No. 37 villages.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation	Moderate	High	**Low**
Livestock Farming	Provisioning	• There are many persons who graze more than 1,500 animals on the shore, in the mangroves, and on adjacent lands. Mainly sheep and goats graze along the shoreline area and the number of animals in the NDC is increasing. Grazing has increased at Ross, Seafield, and Tempie.	Coastal Pasturelands	Local communities grazing animals in: a) No. 37 Village b) Lichfield c) Kingelly d) Seafield	a) Essential b) High c) High d) High	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Critical** **b) High** **c) High** **d) High**
NDC 31 – Union/Naarstigheid							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There is a fishing landing site at Bushlot. Fishing has increased within the NDC with more boats at Bushlot. Catch includes various catfishes, bangamary, butterfish, trout, and mullet. A number of smaller boats catch shrimp. • More than thirty persons are involved in the on land fishing of tilapia and shrimp for commercial purposes.	Marine environment; Mangroves; Drainage canals; Natural ponds	Local people within the NDC who: a) Utilize the landing site at Bush Lot b) Utilize the landing site at No. 29 Village	a) Essential b) Moderate c) High d) High	a) Moderate b) High c) Low d) Moderate	**a) Critical** **b) Low** **c) Critical** **d) High**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		Approximately 10 persons catch shrimp, tilapia, coo coo belly, and cufum daily in the natural swamps, ponds, or drainage canals at Bush Lot, Hopetown, and Lovely Lass. • Crabs are caught in the season and on a regular basis by locals.		c) Fish in the swamps and drainage canals d) Engage in crabbing			
Shoreline Protection	Regulating	• Extensive area of Mangrove forest at Bushlot, Hopetown, and Naarstigheid and new growth at Onverwagt. There is an increase in mangroves, especially at Onverwagt. The extensive coverage of mangroves deters the residents of the NDC from making full use of the sea shore.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Essential	High	**High**
Agriculture: Apiculture	Provisioning	• Beekeeping in the mangroves at Bush Lot, Naarstigheid, Hopetown, and No. 29 Village. • Beekeeping is done Union, Lovely Lass, Onderneeming, Hopetown and No. 29.	**Mangrove Forest**	Local communities engaged in apiculture in: a) Bush Lot b) Hopetown **ES Linkages:** Pollination, Pest control, Mangroves	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
Agriculture, Grazing	Provisioning	• Grazing occurs in many places in the NDC but is more predominant at No. 29 Village and Hopetown with grazing of cattle and other animals. • There are more animals grazing now in the NDC than in 2018. The animals compete with the cash crop farmers for space on the sea dam and reserves.	Mangroves, Sea Dam, Pastures	Local communities, Private cattle farmers who graze animals in: a) No. 29 Village b) Hopetown c) Bushlot **ES Linkages:** Cultivated crops	a) High b) High c) Moderate	a) Moderate b) Moderate c) High	**a) Medium** **b) Medium** **c) Low**
Agriculture, Farming	Provisioning	• Cash crop cultivation in close proximity to the sea dam at Bush Lot, No. 29 & No. 30 villages. Crops include bananas, coconuts, fruits, vegetables, and vine crops.	Sea dam, cultivated areas	Local farmers, Residents	Moderate	Moderate	**Medium**
Religious activities	Cultural	• The religious activities of the Hindus are held at Onverwagt and Bush Lot. A crematorium at Bush Lot is used by the residents of the NDC.	Coastal	Local Hindu communities in: a) Bushlot b) Onverwagt	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Tourism and recreation	Cultural	• Locals utilize Bush Lot, Union, Bel Air, Lovely Lass, and Hope Town Community Centre for recreational purposes. The areas are used by approximately 10-50 persons per day and more on holidays and weekends. Bush Lot has a horse racing track that is used by thousands of persons at least each quarter.	Coastal and Marine, Sand Reef	Local communities in NDC and Region 5 **ES Linkages:** Religious activity, Horse Racing	Essential	Moderate	**Critical**
Wildlife Trapping & Hunting	Provisioning	• Iguanas are caught on the seashore in the August season. Many plover birds are caught using wire in addition to curi curi, stork, egrets, and wild ducks for meat to sell in the market.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Essential	Moderate	**High**
Flood Regulation	Regulating	• Drainage pump installed at Trafalgar/No. 29 Village			Essential	Low	**Critical**
NDC 32 – Bath/Woodley Park							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There is a landing site at the No. 12 Village outfall for boats that engage in commercial fishing in the sea employing over 20 persons. Catch includes queriman, bangamary, butterfish, and some shrimp.	Marine environment; Mangroves ecosystem	Fisherfolk who: a) Utilize the landing site at the No. 12 outfall	a) High b) Essential c) Essential d) Low	a) Low b) Moderate c) High d) High	**a) Critical** **b) Critical** **c) High** **d) Low**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Many persons are fishing in the swamps and the near shore during the out-of-crop season of the sugar estates. It is estimated that 10 persons conduct this activity regularly while during out-of-crop periods it can range from 30-50 persons. Catch shrimp and tilapia daily. • In the summer crabbing seasons, hundreds of persons catch crabs. • One fisherfolk used pin seine along the mudflats for his daily catch.		b) Fish and shrimping in the ponds and swamps c) Crab d) Use pin seines for fishing **ES Linkages:** Economic shrimping & Crabbing			
Religious activities	Cultural	• The religious activities of the Hindus are held at Bath, Experiment, No. 11 & 12 villages along the shore and along the main canal in other areas.	Coastal	Local Hindu communities in: a) No. 12 Village b) Experiment	a) High b) Moderate	a) Moderate b) High	**a) High** **b) Low**
Agriculture: Grazing	Provisioning	• Grazing occurs throughout the NDC and across the shoreline and mangroves with many residents owning animals.	Mangroves, Sea Dam, Pastures	Local communities, private farmers	Moderate	Low	**High**
Cultivated Crops	Provisioning	• Cash crop cultivation in close proximity to the sea dam and on the façade throughout the NDC. Crops include plantains, bananas, coconuts, fruits, vegetables, and vine crops. Some farmers have chickens and ducks.	Sea dam, cultivated areas	Local farmers, residents at: a) No. 12 Village b) Hope	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Shoreline Protection	Regulating	• Extensive area of mangrove forest throughout the NDC. The mangrove protects the mud dams erected for sea defense. Mangroves have been reduced by erosion in some areas in the NDC.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Pollination	Moderate	Moderate	**Medium**
Socioeconomic: Squatting	Provisioning	• Persons squatting along the reserves bordering the sea dam from Bath, Experiment, and Hope mainly due to economic reasons taking advantage of the opportunity to plant crops and keep animals. • There is a lot of squatting along the façade canal throughout the NDC, with the persons engaged in crop farming.	Coastal Habitat	Local persons	Moderate	High	**Low**
Tourism and Recreation	Cultural	• Possible site for picnics in the No. 12 Village.	Shoreline	Local communities	Low	Moderate	**Low**
NDC 33 Woodlands/Bel Air							
Religious Activities	Cultural	• The religious activities of the Hindus are held at No. 6 and 7 and other villages along the main canal bordering the shore.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Agriculture: Farming	Provisioning	• Cash crop cultivation in close proximity to the sea dam and reserves throughout the NDC, except in No. 10 Village, by persons living in close proximity. Crops include peppers, bananas, coconuts, fruits, tomatoes, and carilla. Some farmers have chickens and ducks for home use and sale.	Sea dam; Cultivated areas	Local farmers; Residents	High	Moderate	**High**
Shoreline Protection, Mangroves	Regulating	• Extensive area of mangrove forest throughout the NDC that protects the mud dams erected for sea defense. Grazing occurs in the mangroves and sea dam despite actions taken by NAREI to protect the mangroves. Mangroves were replanted in the area at No. 6 & 7 villages. Some beekeeping is done within	Mangrove Forests	Local communities; Farmers; Beekeepers **ES Linkages:** Fishing, Grazing, Pollination, Beekeeping	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		mangrove at No. 10 Village. Crabs are caught seasonally within mangroves. • There is now mangrove growth throughout the NDC shoreline which has reduced religious and recreational activities along the shoreline. The No. 6 beach is taken over by mangroves and the local people have to travel further to find a beach for recreation.					
Food: wild meat	Provisioning	• Birds are hunted with shotguns by a few hunters on an irregular basis including curi curi, egrets, and wild ducks for meat. Plover birds are caught using wire.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• There are more than 100 persons who graze over 1,000 heads of cows, goats, and sheep on the shore in the mangroves and on adjacent lands. The number of grazing animals in the NDC has reduced due to actions by NAREI.	Coastal, Pasturelands	Local communities in: a) No. 6 Village b) No. 7 Village	a) Moderate b) Moderate	a) Moderate b) High	**a) Medium** **b) Low**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Two fishing boats dock at No. 9. • Numerous persons catch fish and shrimp in the swamps and drainage canals using nets or long seines.	Shoreline, mangroves	a) Fishing boats at No. 9 Village b) Fishing and shrimping in swamps and canals	a) Low b) High	a) High b) High	**a) Low** **b) Medium**
NDC 34 Zeelugt/Rosignol							
Cultural: Religious	Cultural	• Religious activities held at three temples at Rosignol, Victory Dam, and No. 2 Village. • There are 6 Hindu temples at De Edward, Cotton Tree, No. 3, Bennett Dam, Victory Dam and along the main canal	Coastal	Local Hindu communities in: a) Rosignol b) No. 2 Village c) Victory Dam d) Bennet Dam	a) Moderate b) High c) Moderate d) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Medium** **b) High** **c) Medium** **d) Medium**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 90 boats using the Rosignol wharf for commercial fishing. Catch includes queriman, bangamary, butterfish, and some shrimp. • 75 boats using the De Edward port for fishing with a few shrimp boats. • 25 fishing boats use other landing areas along the river daily. • Shrimp is abundant in the swamps. • Crabs are practiced during the summer crabbing season.	Marine environment; Mangroves; River ecosystem	Fisherfolk using the landing sites at: a) Rosignol b) De Edward c) Victory Dam d) Bennet Dam e) Local communities shrimping in the swamp f) Local communities crabbing in the mangroves and swamps **ES Linkages:** Economic shrimping & Crabbing, Fish/Shrimp Processing	a) Essential b) Essential c) High d) High e) Moderate f) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate e) Moderate f) Moderate	**a) Critical** **b) Critical** **c) High** **d) High** **e) Medium** **f) Medium**
Socioeconomic: Wharf Facilities	Provisioning	• River transportation wharf used by over 1,000 persons daily for river launch crossing.	River	Local communities **ES Linkages:** Tourism	Essential	High	**High**
Socioeconomic: Fish/Shrimp Processing	Provisioning	• Processing facility at Rosignol that processes much of the landed fish catch for export.	Coastal	Local fisherfolk, Export market	Essential	Moderate	**Critical**
Livestock Farming	Provisioning	• Grazing occurs throughout shore of the NDC with many residents owning animals. There are more than 400 pigs grazing in Rosignol. A few persons graze	Mangroves; Sea Dam; Pastures	Local communities, private cattle farmers in: a) Victory Dam	a) Moderate b) Moderate c) Essential	a) Moderate b) Moderate c) High	**a) Medium** **b) Medium** **c) High**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		over 100 cows, goats, donkeys, and sheep in Rosignol on the sea dam. Much grazing occurs at Bel Air, Zeelust, and Cotton Tree with over 300 goats, sheep, and cows on the dams and in the mangroves.		b) No. 2 Village c) Zeelugt/Rosignol			
Socioeconomic: Palm Processing Facility	Provisioning	• Processing Facility at Rosignol for processing of Manicole Palm for export.	Coastal	Local harvesters from riverine communities including Amerindians, Export market	Essential	Moderate	**Critical**
Shoreline Protection	Regulating	• Extensive area of Mangrove forest from Zee Zeight to De Edward with ponds in the forest. Mangroves covering the banks of the Berbice River at most locations. Grazing occurs in the mangroves and sea dam at each location. Honey bees are kept at No. 3 Village by one family.	Mangrove Forests	Mangrove in: a) De Edward b) No. 2 Village c) Zeelugt/Rosignol d) Bennet Dam **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination, Beekeeping	a) Moderate c) Moderate d) Moderate	a) Moderate b) High c) High	**a) Medium** **b) Low** **c) Low**
Food: Mangrove Forest	Provisioning	• Crabs, fish, and shrimp caught in ponds in the mangrove forest. Pin seine is used for fishing beside the mangroves in the river.	Mangrove Forests, River Ecosystem	Local communities	High	Moderate	**High**
Food: wild meat	Provisioning	• Iguanas are caught daily in the mangroves by fewer than 50 hunters. • Many plover birds are caught using wire for a trap. Curi curi is not hunted regularly. • Cage birds are caught along the shore.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Socioeconomic: Boat Building	Provisioning	• Boat building at Victory Dam and De Edward with an average of two boats per month with the 35-foot boat selling for GYD$780,000.	Coastal	Local fisherfolk	Moderate	Moderate	**Medium**
Socioeconomic	Provisioning	• The Berbice River Bridge is used by thousands of persons daily and the Berbice River launch transports almost 1000 school children and Government workers on weekdays between Rosignol and New Amsterdam.	Coastal	Local communities (general population)	Essential	Low	**Critical**
Cultivated Crops	Provisioning	• Planting of fruits and cash crops in De Edward and No. 2 Village	Cultivated lands	Local communities	Moderate	Moderate	**Medium**

APPENDIX C

Identified Ecosystem Services and Priority Ratings: Region 6 Coastal

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TABLE C-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 6 COASTAL

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 35 – Ordinance/Fort Lands							
Socioeconomic: Sawmilling	Provisioning	• Sawmill at Sheet Anchor employing 10-50 persons on a part time basis. Use Canje River to transport logs to mill.	Coastal	Local community	High	Moderate	**High**
Socioeconomic, Wharf, Building Materials Depot	Provisioning	• Wharves at Canje Bridge facilitating transport of building supplies (stone, steel, and sand) and boat repairs used by approximately 100 persons daily.	Coastal	Local community, Hardware suppliers, Construction sector, Boat owners	Essential	Moderate	**Critical**
Socioeconomic	Provisioning	• Two crab meat processing plants are located within the NDC.	Sea shore	Local community; crabbers	High	High	**Medium**
Shoreline Protection, River defense	Regulating	• Extensive area of mangrove forest on the riverbanks protecting the land from the Berbice and Canje Rivers.	Mangrove Forests	**ES Linkages:** Agriculture, fishing river defense	Moderate	High	**Low**
Habitat provision, coastal protection	Supporting	• Mangroves provide habitats for wild bees, birds, crabs, fish and shrimp in the mangroves.	Mangrove Forests	Local community	High	Moderate	**High**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Approximately 50 boats docking at Sheet Anchor, Cumberland, and Seawell. The boats catch both fish and shrimp. • Approximately 100 persons catch shrimp and fish in the mangroves and canals using nets and seine for daily use and sale. The downturn of the sugar industry has resulted in approximately 50–60 persons seeking employment in fishing, especially within the swamps along the shoreline areas. Catch is sold within and outside of the NDC. • Crab catching done throughout the year supplying two crab meat processing operations.	Marine habitat and Mangrove Forests	a) Fishing boats landing at Sheet Anchor b) Fishing boats landing at Sheet Anchor Wharf c) Commercial and subsistence fishing in the mangroves d) Crabbing	a) Essential b) Essential c) High d) High	a) Moderate b) Moderate c) Moderate d) High	**a) Critical** **b) Critical** **c) High** **d) Medium**
Livestock Farming	Provisioning	• More than 2,000 head of cattle graze in the Cumberland, Fort Ordinance, Palmyra, and No. 2 area. • Grazing at Sheet Anchor of more than 100 head of cow, goats, and sheep.	Sea Dam, Pastures	Local communities, private cattle farmers that graze animals in: a) Fort Ordinance b) Sheet Anchor c) Cane Field	a) Essential b) High c) Moderate	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) High** **c) Medium**
Cultivated Crops	Provisioning	• Cash crop cultivation in close proximity to the sea dam on private lands and on reserves. Grazing is also done on the lands in this area not under cultivation.	Sea dam; Cultivated areas	Local farmers; Residents	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Religious activity along the dams leading to the Canje River at Sheet Anchor and Cane Field used by less than 10 persons daily and more on religious days.	Seashore, sea dam,	Local Hindus	Moderate	Moderate	**Medium**
Socioeconomic: Informal Housing	Provisioning	• Squatting at Sheet Anchor and Cumberland by 10-20 households. Squatting has increased by 1 or 2 households.	Coastal	Local community, Fisherfolk	High	Moderate	**High**
Food: wild meat	Provisioning	• Sea birds including curi curi, plover, and wisi wisi ducks are caught for meat by a few locals.	Coastal Mangroves	Local people	Moderate	High	**Low**
NDC 36 – Kintyre/No. 37							
Food: aquaculture and wild-caught fish & shellfish: Marine & Coastal	Provisioning	• There are numerous ponds in the area used for shrimp and fish including tilapia and mullet. Persons from throughout the Corentyne Coast benefit from these resources. • Over 1,000 crabs are caught daily by different crews of 4-6 persons. 20 crabs sell for GYD$1,000 locally and in Georgetown. Catches are more significant during the crab marching season. More persons are involved in crabbing.	Coastal environment; Mangroves; River ecosystems	a) Fish and shrimp ponds b) Crabbing, fishing and shrimping at Borlam Dam **ES Linkages:** Tourism, Trapping	a) Essential b) Essential	a) Moderate b) Moderate	**a) Critical** **b) Critical**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: wild meat	Provisioning	• Approximately 10 persons are involved in the daily capture of sea birds including curi curi, plover and wisi wisi ducks are caught for meat at the shoreline and by the ponds.	Mangroves	Local people **ES Linkages:** Tourism	Low	Moderate	**Low**
Cultural: Religious	Cultural	• Religious activity at Seawell and Borlam Dam, with daily and weekly use by the Hindu religious community. • There is a cemetery located in close proximity to the seashore in Bohemia.	Seashore; Sea dam	a) Hindu religious activities b) Cemetery in Bohemia	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Shoreline Protection	Regulating	• Extensive area of mangrove forest protects the local communities from the impacts of the sea. Crabs, fish, shrimp, and birds are abundant.	Mangrove Forests	Mangroves in: a) Borlam Dam b) Bohemia and Warren **ES Linkages:** Fishing, crabbing	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
Flood Regulation	Regulating	• Extensive area of the coast covered by housing and other economic activities are drained by drainage pumps installed at Borlam.	Mangrove Forests	Local communities **ES Linkages:** Fishing, crabbing	High	Moderate	**High**
Livestock Cultivation	Provisioning	• Grazing of more than 1,000 heads of cattle, goats, and sheep.	Coastal, Pasturelands	Local communities in: a) Bohemia/Warren b) Seawell	a) Essential b) Moderate	a) Moderate b) High	**b) Critical** **b) Low**
Tourism and Recreation	Cultural	• Locals utilize Crab Island and Borlam Beach for recreational purposes.	Coastal and Marine	Tourism and recreation	Moderate	Moderate	**Medium**
Socioeconomic	Provisioning	• There is brick making from the burning of clay in lands adjacent to the shoreline. It was reported that the operation has been disrupting the cemetery which is in proximity and reports have been made to the Regional Health Officer. Concerns were raised that brick making increases erosion risk due to the extraction of soil and excavation is moving in the direction of the shoreline.	Coastal	Cemetery; Mangroves; Grazing	Low	Moderate	**Low**
Socioeconomic	Provisioning	Presence of CGX shore base in Seawell and wharf on Crab Island.	Coastal, Mangroves	Businesses; Local communities	Moderate	Low	**High**
NDC 37 – Gibraltar/Fyrish							
Food: aquaculture and wild-caught fish & shellfish: Coastal Mangroves	Provisioning	• There are about 12 shrimp ponds in the NDC with the majority on the seashore. Each pond can earn GYD$200,000 per crop/month in shrimp. • There are a few persons who catch crabs for sale in the NDC at GYD$50 for each adult crab. • Catching crabs, fish, and shrimp for subsistence use has increased.	Marine environment; Mangroves; Crab grass	a) Fishing and shrimping in the ponds for subsistence use and sale b) Crabbing for sale and subsistence use	a) Essential b) Moderate	a) Low b) High	**a) Critical** **b) Low**
Shoreline Protection	Regulating	• Extensive area of mangrove forest on the shore line protecting the coast from the impacts of the sea. Mangroves are in the increase in the NDC due to natural growth but there is some erosion at No.1 Village. The seas defense is being breached to allow for sea water into the shrimp ponds.	Mangrove Forests	a) Local communities protected by mangroves throughout the NDC b) Business persons who breach mangrove for shrimp pond in No. 1 Village/Courtland **ES Linkages:** Agriculture, fishing Sea & River defense	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
Livestock Farming	Provisioning	• There are grazing pastures at Gibraltar and Portland with cows, goats, and sheep and pigs in pasturelands and in the mangroves on the coast.	Coastal Pasturelands	Local communities that graze animals in: a) No. 1/ Courtland b) Fyrish c) Gibraltar	a) Moderate b) High c) High	a) Moderate b) Moderate c) Moderate	**a) Medium** **b) High** **c) High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Religious Activities; Burial Ground	Cultural	• Hindu religious activities are practiced along the shoreline in areas where there is access such as the eastern section of Fyrish and the No. 1 Village. • There is a cemetery in Fyrish that is used for burials by all religions.	Coastal	Local communities using: a) The Fyrish and No. 1 shoreline b) The cemetery in Fyrish	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Food: wild meat	Provisioning	• Sea birds including curi curi, plover, and wisi wisi ducks are caught for meat by a few locals. The number of persons involved in this activity has increased.	Coastal Mangroves	Local people	Low	Moderate	**Low**
NDC 38 - Kilcoy/Hampshire							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There is a large landing site for commercial artisanal fishing vessels Albion. Approximately 450–475 persons from the NDC are employed in fishing. Catch includes catfish, bangamary, butterfish, trout, mullet, and white belly and fat shrimp. • There are about 40 ponds in the NDC used for shrimp farming with each pond reaping an average of 20 buckets of shrimp per month that can sell for GYD$160,000–200,000. • In addition, there are several persons involved in cast net and drag net fishing along the seashore for subsistence purposes. During the out-of-crop sugar seasons, more persons are involved in these types of subsistence fishing. • There are 10-50 persons from the NDC and the Region who catch crabs weekly for sale at GYD $50 for each adult crab. Crab catching is also considered a recreational activity and the crabs caught in this way are for subsistence use.	Marine environment; Mangroves;	a) Local fisherfolk using the landing site at Albion b) Persons using shrimp ponds c) Local communities engaged in crabbing d) Subsistence fishing along the sea shore	a) Essential b) Essential c) Moderate d) High	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Critical** **b) Critical** **c) Medium** **d) High**
Food: wild meat	Provisioning	• Iguanas are caught on the seashore along with sea birds including plovers, egret, curi curi, stork, and wild ducks for meat by a few persons and sold in the local market at 10-40 for GYD$1,000.	Mangroves; shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Primary production, biodiversity	Supporting	• Wild bees are found in the mangroves with hives at Hampshire.	Mangrove Forest	Local communities **ES Linkages:** Pollination, Pest control	Low	Moderate	**Low**
Livestock Farming	Provisioning	• The poultry farm located in Kilcoy and Chesney comprises five large multi-storey chicken pens with each pen containing approximately 20,000 chickens.	Coastal	Local communities Local Businesses	High	Moderate	**High**
Cultural: Religious	Cultural	• Hindu temples are in close proximity to the seashore at Chesney, Hampshire, Nigg, No. 4 Village, and two temples are located in Belvedere. • Hindu religious activities are also conducted on the sea dam in No. 4 Village. • The NDC has a burial ground at the foreshore of No. 4 Village where burial is done for all religions.	Coastal	Local Hindu Community using: a) temples at Chesney and No. 4 b) temples at Belvedere and Hampshire c) temple at Nigg d) Burial Ground in No. 4 Village	a) Moderate b) Moderate c) Moderate d) Moderate	a) High b) Moderate c) Moderate c) Low	**a) Low** **b) Medium** **c) Medium** **d) High**
Cultivated Crops	Provisioning	• A few persons farm on the sea dam and on adjacent lands with mainly cash crops and fruits for subsistence and sale in the community. Mainly done at Nigg, Kilcoy, and Chesney.	Cultivated lands	Local communities	Moderate	Low	**High**
Livestock Farming	Provisioning	• Grazing of cattle in Nigg and Hampshire	Pasturelands	Local communities grazing animals at: a) Hampshire b) Nigg	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Shoreline Protection	Regulating	• Extensive area of Mangrove forest on the shore line protecting the coast from the impacts of the sea. Mangroves are in the increase in the NDC	Mangrove Forests	Mangroves offering shoreline protection at:	a) Moderate b) Low	a) High b) High	**a) Low** **b) Low**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		due to natural growth but there is some erosion at No.1 Village. The seas defense is being breached to allow for sea water into the shrimp ponds. Mangrove cover has increased.		a) Hampshire b) Albion c) Nigg **ES Linkages:** Agriculture, fishing Sea & River defense	c) Moderate	c) Moderate	**c) Medium**
Socio-Economic	Provisioning	• Land in Hampshire close to the seashore has been earmarked for the establishment of a new industrial site	Sea shore; shoreline	Local business communities	Low	Low	**Medium**
NDC 39 – Rose Hall Town							
Tourism and Recreation	Cultural	• There is a long stretch of beach within the Town Council that is used by the wider community and is frequented by over hundreds persons daily and approximately 500 on weekends. In 2019, there were a comparable number of persons on the beaches at Rose Hall and No. 63 beach during the Easter holidays.	Coastal and Marine	Local communities in NDC and Region 6 **ES Linkages:** Fishing, Grazing	Essential	Low	**Critical**
Shoreline Protection	Regulating	• Extensive area of mangrove forest at the shore protecting the town from the impacts of the sea. Animals graze within mangrove area and the extent of mangrove coverage in the municipality has declined. However, mangroves are still harvested for use as firewood, in construction and to be used as fishing rods. Mangroves are being monitored.	Mangrove Forests	Local communities **ES Linkages:** Fishing, grazing	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Many plover birds are caught using wire for sale at the local market.	Mangroves, shoreline	Local communities	Low	High	**Low**
Cultural: Religious	Cultural	• The Hindu religious activities are held at the Rose Hall beach, which provides space and privacy. Religious activities by Hindus on the Rose Hall beach has increased and approximately 200 persons use the area on a weekly basis, with more on Sundays and Tuesdays. Thousands of persons use the area on special days of worship for Hindus.	Coastal	Local Hindu communities	Essential	Low	**Critical**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There is a landing site for fishing boats at Rose Hall. Pin seine fisherfolk also use this site for catching fish for subsistence and for sale. Fishes include bangamary, butterfish, trout, and mullet. • Fish pond for locals to catch fish, shrimp and crabs in Williamsburg	Marine environment; Mangroves;	a) Local fisherfolk using the Rose Hall site b) Local communities using the fish pond	a) Moderate b) High	a) Moderate b) High	**a) Medium** **b) Medium**
Livestock Farming	Provisioning	• There are approximately 100 animals grazing on the shore and near shore areas.	Coastal; Pasturelands	Local communities	High	High	**Medium**
Cultivated Crops	Provisioning	• There are small farms on the sea dam and on adjacent lands used by persons living in proximity planting fruits and cash crops. Farming on the sea dam and on adjacent lands has decreased due to saline intrusion.	Coastal, Pasturelands	Local communities	Moderate	High	**Low**
NDC 40 – Port Mourant/John							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are 9 boats using the Port Mourant outfall employing 33–40 persons, as a landing area for fish and shrimp. Fishing is considered a second job for sugar workers during out-of-crop seasons on the sugar estates. • Approximately 20–25 persons catch shrimp, tilapia, coo coo belly, and cufum in the swamp or drainage canals along the sea dam on a daily basis. During out-of-crop seasons, up to 100 persons catch fish and shrimp in swamps and drainage canals for subsistence use and for sale. • There are approximately 100 shrimp and fish ponds in the NDC owned by 40 persons in the NDC. Ponds have been expanded and there are different sections for species. In addition, areas formerly used for rice cultivation have been converted to shrimp and fish ponds. The ponds in Babu John have been rehabilitated and are currently in use. All ponds in the NDC are privately owned.	Marine environment; Mangroves; river ecosystem	a) Fisherfolk using the Port Mourant outfall b) Owners of private fish and shrimp ponds c) Local people fishing in swamps and drainage canals	a) High b) Essential c) High	a) Moderate b) Moderate c) Moderate	**a) High** **b) Critical** **c) High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Livestock Farming	Provisioning	• A farm at John has five large multi-story pens with approximately 5,000 chickens per pen; it employs more than 20 persons full time. • More than 8,000 animals graze on the shore, in the mangroves, and on adjacent pastures. More than 1,000 animals graze in Tain. The number of animals in the NDC is increasing. • There is a ranch at Babu John with 400-500 animals. The NDC has no established pasture.	Coastal	Local communities, Local Businesses: a) Operating poultry farms b) Grazing animals in Tain c) Grazing animals in Port Mourant	a) High b) Essential c) High	a) Moderate b) Moderate c) High	**a) High** **b) Critical** **c) Medium**
Shoreline Protection	Regulating	• Mangrove forest at the shore aids in capturing the sediments as the shore is built. There is no monitoring of mangrove cover and mangroves are reported by the NDC to be cut by shrimp farmers to access the water for ponds and to create ponds. Some persons collect dried mangrove roots for use in their kitchen gardens and as firewood.	Mangrove Forests, Coastal	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation	Moderate	High	**Low**
Food: wild meat	Provisioning	• Shore birds including plover and spika are caught using wire for sale at the local market at GYD$1,500–2,000 per string of about 20 birds. Curi curi and carrow are sold at 2 for GYD$1,000–1,500. Although a few persons routinely catch these birds, there are peak numbers of persons involved on a seasonal basis.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• The religious activities of the Hindus are held at Port Mourant and Tain. Prayers and daily worship are held at the Port Mourant beach extending from Rose Hall. • Religious activities are held at Port Mourant. In addition, the main cremation site at Babu John is dedicated to late President Cheddi Jagan. There is also a cemetery at Babu John.	Coastal	a) Local Hindu communities at Port Mourant b) Babu John Crematorium in Tain	a) Moderate b) High	a) Moderate b) Low	**a) Medium** **b) Critical**
Tourism and recreation	Cultural	• Locals utilize the Port Mourant beach from the Rose Hall entrance for recreational purposes.	Coastal and Marine	Local communities in NDC and Region 6	Moderate	Moderate	**Medium**
NDC 41 – Bloomfield/Whim							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• The outfalls at Letter Kenny and Whim are used as landing sites for fishing boats. They are not frequently used, as the channels are heavily silted making access to the landing sites difficult. However, approximately 28 fishing boats are owned by persons from the NDC who use landing sites at Adventure and Complex 66. In addition, more than 100 persons in the NDC are employed as fisherfolk on boats at different landing sites throughout the Corentyne Coast. Catch various catfishes, bangamary, butterfish, trout, and mullet. • Approximately 15 persons catch crabs on a regular basis for sale. The number of persons engaged in crabbing increases during the summer crab season. • Approximately 30 ponds in the area for shrimp farming which are owned by 10–15 people. One bucket valued at GYD$10,000. • Approximately 15 persons fish along the shoreline using pin seines and cast nets.	Marine environment; Mangroves; Drainage canals; Natural ponds	a) Fisherfolk using the landing site at Letter Kenny b) Fisherfolk using the landing site at Whim c) Owners of shrimp ponds in the NDC d) Persons engaged in crabbing **ES Linkages:** Fishing, Grazing, Erosion regulation, Tourism	a) High b) High c) High d) Moderate	a) High b) High c) Moderate d) Moderate	**a) Medium** **b) Medium** **c) High** **d) Medium**
Shoreline Protection	Regulating	• Mangrove forest covers most of the shore with new growth in some areas as the silt washes ashore and is trapped. Cows and goats are found grazing in the mangroves.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	High	Moderate	**High**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC but is more predominant at Whim to Letter Kenny, with hundreds of heads of cattle, goats, and sheep. Grazing along the sea dams and shoreline has increased; this is attributed to former sugar workers seeking alternative employment.	Mangroves; Sea Dam; Pastures	Local communities; Private cattle farmers	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Cultivated crops	Provisioning	• Cash crop cultivation in close proximity to the sea dam at Whim and Letter Kenny. Crops include watermelon, muskmelon, cucumbers, bora, tomatoes, and eggplant. Cultivation of cash crops and fruit in close proximity to the sea dams increases during the wet seasons when freshwater is easily available.	Sea dam; Cultivated areas	Local farmers; Residents; Businessmen in: a) Letter Kenny and Whim	a) Moderate	a) Moderate	**a) Medium**
Cultural: Religious	Cultural	• The religious activities of the Hindus are held from Bloomfield to Letter Kenny. Persons from within and outside of the NDC come to these areas for worship. • There are three Hindu temples located in close proximity to the shoreline at Letter Kenny and Whim. • There are cemeteries at Letter Kenny and Whim which are used by all religions.	Coastal	a) Local Hindu communities using shoreline between Bloomfield and Letter Kenny b) Local Hindu communities using the temples c) Cemeteries at Letter Kenny and Whim	a) High b) High c) Moderate	a) High b) Moderate c) Low	**a) Medium** **b) High** **c) High**
Food: wild meat	Provisioning	• Shore birds including egret, curi curi, dukla, plover, wisi wisi, and spika are caught for meat or sale in the market.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	High	**Low**
Social	Provisioning	• There is a nursery school located in close proximity to the seashore in Letter Kenny.	Mangroves; Shoreline	Local children; local communities	High	High	**Medium**
Socio-economic	Provisioning	• A water well and pump system was installed by Guyana Water Incorporated (GWI) Letter Kenny and provides water to Whim, Bloomfield, Letter Kenny and Auchlyne.	Mangroves; Shoreline	Local communities	Essential	Moderate	**Critical**
NDC 42 – Lancaster/Hogstye							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are 12 boats that use the Hogstye/Adventure outfall for fishing. The number of large fishing boats landing at the Hogstye/Adventure outfall has increased as there is easy access and the landing site at Complex 66 is crowded. None of the boats at the outfall are owned by persons from the NDC. However, persons from the NDC, mostly from Lancaster, work on fishing boats that land at various sites along the Corentyne Coast. • Persons throughout the NDC utilize pin seines and cast nets for fishing along the shoreline. • There is one shrimp pond and one tilapia pond in Lancaster occupying 198 acres of land close to the seashore. Two persons own these ponds.	Marine environment; Mangroves;	a) Fisherfolk using the landing site at Hogstye/Adventure b) Local fisherfolk fishing with pin seines and cast nets along the shoreline c) Local persons who own the shrimp and fish ponds	a) High b) High c) High	a) Moderate b) High c) Moderate	**a) High** **b) Medium** **c) High**
Food: wild meat	Provisioning	• Iguanas are hunted daily for meat and for sale by young persons in the NDC who are unemployed. There is limited hunting of birds in the NDC.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	High	**Low**
Cultural: Religious	Cultural	• The religious activities of the Hindus are held mainly at Manchester and Alness where sand beaches facilitate these activities. These activities are increasing because access to the beaches has improved.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC and across the shore with many residents owning more than 5000 cows, goats, sheep, pigs, and horses.	Mangroves, Sea Dam, Pastures	Local communities, private cattle farmers	Moderate	Moderate	**Medium**
Shoreline Protection	Regulating	• Mangrove forest exists throughout the NDC on the shore and is reported to be destroyed by the shrimp farmers. Grazing occurs in the mangroves and on the sea dam. Natural regrowth of mangroves is continuing.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Pollination, Bird hunting	High	Moderate	**Medium**
Cultivated Crops	Provisioning	• Cultivation of cash crops and fruits along the shoreline throughout the NDC. These activities are increasing and more crops are planted during the wet seasons. Crops include watermelon, bora, tomatoes, muskmelon, etc.	Sea dam, cultivated areas	Local farmers, residents	High	Moderate	**High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• In Lancaster there are conflicts for land between the farmers and the owners of the fish and shrimp ponds. In addition, there are complaints from some residents of the NDC that spraying pesticides on the crops cultivated on the seashore adversely impacts their lives.					
Tourism and Recreation	Cultural Services	• Locals utilize the Manchester and Alness beaches for recreational purposes with over 100 persons on weekends. These activities are increasing because access to the beaches has improved.	Coastal and Marine	Local communities in NDC and Region 6	High	Moderate	**Medium**
NDC 43 Black Bush Polder							
Drainage	Regulating	• The agricultural settlement has two drainage outlets at No. 43 and at Adventure, with drainage pumps to drain the excess water.	Coastal; cultivated areas	Local farmers, residents	Essential	High	**High**
Religious Activities	Cultural	• The religious activities some residents are held at Adventure beach for special ceremonies.	Coastal	Local Hindus	Moderate	Moderate	**Medium**
Wildlife Trapping & Hunting	Provisioning	• Birds are hunted with shotguns by a few persons on an irregular basis including curi curi, egrets, and wild ducks for meat. Other persons buy the birds at the market.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Low	Moderate	**Low**
Food: aquaculture and wild-caught fish & shellfish: Coastal & mangroves	Provisioning	• A small group of persons visit the mangroves on the coast at No. 43–47 villages to catch crabs in season and on occasion out of season. • Black belly shrimp from the shrimp ponds are sold in the NDC on a daily basis by vendors from the coast.	Marine environment; Mangroves	Local people **ES Linkages:** Economic shrimping & Crabbing	a) Low b) High	a) High b) High	**a) Low** **b) Medium**
NDC 44 Good Hope/No. 51							
Shoreline Protection	Regulating	• Extensive area of mangrove forest from No. 47–49 villages. Mangrove coverage throughout the NDC is increasing throughout the NDC and the Council is actively trying to stop the harvesting of mangroves because of its importance to protecting the shoreline of the NDC.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	High	Moderate	**High**
Primary production; biodiversity	Supporting	• Wild bees are present in the mangroves in No. 45, No. 47, No. 48, No. 50, and No. 51. Honey is harvested from these hives for subsistence use. However, the numbers of bees are increasing and there have been complaints of bees swarming residences in these areas. • Birds and crabs are abundant. Grazing also occurs in the mangroves and on the sea dam.	Mangrove Forests	Local communities	Low	Moderate	**Low**
Livestock Farming	Provisioning	• One person grazes goats on the sea dam and in the mangroves at No. 49 Village. • In addition, several other persons graze cows, goats and sheep at No. 45, No. 47, No. 48, No. 50, and No. 51 villages.	Mangroves, Sea Dam, Pastures	Local communities; Private cattle farmers who graze animals in: a) No. 49 Village b) Other villages in the NDC	a) Moderate b) High	a) High b) High	**a) Low** **b) Medium**
Cultural: Religious	Cultural	• Religious activities are held in No. 49 and No. 51 villages with the most persons on Fridays and Sundays. There is easy access to the shoreline at No. 49 Village.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Hunting of iguanas has increased significantly in the mangroves throughout the NDC. Persons from throughout the Corentyne Coast including New Amsterdam visit the NDC to catch iguanas for sale. • Hunting of shore birds has increased and is done daily at No. 45, No. 48, No. 50, and No. 51 villages. • In addition, cage birds/finches are caught for sale and training in the NDC at No. 45, No. 48, No. 50 and No. 51 villages.	Mangroves, shoreline	People who hunt: a) Iguanas b) Shore birds for meat and sale, and cage birds for sale **ES Linkages:** Tourism	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Food: aquaculture and wild-caught fish &	Provisioning	• A few boats use the landing site at No. 51 Village. The boats mainly fish including bangamary, butterfish, trout, and mullet.	Marine environment; Mangroves	Local fisherfolk Local people who:	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
shellfish: Marine and Coastal		• Persons fish along the shoreline using pin seines and cast nets daily throughout the NDC. • There are four large shrimp ponds in the No. 49 Village which are all privately owned. • In the No. 51 Village, there is a swamp area where persons through the NDC catch fish and shrimp for subsistence use. This area is also used by persons from the No. 52 Village, located outside of the NDC. • Approximately 30–40 persons from within and outside of the NDC catch crabs in the mangrove forests in the NDC. In addition, catch is sold both within and outside the NDC.		a) Use the landing site at located in No. 51 Village b) Fish along the shoreline c) Own private shrimp ponds d) Fish in the communal ponds e) Catch crabs	c) High d) High e) High	c) Moderate d) Moderate e) Moderate	**c) High** **d) High** **e) High**
Socioeconomic: Brick burning	Provisioning	• Brick burning by 4-8 persons on the sea dams using dried mangrove and lumber as fuel.	Coastal	Local communities	Moderate	Moderate	**Medium**
Cultivated Crops	Provisioning	• Cultivation of cash crops and fruits including coconuts on the sea dam and adjacent lands in No. 47 Village has stopped due to significant saltwater intrusion where the dam was eroded and there were breaches in the mangroves. • Farming is continuing on the sea dams on No. 50 and No. 51 villages.	Coastal; Pasturelands	a) Local communities farming on the sea dams b) Local communities planting coconuts on the sea dams	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
NDC 45 Macedonia/Joppa							
Shoreline Protection	Regulating	• Extensive forest of mangroves in the NDC. Grazing occurs in the mangroves and on sea dam. Shrimp and fish ponds in the mangroves used by locals. Mangroves are reduced due to erosion of the shore. • There is extensive mangrove cover in the NDC and the mangrove stand has been increasing.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Moderate	Moderate	**High**
Livestock Farming	Provisioning	• Cows, goats, and sheep graze throughout the NDC in Bengal, Joppa, Brighton, Eversham, Kiltaira, and No. 35 Village. The least amount of grazing occurs in Eversham. • In between the rice crops, some animals are taken to the rice fields to graze.	Coastal, Mangroves, Sea Dam, Pastures	Local communities, Cattle farmers who graze animals in: a) No. 35 Village b) Brighton c) Kiltaira d) Eversham	a) Moderate b) High c) Moderate d) Moderate	a) Moderate b) Moderate c) Moderate d) High	**a) Medium** **b) High** **c) Medium** **d) Low**
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• Fishing boats that use the outfall in No. 43 Village has declined and larger boats use the landing at Complex 66. 5 boats use the Eversham outfall. Catch of bangamary, mullet, catfish, etc. • Persons fish along the shoreline using pin seines and cast nets. • There are 5 privately owned shrimp ponds on the sea dams of Bengal, Kiltyre, and No. 36 Village. • Approximately 100 persons catch shrimp, tilapia, and hassar in the mangroves, canals, and along the shoreline using pin seines and cast nets daily for subsistence use. If there is excess catch, then it is sold within the NDC. Turtles are sometimes caught in the mangroves for meat. • Crabbing is a significant activity in the NDC and during the crab season persons from Canje visit the NDC to catch crabs for sale.	Marine environment; Mangroves;	Local fisherfolk and local people: a) Fishing boats at the No. 43 Village b) Fishing boats at Eversham c) Privately owned shrimp ponds d) Fishing along the shoreline; and in mangroves, swamps and canals e) Crabbing	a) Low b) High c) High d) High e) High	a) High b) Moderate c) Moderate d) Moderate e) Moderate	**a) Low** **b) High** **c) High** **d) High** **e) High**
Cultivated Crops	Provisioning	• Cultivation of cash crops, fruits, and coconuts is continuing on the government reserves in the Brighton Canal, Kiltyre, and Eversham. However, there are challenges with saltwater intrusion and high water levels close to the mangroves. Cultivation of cash crops and fruits increases during the wet seasons which fresh water is available.	Sea dam, cultivated areas	Local farmers, residents	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Hindu religious activities occur at the shoreline in No. 43 Village. Most persons use the No. 63 beach.	Seashore, sea dam	Local Hindus	Low	High	**Low**
Socioeconomic: Boat Building	Provisioning	• Boat building at No. 43 outfall. There is also boat maintenance and seine mending at the No. 43 outfall.	Coastal	Local fisherfolk, Boat builders, Lumber dealers	Essential	Moderate	**Critical**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: wild meat	Provisioning	• A few persons catch plover using wire or seine. Curi curi and wild ducks are shot for meat.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
NDC 46 Bushlot/Adventure							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 6 boats using Bushlot/Kildonan outfall for docking. • 12 boats use the Adventure outfall for docking. A total of 20-25 persons work these boats. • Persons fish along the shoreline using pin seines and cast nets. Shrimp caught on the shore with seine by locals daily. The number of persons who fish along the shoreline using pin seines and cast nets is increasing. These persons are generally seeking alternative sources of employment following the closure of sugar estates. • A small group of persons visit the mangroves on the coast regularly to catch crabs and more persons in season. • There are three shrimp ponds in the NDC. Two are in Bushlot Farm and are privately owned by two persons. A communal pond is in Bushlot.	Marine environment; Mangroves; Drainage canals;	Fisherfolk and local people who: a) Bushlot/Kildonan landing site b) Adventure landing site c) Fish along the shoreline d) Private Shrimp ponds e) Communal pond and fishing in mangroves and swamps f) Catch crabs **ES Linkages:** Fishing, erosion regulation, Tourism	a) High b) Essential c) High d) High e) High f) High	a) Moderate b) Moderate c) High d) Moderate e) Moderate f) Moderate	**a) High** **b) Critical** **c) Medium** **d) High** **e) High** **f) High**
Food: wild meat	Provisioning	• Shore is highly populated by thousands of birds. A few persons, mainly in Bushlot, catch plover using wire or seine. Curi curi and wild ducks are shot for meat for sale. A few persons also catch iguanas. This is mostly done by young people who have completed secondary school and are unemployed.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Hindu religious activities are mainly conducted on the Bushlot beach for Hindu religious activities from other areas as far east as Hampshire use the beach for religious purposes.	Seashore, sea dam,	Local Hindus using: a) Bushlot beach b) other areas in the NDC	a) Moderate b) Moderate	a) Low b) High	**a) High** **b) Low**
Tourism and Recreation	Cultural	• Approximately 100 persons use the Bushlot Beach on a weekly basis for recreation purposes. There are several hundred persons on special holidays like Easter weekend.	Coastal and Marine	Local communities in NDC and Region 6	High	Moderate	**High**
Cultivated Crops	Provisioning	• Cultivation of cash crops and fruits in continuing near the sea dam from Bushlot–Adventure. Cultivation has increased and this is also linked to higher levels of unemployment resulting from the closure of the sugar estates. There is no farming on private lands.	Sea dam; Cultivated areas	Local farmers, residents	High	Moderate	**High**
Shoreline Protection	Regulating	• Extensive area of Mangrove forest in the NDC protecting the mud or sand sea defense. Birds and crabs are abundant and used by locals. Grazing in the mangroves and sea dam particularly by residents living in proximity. • Mangrove cover at Kildonan has been increasing. Persons from the NDC use dried mangroves in their kitchen gardens and sometimes as firewood.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• Grazing of goats and sheep along the seashore in Kildonan.	Mangroves	Local communities	Moderate	Moderate	**Medium**
NDC 47 Maida/Tarlogie							
Shoreline Protection	Regulating	• Mangrove forest covers the entire shore protecting the fragile mud sea defense. In 2018, NAREI established a mangrove restoration plot in Wellington Park. These mangrove seedlings have died. However, there are mangroves on other areas in the NDC and new natural growth is continuing in Kilmarnock.	Coastal, Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Essential	High	**High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Agriculture: Grazing	Provisioning	• More than 1,000 cows and sheep graze along the shoreline throughout the NDC. The owners of these animals reside in Wellington Park, Philippi, and Kilmarnock.	Mangroves; Sea Dam; Pastures	Local communities; Private cattle farmers	High	Moderate	**High**
Religious Activities	Cultural	• Religious activities held in areas with access to the sea at Wellington Park, Kilmarnock, Maida, and Tarlogie.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Curi curi, flamingo, duckla, wisi wisi, and plover birds are hunted regularly for meat or sale. • Hunting of iguanas and sea birds for meat and sale in the mangroves is increasing and approximately 20–25 persons do this daily.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Food: aquaculture and wild-caught fish & shellfish: Marine and coastal	Provisioning	• 14 boats landing at Maida, Kilmarnock, and Wellington Park depending on the ease of traversing the channels to access the sites. Approximately 60 persons are employed in these boats. Catch includes catfish, bangamary, butterfish, trout, mullet, snook, basha, etc. • Persons fish along the shoreline using pin seines and cast nets. • Crabbing is also an important source of livelihoods throughout the year in the NDC. Crab catching is also done by several persons for recreation. • There are canals and swamp basins in Tarlogie that are open for communal catch of fish and shrimp. • Large area in the NDC with shrimp ponds harvesting approximately 125 buckets of shrimp monthly valued at GYD$1,000,000. Additional privately owned shrimp ponds have been created on Wellington Park, Maida, and Kilmarnock. Approximately 8–10 persons own the ponds in the NDC.	Marine environment; Mangroves;	Local fisherfolk Local people who: a) Utilize the landing sites at Maida, Kilmarnock, and Wellington Park. b) Catch fish and shrimps in swamps and fish along the shoreline c) Own private shrimp ponds d) Catch crabs	a) High b) High c) Essential d) High	a) Moderate b) Moderate c) Moderate d) Moderate	**a) High** **b) High** **c) Critical** **d) High**
Cultivated Crops	Provisioning	• There are small farms on the sea dam and on adjacent lands at Maida, Tarlogie, and Wellington Park planting fruits and cash crops.	Coastal, Pasturelands	Local communities	High	Moderate	**High**
NDC 48 No. 52/74 Villages							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are more than 400 boats at No. 66 Village outfall for nearshore and deep sea fishing. Fishing boats from Regions 4 and 5 and along the Corentyne Coast use this landing site. • 100 boats use the No. 65 Village outfall for fishing activities with shrimp. • At No. 63 Village, there are approximately 20 small boats that use pin seines to fish along the shoreline. In total, there are approximately 60–75 small boats in the NDC that practice pin seine fishing along the shoreline for sale. • 10-30 persons daily catch shrimp and fish on the shore by the beach using hand seine. Shrimp, mullet, and sardines are caught for sale. • Erosion of mangroves has significantly reduced crabbing activities and crabs are only caught during crab marching seasons. In crab season more than 50 persons daily catch crabs. • Approximately 4,000 persons are directly indirectly employed in the fishing sector in this NDC.	Marine environment; Mangroves; Drainage canals;	Fisherfolk who: a) Use the landing site at No. 66 Village b) Use the outfall at No. 65 Village c) Conduct pin seine fishing and fish along the shoreline d) Catch crabs **ES Linkages:** Fishing, Fish mongering, Boat Building; Mangroves	a) Essential b) Essential c) Essential d) High	a) Low b) Moderate c) High c) Moderate	**a) Critical** **b) Critical** **c) High** **d) High**
Socio/economic	Provisioning	• Approximately 10 meters from the No. 65 outfall, construction of a fish processing plant has commenced. The owner of this processing plant is has also purchased 45 new fishing boats, which may eventually land at the processing plan. Approximately 500 persons are expected to be employed at the fishing processing plant.	Mangroves, outfall, shoreline	Local business persons, fisherfolk, local communities	High	Moderate	**High**
Food: wild meat	Provisioning	• Many iguanas are caught and sold for GYD$4,000-5,000 each. Few birds are caught using nets or wire though the practice is illegal at the No. 63 beach.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Shoreline Protection	Regulating	• Mangrove forest covers most of the NDC offering protection and aids in capturing the sediments as the shore is built. There is significant to complete erosion of mangroves in No. 52–No. 63, No. 67, No. 69,	Mangrove Forests, Coastal	Local communities	High	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		No. 70, No. 73, and No. 74 villages. There is no cutting of mangroves and it is likely that these are natural deaths due to the age of the stand.		**ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination			
Livestock Farming	Provisioning	• Previously, thousands of animals grazed throughout shoreline areas of the NDC. Grazing of animals along the shoreline has decreased significantly. Due to the erosion of the mangrove forests, grazing lands have been lost to the sea and available lands are not private property. As a result, grazing has shifted largely to the back-dam areas. At present, more persons are involved in cattle rearing but there are fewer livestock overall in the NDC.	Mangroves, Sea Dam, Pastures	Local communities, Private cattle farmers who graze animals at No. 61 and No. 63 villages	High	Moderate	**Medium**
Cultural: Religious	Cultural	• Religious activities held in the area at No. 63 beach with 20-50 persons daily and hundreds on weekends. • Religious activities at No. 73 beach with 20 persons daily and more than 200 on weekends. • In general, religious activities are held throughout the NDC where there is easy access to the shoreline including No. 69, No. 70, and No. 71 villages.	Coastal	Local Hindu communities Christians (baptisms/ outings) Muslims (Outings) with: a) Religious activities at No. 63 beach b) Religious activities at No. 73 beach c) Other locations in the NDC	a) Essential b) High c) Moderate	a) Low b) Moderate c) Moderate	**a) Critical** **b) High** **c) Moderate**
Socioeconomic: Boat Building	Provisioning	• Boat building occurs on both sides of the dam at Complex 66. Surinamese fisherfolk also order fishing boats at the boat building sites at Complex 66 due to the quality of wood used in Guyana and the skills of the boat builders. • A boat construction facility has also been opened adjacent to the new fish process plant at No. 65 Village.	Coastal	Local fisherfolk, boat builders, lumber dealers	Essential	Moderate	**Critical**
Tourism and Recreation	Cultural	• 50-100 persons use the No. 63 beach daily for recreational purposes with hundreds of persons on weekends and thousands on Easter and August weekends. • No. 69–No. 70 beach is used by 20-50 persons daily and over 100 on weekends and holidays.	Coastal and Marine	Local communities in NDC, Region 6 and other areas of the Country using: a) No. 63 beach b) No. 69 to 70 beach and other beaches, recreational sites in the NDC	a) Essential b) High	a) Low b) Moderate	**a) Critical** **b) High**
Cultivated Crops	Provisioning	• Cash crop cultivation along most areas of the shore and on sea dam on private lands with coconuts and other crops. Peeled dried coconuts sells at GYD$4,000–6,000 per hundred. Cash crop cultivation along the shoreline has also decreased due loss of lands as a result of mangrove erosion.	Sea dam, cultivated areas	Local farmers, residents	High	Moderate	**High**
NDC 49 Corriverton Town Council							
Socioeconomic: Renewal Energy	Provisioning	• Private company has installed a wind turbine of 275 KVA capacity on the riverbank, but it is not yet operational. The business is awaiting permission from the Government of Guyana before it can be used.	Coastal	Local businessmen Township	Moderate	High	**Low**
Socioeconomic: Wharf for Passengers & Cargo	Provisioning	• The wharf located at Line Path is used by farmers and loggers for transport of their produce from Orealla and Siparuta to Corriverton. • Passengers use the 'backtrack route' at No. 78 Village to access the speedboat service to Suriname. When in operation, the ferry to Suriname lands at Moleson Creek, which is not located in the municipality.	Coastal; River	Local boatmen, Businessmen; locals; Guyanese, Surinamese using: a) Wharf in Line Path b) Speedboat service to Suriname	a) Essential b) Essential	a) Moderate b) Moderate	**a) Critical** **b) Critical**
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are more than 40 boats at No. 79 Village seawall for fishing in the Corentyne River and catch fish and shrimp. • Nine fishing boats docked for fishing activities in the river and the sea including sardines.	Marine environment; Mangroves; Drainage canals;	Fisherfolk and locals who: a) Utilize the landing site at No. 79 Village b) Fish along the shoreline	a) High b) Essential	a) Low b) Moderate	**a) Critical** **b) Critical**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Approximately 10–50 persons are engaged in daily use of seines and cast nets for catching mullet and shrimp. • Catching sardines is seasonal and more than 100 persons are engaged in using seines to catch sardines when in season. When in season, catching sardines is also considered a recreational activity.		**ES Linkages:** Fishing, Fish mongering, Boat Building, Shrimping			
Socioeconomic: Boat Building	Provisioning	• Boat building at No. 84 Village outfall with 2 boats under construction by a crew of 4 persons. • Boat building at Line Path Skeldon by a crew of 6 persons. • Speed boat construction is done at the No. 78 Village.	Coastal	Local fisherfolk, boat builders, lumber dealers involved in boat building at: a) Line Path b No. 84 outfall c) No. 78 Village	a) Moderate b) High c) High	a) Moderate b) Moderate c) Moderate	**a) Medium** **b) High** **c) High**
Shoreline Protection: River Dam Protection	Regulating	• There has been significant erosion of mangrove cover from No. 75 Village to Scottsburg. The municipality requested support from NAREI to replant mangroves in the area. However, rip rap sea defense structures have been installed in Scottsburg. Mangroves are not harvested but some persons collect dried mangroves to use as firewood. • Erosion of the sand bank in No. 79 Village has decreased use of the area for recreational purposes.	Mangrove Forests, Coastal	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Religious activities held in the area at Line Path, Scottsburg, Springlands, and Spring Garden by 20-50 persons daily and hundreds on weekends. • Some Christian groups also perform baptisms in these areas.	Coastal	Local Hindu and Christian communities, using shoreline areas for worship Burial site	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Food: wild meat	Provisioning	• More than 10 persons are engaged in hunting of iguanas on a weekly basis along the shoreline in Scottsburg. Each week about 50 iguanas are caught and sold forGYD$4,000-5,000 each by 5-7 persons. A few rabbits are also caught for meat.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• There are fewer than 30 cows grazing along the shoreline in the NDC. According to the bylaws of the TC, there should be no livestock farming in the town.	Mangroves, Sea Dam, Pastures	Local communities, private cattle farmers	Low	High	**Low**
Tourism and Recreation	Cultural	• There are approximately five tour operators who provide trips down the Corentyne River. Sometimes regattas and other events like pageants are held in communities in the river such as Orealla. • Locals use beaches and shoreline areas in the municipality for relaxation and recreation in No. 79 Village, Springlands, and Scottsburg.	Coastal and River	a) Local communities in Town and Region 6 and Suriname involved in tourism in the Corentyne River b) Locals using beaches and shoreline areas for recreation	a) Moderate b) Moderate	a) Low b) Moderate	**a) High** **b) Medium**
Socioeconomic: Informal Housing	Provisioning	• Squatting occurs at Line Path, Dukestown, Scottsburg, and No. 78 & No. 79 villages by approximately 30 households.	Coastal	Local fisherfolk, local people squatting in the municipality	High	Moderate	**High**
Cultivated Crops	Provisioning	• Approximately 35 persons are engaged in cash crop and fruits cultivation most areas of the shore and sea dam at Line Path, Scottsburg, Dukestown, and No. 75 Village. • Irrigation pump located at the koker in No. 74 Village	Sea dam; cultivated areas	a) Local farmers, residents cultivating crops on sea dams b) Local farmers benefiting from irrigation pump	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**

APPENDIX D

NDCs Meeting Schedule

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REGION 5 NDCS

Name of NDC	Date and Time (2018)		Date and Time (2019)	
Woodlands/Farm	Wed, Jan 17	9:30 AM	Mon, May 20	9:00 AM
Hamlet/Chance	Wed, Jan 17	1:30 PM	Mon, May 20	11:00 AM
Profit/Rising Sun	Wed, Jan 17	3:00 PM	Mon, May 20	2:00 PM
Mahaicony/Abary	Thur, Jan 18	9:30 AM	Tue, May 21	9:00 AM
Union/Naarstigheid	Thur, Jan 18	1:30 PM	Tue, May 21	2:00 PM
Seafield/Tempie	Fri, Jan 19	9:30 AM	Tue, May 21	11:00 AM
Bath/Woodley Park	Mon, Jan 22	9:30 AM	Wed, May 22	9:00 AM
Woodlands/Bel Air	Mon, Jan 22	1:30 PM	Wed, May 22	11:00 AM
Zeelugt/Rosignol	Tues, Jan 23	9:30 AM	Wed, May 22	2:00 PM

REGION 6 NDCS

Name of NDC (Coastal)	Date and Time (2018)		Date and Time (2019)	
Ordinance/Fort Lands	Wed, Jan 24	1:30 PM	Mon, June 24	8:30 AM
Kintyre/No.37	Thur, Jan 25	9:00 AM	Mon, June 24	11:00 AM
Gibraltar/Fyrish	Thur, Jan 25	1:30 PM	Mon, June 24	2:00 PM
Kilcoy/Hampshire	Fri, Jan 26	9:00 AM	Tues, June 25	8:30 AM
Rose Hall Town Council	Fri, Jan 26	1:30 PM	Tues, June 25	11:00 AM
Port Mourant/John	Mon, Jan 29	9:00 AM	Tues, June 25	3:00 PM
Bloomfield/Whim	Mon, Jan 29	1:30 PM	Wed, June 26	9:00 AM
Lancaster/ Hogstye	Tues, Jan 30	9:00 AM	Wed, June 26	11:00 AM
Black Bush Polder*	Tues, Jan 30	1:30 PM		
Good Hope/No.51	Wed, Jan 31	9:00 AM	Thur, June 27	2:00 PM
Macedonia/Joppa	Wed, Jan 31	1:30 PM	Thur, June 27	11:00 AM
Bushlot/Adventure	Thur, Feb 1	9:00 AM	Wed, June 26	2:00 PM
Maida/Tarlogie	Thur, Feb 1	1:30 PM	Thur, June 27	9:00 AM
No. 52/No. 74	Fri, Feb 2	9:00 AM	Fri, June 28	9:00 AM
Corriverton Town Council	Fri, Feb 2	1:30 PM	Fri, June 28	11:00 AM

* Not included in the validation exercise

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APPENDIX E

Validation Data Summary

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ACRONYMS

CDC	Community Development Councils
GIS	Geographic Information System
NAREI	National Agricultural Research and Extension Institute
NDC	Neighbourhood Democratic Council
TC	Town Council
VC	Village Council

1. INTRODUCTION

As detailed in Section 1.2, after documenting the findings and analysis, the final phase in the process was to validate the compiled data and verify that the associated detailed mapping was accurate. An ecosystem services validation exercise commenced in May 2019 and concluded in July 2019. As described in Section 2.4, in addition to validating previously recorded information, the validation exercise allows for the collection of any new data relating to ecosystem services functions and values since the previous engagements, while also providing the opportunity to collect updated socioeconomic data at the community level.

The information presented in this Validation Data Summary appendix is limited to the feedback obtained from stakeholders during the validation stage whereby the socioeconomic and biodiversity experts presented the findings of the ecosystem services study and the coastal sensitivity maps on which the results of the ecosystem services study were displayed. These were presented to 62 of the original 64 Neighbourhood Democratic Councils (NDCs), Town Councils (TCs), Village Councils (VCs), and Community Development Councils (CDCs) in the coastal area of Regions 1, 2, 3, 4, 5, and 6.

The responses received during the validation exercise are detailed below, presented by region and stakeholder group. Feedback regarding additional or changed ecosystem services data is reflected under the “Ecosystem Services Survey” heading. Issues not directly related to ecosystem services functions or values, but related generally to socioeconomic status, are also noted under “Other data collected” headings for the purpose of documentation. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time which has lapsed since the 2017/2018 original data were collected and the 2019 validation exercise. In some cases, there are specific notes regarding changes that will be made within the Liza Project Geographic Information System (GIS) database. These are captured within the responses in order to maintain accuracy in the reporting and subsequent mapping efforts. The findings outlined in this appendix are provided in detail within the Detailed Findings Sections of the report.

Some minor changes and updates were recommended as indicated by individual focus groups. These minor updates relate mainly to adjustments in the quantitative data for some ecosystem services presented, as well as location of some activities. In a few instances, additional uses/services in some areas were recommended to be included. The spatial adjustments of locations and inclusion of new uses have been updated in the Liza GIS Database.

Additional socioeconomic data at the NDC, CDC, VC, and TC level were also collected, including updated population figures.

The NDCs, CDCs, VCs, and TCs generally expressed gratitude for the information shared and the opportunity to participate in the original screening and scoping process, and subsequent validation exercise. At their request, finalized maps of their area depicting the ecosystems services within their area as well as the summarized analysis was provided to each of the participating NDCs, CDCs, VCs, TCs, and Regional Councils in December 2019.

The NDCs, CDCs, VCs, and TCs generally expressed gratitude for the information shared and the opportunity to participate in the original screening and scoping process, and subsequent validation exercise. At their request, finalized maps of their area depicting the ecosystems services within their area as well as the summarized analysis was provided to each of the participating NDCs, CDCs, VCs, and TCs and Regional Councils in December 2019.

1.1 Region 5

This section presents the feedback from the ecosystem services validation exercise within Region 5. Engagements with the following NDCs within Region 5 were conducted during the period 20 May to 22 May 2019:

- Woodlands/Farm
- Hamlet/Chance
- Mahaicon/Abary
- Profit/Rising Sun
- Seafield/Tempie
- Union/Naarstigheid
- Bath/Woodley Park
- Woodlands/Bel Air
- Zeelugt/Rosignol

1.1.1 Woodlands/Farm NDC

Ecosystem Services Survey

- There is significant hunting along the NDC shoreline for iguanas, labba, and wild birds for domestic and commercial purposes.
- There is significant fishing within the Bellamy Canal behind the sea dam. More than ten people visit this canal daily during the dry season to catch fish and shrimp.
- A new beach is being built up at Taymouth Manor that has potential for recreation activities. Current access to the area is a challenge, but the NDC is hoping to build the necessary infrastructure.
- The sea defense is under threat, with erosion taking place in some sections, particularly the Fairfield seashore.
- There is beekeeping within the NDC but not at the shoreline. However, the bees might be feeding within the mangroves at the shoreline.
- [Note: The Fish Landing Site that was included under the Unity/Vereegining NDC (Region 4) is actually within this NDC area and should be labeled as such in the GIS database.]

Other Data Collected

- The population is approximately 20,000.

- Small businesses within the NDC are increasing.
- There has been an increase in coconut cultivation recently.

1.1.2 Hamlet/Chance NDC

Ecosystem Services Survey

- There is significant hunting of iguanas on the seashore and along the banks of the Mahaicony River. Songbirds are caught for trade. Birds caught along the shore and river banks include Twa Twa, Grasie, Canary, Red, and Love birds.
- More than ten people catch fish by lines and nets daily in the Mahaicony River for subsistence.
- Few cattle graze within the NDC, but the main stocks are kept at the backlands where there are pastures.

Other Data Collected

- The population is approximately 1,500.

1.1.3 Mahaicony/Abary NDC

Ecosystem Services Survey

- The number of boats fluctuates with the fish season. In summer, the number increases when the catch is plentiful. The sargassum is a constant burden to the fisherfolk, affecting their nets and ability to catch fish. There are numerous wrecks in the area that affect the fisherfolk as their nets become tangled. Drift mud also affects fishing activities.
- People from other regions come to the mangroves and swamps to catch shrimp and crabs during the summer months.
- Songbirds are caught during the summer months when they are plentiful on the shore and river banks.
- There is an increased use of the beach at Good Faith as beaches in other areas are being covered by mud and taken over by mangroves. There is a small beach at Abary that is frequented by a number of people.

Other Data Collected

- The population is approximately 8,000.
- There has been an increase in agriculture, consisting of both crops and livestock.

1.1.4 Profit/Rising Sun NDC

Ecosystem Services Survey

- The fishing boats move according to the migration of the fish to different fishing grounds. Six people set pin seines in low tide on the mud flats.

- There is an increase in birdwatching in the area by tourists, which is promoted by the Georgetown birdwatching groups. Species of note include curri curri, pellew, and duckla. There are thousands of duckla in the area in the afternoons when the tide is low.
- More than 2,000 sheep, goats, and cattle graze in the NDC, but the activity is plagued by thieves.
- The beach is used by many people and expected to be used by more as a bridge and a new road are built to access the beach.

Other Data Collected

- The population is approximately 7,500.
- There is an increase in small-scale agricultural activity, including both livestock and crop farming.

1.1.5 Seafield/Tempie NDC

Ecosystem Services Survey

- The mangroves have reduced at Jacoba and more fishing boats are now in the area as the mud is washing away.
- Erosion has significantly reduced the shoreline within the NDC over the years. The area has old sluices that are in the sea approximately 1 kilometer (.62 mile) from the present shoreline.
- The farmers are fearful of the salt water intruding onto their farms as some people are cutting the mangroves for their own purposes in # 42 and # 37 Villages.
- Grazing has increased at Ross, Seafield, and Tempie.
- Cash crop cultivation is increasing along the sea defense.

Other Data Collected

- The population is approximately 5,000.
- There is an increase in small scale agricultural activity, including both livestock and crop farming.

1.1.6 Union/Naarstigheid NDC

Ecosystem Services Survey

- Fishing has increased within the NDC with more boats at Bushlot.
- More than 30 people are involved in the on-land fishing of tilapia and shrimp for commercial purposes.
- There is an increase in mangroves, especially at Onverwagt. The extensive coverage of mangroves deters the residents of the NDC from making full use of the seashore.
- Recreation activities are facilitated by the Hope Town Community Center. Other locals use Bushlot, Union, Bel Air, and Lovely Lass for recreation purposes.

- There are more animals grazing now in the NDC than in 2018. The animals compete with the cash-crop farmers for space on the sea dam and reserves.
- There are no religious activities at Lovely Lass. [Note: Remove this point from the map.] These activities are conducted at Onverwagt and Bush Lot.
- Many sea birds are hunted for meat and sale in the local markets. Iguanas are hunted mainly during the summer months when they are more plentiful in the area.
- Beekeeping is conducted at Union, Lovely Lass, Onderneeming, Hopetown, and # 29.

Other Data Collected

- The population is approximately 15,000 and is increasing due to new housing areas.

1.1.7 Bath/Woodley Park NDC

Ecosystem Services Survey

- Many people are fishing in the swamps and nearshore during the period when sugar estates are out of season. It is estimated that 10 people conduct this activity regularly, with a peak of 30 to 35 people when crops are out of season. Locals can be seen dragging long seines within the various swamps to catch shrimp.
- In July and August, hundreds of people catch crabs by the thousands in the region, including the NDC. [Note: The priority rating in the GIS database for this activity should be changed to medium.]
- One fisherfolk used pin seine along the mudflats for his daily catch.
- Experiment, Bath, # 11, and # 12 villagers use the façade canal for religious purposes, as the shore is almost inaccessible.
- Grazing is about the same in the NDC from 1 year ago and is plagued by thieves.
- There is significant squatting along the façade canal throughout the NDC. The squatters engage in crop farming.
- Mangroves have been reduced by erosion in some areas in the NDC.

Other Data Collected

- The population is approximately 18,000.
- There has been an increase in economic activities within the NDC, including cash crop cultivation, taxi services, wash bays, and supermarkets.

1.1.8 Woodlands/Bel Air NDC

Ecosystem Services Survey

- There is mangrove growth throughout the NDC shoreline, which has reduced religious and recreational activities along the shoreline. The # 6 beach has been taken over by mangroves and the local people are forced to travel further to find a beach for recreation.
- There is no bee keeping at # 10, as was indicated on the map. [Note: Remove this from the map.] However, there are wild bees and bee hives in the NDC.
- Two fishing boats now dock at # 9 Village.
- There is cash crop cultivation throughout the NDC except in the # 10 Village.
- There is grazing of animals throughout the NDC. The National Agricultural Research and Extension Institute (NAREI) Ranger monitors for grazing within the mangroves.
- Many people catch fish and shrimp in the swamps and drainage canals using nets or long seines.

Other Data Collected

- The population is approximately 1,200.
- There has been a slight increase in agricultural activities.

1.1.9 Zeelugt/Rosignol NDC

Ecosystem Services Survey

- The cremation site at # 2 is no longer used by the people of the NDC.
- There are approximately seven Hindu temples at De Edward, Cotton Tree, # 3, Bennett Dam, Victory Dam, and along the main canal.
- The Berbice River Bridge is used by thousands of people daily and the Berbice River launch transports approximately 1,000 school children and government workers on weekdays between Rosignol and New Amsterdam.
- There are now 90 boats at Rosignol and 75 boats at De Edward. More fishing boats are ordered from Crabwood Creek, where there is better wood available for construction.
- Many cows, goats, sheep, donkeys, and pigs are found grazing the NDC.
- Cage birds are caught along the shore.
- Shrimp is abundant in the swamp and crabs are caught during the season.
- Iguanas are hunted almost daily by approximately 50 people in the NDC.

Other Data Collected

- The population is approximately 2,000.

- There has been an increase in economic activities within the area, especially at Rosignol and De Edward.

1.2 Region 6

This section presents the feedback from the ESS Validation Exercise within Region 6. Engagements with the NDCs and TCs within Region 6 were conducted during the period of 24 to 28 June 2019:

- Ordinance/ Fort Lands
- Kintyre/ No. 37
- Gibraltar/ Fyrish
- Kilcoy/ Hampshire
- Rose Hall Town Council
- Port Mourant/ John
- Bloomfield/ Whim
- Lancaster/ Hogstye
- Bushlot/ Adventure
- Maida/ Tarlogie
- Macedonia/ Joppa
- Good Hope/ No. 51
- No. 52/ No. 74
- Corriverton Town Council

1.2.1 Ordinance/ Fort Lands NDC

Ecosystem Services Survey

- The sawmill located at Sheet Anchor continues to operate and employs between 10 and 50 workers on a part-time basis. Logs are transported to the sawmill using the Canje River.
- The wharves located at the Canje Bridge are used to dock vessels either transporting building supplies or waiting for boat repairs. Approximately four vessels dock at the wharves daily. Boat repairs are also continuing.
- Fishing boats dock at Sheet Anchor, Cumberland, and Seawell; however, the majority of these boats dock at Sheet Anchor because of the wharf.
- The closure of the sugar estates has caused former employees to seek new employment opportunities; and many of them have ended up in the agriculture sector raising livestock. This has increased the number of livestock to more than 2,000 head of cattle grazing at Cumberland, Fort Ordinance, Palmyra, and No. 2, and more than 100 head of cattle, goats, and sheep grazing in Sheet Anchor.
- Similarly, the downturn of the sugar industry has resulted in approximately 50 to 60 people seeking employment in fishing, especially within the swamps along the shoreline areas. Catch is sold within and outside of the NDC.

- Cash crop cultivation is occurring in close proximity to the seawall, including in Seawell. It was prevalent in the past, but slowed in recent years; however, with the downturn of the sugar industry, it appears to be increasing.
- There has been no change in the extent of mangrove coverage in the NDC. Mangroves are a habitat for wild bees, birds, crabs, fish, and shrimp.
- Fish and shrimp are caught daily in the mangroves and canals using cast nets and seines and are sold on the market.
- Locals hunt seabirds such as curi curi, plower, and wisi wisi ducks for meat.
- Crabbing occurs throughout the year and there are two crab meat processing operations located in the NDC.
- Squatting on the seawall at Sheet Anchor and Cumberland has increased by a few households.
- Religious activities are conducted by Hindu communities at Sheet Anchor and on the dams leading to the Canje River. People from the NDC also use dams in Canefield, a neighboring community, for religious purposes.

Other Data Collected

- The population within the NDC area is 8,500 and is relatively stable. A new residential area has opened in Fort Ordinance where approximately 2,500 to 3,000 people reside. Although it has not yet been handed over to the NDC by the Government of Guyana, the NDC has already provided some services to the area.
- Cash crop cultivation in areas close to the seawall in Seawell was prevalent in the past but had declined in recent years. However, cultivation has recommenced in this area by former sugar workers.

1.2.2 Kintyre/ No.37 NDC

Ecosystem Services Survey

- More residents are involved in crabbing and raising livestock due to high levels of unemployment from the closure of the sugar estates.
- The downturn in sugar has also led to an increase in grazing of animals in the NDC.
- Approximately 10 residents are involved in daily hunting of seabirds such as curi curi, plower, and wisi wisi ducks for meat and for sale. More residents participate in hunting during peak seasons (for example, curi curi during the dry season).
- There is a cemetery located in close proximity to the seashore in Bohemia.
- There is brick making in lands adjacent to the shoreline. Soil from the NDC is extracted to burn for the creation of bricks. However, complaints have been lodged to the Regional Health Officer because it is disrupting the nearby cemetery. In addition, concerns were raised that brick making

increases erosion risk due to the extraction of soil and excavation in the direction of the shoreline.

- There has been no change to the extent of mangrove cover in the NDC. Mangroves protect the NDC from the impacts of the sea. In addition, crabs, shrimp, fish, and seabirds are abundant.
- Shrimp and fish are still caught in the communal fish ponds located in the NDC. Residents throughout the Corentyne Coast benefit from the use of these ponds.
- Hindu religious activities are practiced in Borlam daily, particularly on Sundays.
- Drainage pumps located at Borlam are still operational.
- Crab Island and Borlam Beach are used for recreational purposes.
- There is no farming of cash crops and fruits on the sea dam and adjacent areas.

Other Data Collected

- The population within the NDC area is 1,000 and is relatively stable.
- It was reported that mosquitoes are more prevalent when culverts are opened, which the NDC does to allow shrimp to swim from the ocean into shrimp ponds.
- At present, two species of crab are being caught; however, the “sheriga” crabs, which were previously abundant, are now scarce.

1.2.3 Gibraltar/ Fyrish NDC

Ecosystem Services Survey

- The main source of livelihoods in the NDC comes from livestock farming. There is pig farming in the back dam of No. 1 Village and two large poultry farms in the Fyrish back dam.
- There has been no change to the 12 shrimp ponds located along the seashore.
- Many residents of the NDC were employed by the sugar industry and were retrenched when the estates closed. Many people pursued alternative livelihoods such as crabbing, fishing, shrimping, and raising livestock farming.
- Cattle, goats, sheep, and pigs graze on lands adjacent to the mangroves.
- There is a cemetery in Fyrish that is used for burials by all religions.
- Sea birds such as curi curi, plower, and wisi wisi ducks are hunted for meat and sale. The number of residents involved in these activities has increased, also likely due to the downturn in the sugar industry.
- Hindu religious activities are practiced along the shoreline in areas where there is access to the shoreline such as the eastern section of Fyrish and the No. 1 Village.
- The No. 4 Village is not located within the NDC. However, people from the NDC use the dam in the No. 4 Village for Hindu religious activities.

Other Data Collected

- The NDC population is approximately 5,600 and remains stable.
- There are grazing pastures (cattle, goats, sheep, and pigs) in each of the four villages located in the NDC. The NDC is receiving support from the Government of Guyana for the construction of pastures. There is a new pasture in the No. 1 Village.
- The Government of Guyana provided an excavator to clear the channels around the sea dam to facilitate easier refilling and emptying of the shrimp ponds. Currently, the NDC is engaged with the Sea Defence Board to ensure that the sea dams are sufficient to protect lands from the impacts of the sea.
- In the past, there was a breach of the sea dam as a result of shrimping activities (to refill the shrimp ponds in the NDC), resulting in saline intrusion into residential areas, and the destruction of more than 1,000 mango trees in the back dams of Fyrish and Gibraltar.
- There is no landfill in the NDC and consequently residents and businesspeople (as they are required to pay) illegally dump garbage on the access dam. A significant quantity of garbage ends up in the channels. The NDC is allowed to dispose of garbage free of cost at the landfill located in the Rose Hall Municipality. However, businesspeople are required to pay to dispose of their garbage at the Rose Hall landfill and most are unwilling to do so.

1.2.4 Kilcoy/Hampshire NDC

Ecosystem Services Survey

- The number of fishing boats associated with the Albion landing site has increased to 160 boats during off-season and to175 boats during peak season. Approximately 450 to 475 residents are employed in fishing[6].
- More residents than in years past are involved fishing, crabbing, and hunting for subsistence and sale as a result of the downturn in the sugarcane industry. This includes:
    - Fishing with cast and drag nets;
    - Crabbing; and
    - Hunting iguanas and sea birds in the mangroves.
- There are 40 privately owned shrimp ponds in the NDC in close proximity to the sea dam.
- Iguanas and seabirds are caught for meat and sale in the mangroves. These activities are mostly done by young people who have completed secondary school but are unemployed. Young people from within and outside of the NDC are engaged in this activity.

[6] Based on data collected from fisherfolk at the Albion landing site as part of the Participatory Fishing Study (PFS), approximately 50 boats routinely use the Albion landing site. It is unlikely that the landing site has capacity for 175 boats. Based on the PFS findings, boats that previously landed at Albion are docking at the Adventure landing site due to ease of access and clearance of the channel. As a consequence, while more people in the NDC are involved in fishing, they are using alternative landing sites located on the Corentyne Coast.

- The number of people from the NDC who catch crabs on a weekly basis for sale has increased. In addition, crab catching is also considered a recreational activity and the crabs caught are for subsistence use.
- The poultry farm located in Kilcoy and Chesney has five large multi-story chicken pens, which house approximately 100,000 chickens.
- A few residents engage in farming of cash crops and fruits for subsistence and sale on the sea dam and adjacent lands.
- Hindu temples are in close proximity to the seashore at Chesney, Hampshire, and Nigg, and two temples are located in Belvedere. Hindu religious activities are also conducted on the sea dam in No. 4 Village.
- Wild bees are found in hives in the mangroves at Hampshire.
- The extent of mangrove cover in the NDC has increased, extending further offshore. In previous years, there was significant harvesting of mangroves resulting in almost 1 kilometer of erosion inland. However, mangrove harvesting has been reduced.

Other Data Collected

- The population of the NDC is 25,000 and is increasing as new housing accommodations have been built in Kilcoy/Chesney and Block X of Belvedere/Nigg/Hampshire.
- Land has been earmarked by the Government of Guyana in Hampshire North for the establishment of a new industrial site.
- There is cattle rearing in Hampshire but it is not located in proximity to the seashore.
- Region 6 is heavily dependent on GUYSUCO and negative effects of the closure of the estates are being experienced throughout the region.
- In previous years, there was significant harvesting of mangroves resulting in almost 1 kilometer of erosion inland. However, mangrove harvesting has been reduced although a few people still cut mangroves to use in their kitchen gardens.

1.2.5 Rose Hall Town Council

Ecosystem Services Survey

- The beach in Rose Hall and No. 63 remain popular, with comparable users during the Easter holidays in 2019. Rose Hall has increased in popularity; hundreds of people visit it daily—upwards of 500 people on weekends.
- Religious activities by Hindus on the Rose Hall beach has increased and approximately 200 people use the area on a weekly basis, with more on Sundays and Tuesdays. Thousands of people use the area on special days of worship for Hindus.

- There has been no change in the number of people engaged in fishing in the NDC[7].
- The extent of mangrove coverage in the municipality has declined, as trees and cover are harvested for firewood, building materials, and fishing rods.
- Approximately 100 cattle, sheep, and goats are grazed on the shore and nearshore areas.
- Seabirds are caught for subsistence and sale, and include spika, cranes, and wisi wisi ducks. Some residents from the municipality visit fish ponds located in other areas of the Corentyne Coast to catch large birds for sale.
- Farming on the sea dam and on adjacent lands has decreased due to saline intrusion.

Other Data Collected

- There are approximately 15,000 people in the municipality.
- The access road to the Rose Hall beach is in poor condition. The Ministry of Social Cohesion visited the municipality to assess opportunities for improving infrastructure, including construction of an access road and providing electricity. However, this project is on hold.
- Region 6 was very dependent on the sugar industry. Many businesses in the municipality depended on "crop seasons" of the sugar estates. In addition, the closure of the estate in Rose Hall has negatively affected the revenues in the municipality as fewer people purchase from vendors in the markets and vendors are unable to pay their rates to the TC. Similarly, residents from the municipality who lost their jobs are employed in alternative activities such as farming for subsistence use and fishing in canals in the back dams.

1.2.6 Port Mourant/ John NDC

Ecosystem Services Survey

- There are nine boats employing between 33 to 40 people that use the Port Mourant outfall for fishing and shrimping. Fishing is considered a second job for sugar workers during out-of-crop seasons.
- Approximately 20 to 25 residents catch fish and shrimp in the swamp areas and drainage canals on a daily basis, while up to 100 residents catch fish and shrimp in these same areas during out-of-crop seasons.
- There are approximately 100 shrimp and fish ponds owned by 40 people in the Rose Hall to Babu John area. Ponds have been expanded, converted, or restored, and there are different sections for diverse species. In addition, areas formerly used for rice cultivation have been converted to shrimp and fish ponds. The ponds in Babu John have been rehabilitated and are currently in use. All ponds in the NDC are privately owned.
- The poultry farm at Johns has five large multi-story pens with approximately 25,000 chickens.

[7] Note: Based on findings of the PFS, the number of vessels operating at the Rose Hall landing site has declined over the last six months due to the difficulty accessing the channel and personal challenges encountered by the fisherfolk.

- Sea- and shore birds are hunted for subsistence and for sale. Although a few people routinely catch these birds, there are peak numbers of people involved on a seasonal basis.
- There has been no change in mangrove cover in the NDC but there is no monitoring. Some people collect dried mangrove roots for use in their kitchen gardens and as firewood.
- Religious activities are held at Port Mourant. In addition, the main cremation site at Babu John is dedicated to the late President Cheddi Jagan. There is also a cemetery at Babu John.

Other Data Collected

- There are approximately 16,000 people in the NDC. The population may be increasing as several people from New Amsterdam, Mara, Canje, and Black Bush Polder have relocated to the NDC.
- The closure of the sugar estates in Region 6 has significantly affected the quality of life in the NDC. Former sugar workers have been struggling to find alternative livelihoods such as fishing and subsistence farming. The overall reduction in disposable income in the NDC has adversely affected businesses and vendors in the Port Mourant market. In addition, sports like cricket have been severely affected following the closure of the estates.

1.2.7 Bloomfield/ Whim NDC

Ecosystem Services Survey

- The outfalls at Letter Kenny and Whim are used as landing sites for fishing boats; however, they are infrequently used because the channels are heavily silted making passage difficult.
- Approximately 28 fishing boats are owned by people from the NDC who use landing sites at Adventure and Complex 66. In addition, more than 100 people in the NDC are employed as fisherfolk on boats at different landing sites throughout the Corentyne Coast.
- Approximately 15 people catch crab on a regular basis for sale.
- Approximately 15 people fish along the shoreline using pin seines and cast nets.
- There are approximately 30 shrimp ponds owned by 10 to 15 people from the NDC.
- As a result of the downturn in the sugar industry, grazing of cows, goats, and sheep along the sea dams and shoreline has increased.
- Cultivation of cash crops and fruits in close proximity to the sea dams at Letter Kenny and Whim occurs during the wet seasons when freshwater is easily available.
- Hindu religious activities are held between Bloomfield to Letter Kenny. People from within and outside of the NDC come to these areas for worship.
- There are three Hindu temples located in close proximity to the shoreline at Letter Kenny and Whim.
- There are cemeteries at Letter Kenny and Whim which are used by all religions.

- There is a nursery school located in close proximity to the seashore in Letter Kenny.
- A Guyana Water Inc. water pump is located in Letter Kenny and provides water to Whim, Bloomfield, Letter Kenny, and Auchlyne.

Other Data Collected

- The NDC population is approximately 4,000 and it is expected to increase because of new housing accommodations in Bloomfield.
- The owners of the fish and shrimp ponds destroy the mangroves to allow for emptying and refilling of their ponds. Some residents collect dried mangroves for use in their kitchen gardens and as firewood.
- The activities in the NDC are the same as a year ago, but participation in fishing, raising livestock, and cultivating crops has increased as a result of the downturn in the sugar industry.

1.2.8 Lancaster/ Hogstye NDC

Ecosystem Services Survey

- There are 12 boats that use the Hogstye/Adventure outfall for fishing. The number of large fishing boats landing at the Hogstye/Adventure outfall has increased, as there is easy access to the landing and alternative landing sites (e.g., Complex 66) are overcrowded. None of the boats at the outfall are owned by people from the NDC; however, NDC residents, mostly from Lancaster, work on the fishing boats that land at various sites along the Corentyne Coast.
- People throughout the NDC utilize pin seines and cast nets for fishing along the shoreline.
- There is one shrimp pond and one tilapia pond in Lancaster occupying 198 acres of land close to the seashore. Two people own these ponds.
- Iguanas are hunted daily for subsistence and sale by unemployed young people in the NDC. There is limited hunting of birds in the NDC.
- The beaches at Alness and Manchester are utilized for recreation, relaxation, and religious purposes. These activities have increased due to improved access.
- Grazing of cows, goats, sheep, and horses occurs throughout the shoreline of the NDC.
- Pig farming and grazing in Manchester has stopped; however, a new developer has requested permission from the NDC to construct pig pens along the shoreline.
- Natural regrowth of mangroves is continuing in the NDC.
- Cultivation of cash crops and fruits along the shoreline has increased, with more crops being planted during the wet seasons. In Lancaster, there have been land conflicts between farmers and owners of the fish and shrimp ponds. In addition, there are complaints from some residents of the NDC that spraying of pesticides on the crops adversely impacts their lives.

Other Data Collected

- The NDC's population is approximately 2,500 people and is relatively stable.
- There is squatting in Manchester, Ulverston, Liverpool, and Lancaster.

1.2.9 Bushlot/ Adventure NDC

Ecosystem Services Survey

- There are approximately 6 fishing boats that dock at the Bushlot/Kildonan outfall and 12 boats at the Adventure outfall.
- As a result of the downturn in the sugar industry, the number of residents who fish along the shoreline using pin seines and cast nets has increased.
- Shorebirds are hunted mostly in Bushlot for subsistence and sale. A few residents also hunt iguanas. This is mostly done by young people who have completed secondary school and are unemployed.
- Although a few residents regularly catch crabs for sale during off season, more residents are involved during crab season.
- There are three shrimp ponds in the NDC—two are in Bushlot Farm and are privately owned by two people, and one is in Bushlot and communal.
- There is no squatting along the seashore. There is only one structure in Kildonan and this is used by the sluice attendant.
- Approximately 100 people use the Bushlot beach on a weekly basis for recreation purposes, although several hundred people use the beach on special holidays like Easter.
- The use of the Bushlot beach for Hindu religious activities has also increased and people from other areas as far east as Hampshire use the beach for religious purposes.
- Cultivation of cash crops and fruits has increased along the sea dam from Bushlot to Adventure and is attributed to higher levels of unemployment resulting from the closure of the sugar estates. There is no farming on private lands.
- Mangrove cover at Kildonan has increased. People from the NDC use dried mangroves in their kitchen gardens and sometimes as firewood.

Other Data Collected

- The NDC population is estimated to be over 6,000, with 3,400 of voting age.

1.2.10 Maida/ Tarlogie NDC

Ecosystem Services Survey

- The mangrove seedlings planted in the NAREI restoration plot in Wellington Park have died, with sawdust washing up onshore being the likely cause. However, the mangroves in other areas in the NDC, such as Kilmarnock, have grown.
- More than 1,000 cows and sheep graze along the shoreline throughout the NDC. The owners of these animals reside in Wellington Park, Philippi, and Kilmarnock.
- Hindu religious activities are held in areas where there is access to the sea such as Wellington Park, Kilmarnock, Maida, and Tarlogie.
- Hunting of iguanas and seabirds for subsistence and sale in the mangroves has increased, with approximately 20 to 25 people participating daily.
- Crabbing for subsistence and recreation remains important in the NDC.
- Approximately 14 fishing boats land at Tarlogie, Maida, Kilmarnock, and Wellington Park depending on the ease of traversing the channels to access the sites. Approximately 60 people are employed in these boats.
- The number of residents who fish along the shoreline using pin seines and cast nets has increased.
- More people are planting cash crops and fruits along the sea dam in Maida. Cultivation on the sea dam and adjacent lands is also continuing in Tarlogie and Wellington Park.
- Additional privately owned shrimp ponds have been created on Wellington Park, Maida, and Kilmarnock, with approximately 125 buckets harvested from these ponds monthly. Approximately 8 to 10 people own these ponds.
- There are canals and swamp basins in Tarlogie open for communal fishing and shrimping.

Other Data Collected

- The NDC's population is approximately 3,500 people and is relatively stable.
- Rice cultivation is on the decline, as the farmers have encountered several challenges.
- Decline in mangrove cover resulted in saltwater intrusion in Wellington Park which affected cash crop farming.

1.2.11 Macedonia/ Joppa NDC

Ecosystem Services Survey

- There is extensive mangrove cover in the NDC and the mangrove stand has been increasing.
- More than 8,000 cows, goats, and sheep graze in Bengal, Joppa, Brighton, Eversham, Kiltaira, and No. 35 Village. The least amount of grazing occurs in Eversham. In addition, in between the rice crops, some animals are taken to the rice fields to graze.

- Fishing boats that use the outfall in No. 43 Village have declined, as larger boats use the landing at Complex 66. However, there are facilities for boat construction and maintenance and seine mending at the No. 43 outfall.
- There are approximately five boats that use the Eversham Outfall.
- There are five privately owned shrimp ponds on the sea dams of Bengal, Kiltyre, and No. 36 Village.
- Approximately 100 residents catch shrimp, tilapia, and hassar in the mangroves, canals, and shorelines using pin seines and cast nets daily for subsistence. If there is excess catch, it is sold within the NDC.
- Crabbing is important in the NDC, with residents from Canje visiting the NDC during crab season.
- Turtles are sometimes caught in the mangroves for subsistence.
- Cultivation of cash crops and fruits has continued on the government reserves in Brighton Canal, Kiltyre, and Eversham. However, there are challenges with saltwater intrusion and high water levels. Cultivation of cash crops and fruits increases during the wet seasons which fresh water is available.
- Hindu religious activities occur at the shoreline in No. 43 Village.

Other Data Collected

- The NDC population is 3,535 and remains relatively stable.
- The government has constructed sea defense dams from Wellington Park to Eversham in 2018 and 2019. Previously, there was erosion of the mangroves and breach of the sea defense that resulted in flooding of the shoreline area and public road of the No. 43 Village.
- The closure of the sugar estates has affected livelihoods in the NDC and former sugar workers are seeking alternative employment in the agriculture and fishing sectors.

1.2.12 Good Hope/ No. 51 NDC

Ecosystem Services Survey

- Wild bees are present in the mangroves in No. 45, No. 47, No. 48, No. 50, and No. 51. Honey is harvested from these hives for subsistence use. However, the numbers of bees are increasing and there have been complaints of bees swarming residences.
- Approximately 30 to 40 people from within and outside of the NDC catch crabs in the mangrove forests in the NDC for sale.
- Hunting of iguanas has increased significantly in the mangroves throughout the NDC. People from the Corentyne Coast, including New Amsterdam, visit the NDC to catch iguanas for sale.

- Hunting of shorebirds has increased and is done daily at No. 45, No. 48, No. 50, and No. 51 Villages. In addition, cage birds are caught for sale and training in the NDC at No. 45, No. 48, No. 50, and No. 51 Villages.
- One resident of No. 49 Village grazes goats on the sea dam and in the mangroves, while other residents graze cows, goats, and sheep at No. 45, No. 47, No. 48, No. 50, and No. 51 Villages.
- A few boats still use the landing site at No. 51 Village. No. 43 is outside of the NDC district.
- People fish along the shoreline using pin seines and cast nets daily throughout the NDC.
- There is brick burning by four to eight people on the sea dams of No. 51 Village.
- Cultivation of cash crops and fruits on the sea dam and adjacent lands in No. 47 Village has stopped due to significant saltwater intrusion where the dam was eroded and there were breaches in the mangroves. Farming is continuing on the sea dams on No. 50 and No. 51 Villages.
- There are four large shrimp ponds in the No. 49 Village, which are all privately owned.
- In the No. 51 Village, there is a swamp area where people catch fish and shrimp for subsistence use. This area is also used by residents from the No. 52 village, located outside of the NDC.
- Mangrove coverage throughout the NDC is increasing and the TC is actively trying to stop the mangrove harvesting.
- Religious activities are held in No. 49 and No. 51 Villages with the most people on Fridays and Sundays. There is easy access to the shoreline at No. 49 Village.

Other Data Collected

- There were 2,354 people and 735 households in the NDC in 2013. This is relatively stable.
- Following the breach of the sea defense at No. 47 Village, the government constructed a sand foundation for the sea dam. There was no future work and the sand dam has already experienced significant erosion. There were no sea defense works from No. 48 to No. 51 Villages.

1.2.13 No. 52/ No. 74 Villages NDC

Ecosystem Services Survey

- Approximately 4,000 people in the NDC are directly or indirectly employed in the fishing sector.
- The number of fishing boats using the landing at Complex 66 has increased to approximately 400. Fishing boats from Regions 4, 5 and along the Corentyne Coast use this landing site.
- There are approximately 100 boats at the No. 65 outfall.
- Approximately ten meters from the No. 65 outfall, construction of a fish processing plant has commenced, which is expected to employ 500 people. The owner of this processing plant has also purchased 45 new fishing boats.

- At No. 63 village, there are approximately 20 small boats that use pin seines to fish along the shoreline. In total, there are approximately 60 to 75 small boats in the NDC that practice pin seine fishing along the shoreline for sale.
- The number of people involved in hand seine and cast net fishing along the shoreline has increased.
- There is significant to complete erosion of mangroves in No. 52 – No. 63, No. 67, No. 69, No. 70, No. 73, and No. 74 Villages. There is no cutting of mangroves and it is likely that these are natural deaths due to the age of the stand.
- Due to the erosion of mangroves, crabbing has significantly declined and crabs are only caught during crab season.
- Hunting of iguanas in the mangroves has continued, while only a few people hunt birds (as they are not prevalent in the area).
- Grazing of animals along the shoreline has decreased significantly because of mangrove forest erosion. Grazing has shifted largely to the back dam areas, but cattle farmers face challenges with rustlers in the back dams.
- More people are involved in cattle rearing than before, but there is less livestock overall in the NDC.
- Cash-crop cultivation along the shoreline has decreased due loss of lands as a result of mangrove erosion.
- Boat building occurs on both sides of the dam at Complex 66. Surinamese fisherfolk order fishing boats at the boat-building sites at Complex 66 due to the quality of wood used in Guyana and the skills of the boat builders. A boat construction facility has also been opened adjacent to the new fish process plant at No. 65 Village.
- Religious activities are held throughout the NDC where there is easy access to the shoreline including No. 63, No. 69, No. 70, No. 71, and No. 73 Villages.

Other Data Collected

- The population of the NDC is approximately 20,000 and it is relatively stable.
- The closure of the sugar estates in Region 6 has had significant adverse impacts on livelihoods and well-being of people in the NDC. In particular, there has been a significant increase in the number of people involved in fishing and livestock farming in the NDC since the closure of the estates. It is estimated that over 1,000 people are involved in the fishing sector.

1.2.14 Corriverton Town Council

Ecosystem Services Survey

- A wind turbine with a capacity of 275 KVA was installed on the riverbank, but is not yet operational. The company is awaiting permission from the Government of Guyana before it can proceed.

- The wharf located at Line Path is used by farmers and loggers to transport their commodities from Orealla and Siparuta to Corriverton.
- Passengers use the "backtrack route" at No. 78 Village to access a ferry service to Suriname. When in operation, the ferry lands at Moleson Creek, which is not located in the municipality.
- There are approximately 40 boats at No. 79 Village that fish in the Corentyne River and catch various species of fish and shrimp.
- Approximately 10 to 50 people are engaged in daily use of seines for catching mullet and shrimp.
- Catching sardines is seasonal, with more than 100 people engaged during peak season using seines.
- Speed boat construction is done at the No. 78 Village.
- Hindu religious activities occur at Line Path, Scottsburg, Spring Garden, and Springlands. Some Christian groups also perform baptisms in these areas.
- There has been significant erosion of mangrove cover from No. 75 Village to Scottsburg. The municipality requested support from NAREI to replant mangroves in the area. Rip rap sea defense structures have been installed in Scottsburg.
- Mangroves are not harvested but some people collect dried mangroves to use as firewood.
- Erosion of the sand bank in No. 79 Village has decreased use of the area for recreational purposes.
- The area on the No. 78 Village shoreline, which was earmarked for developmental works by the municipality, is now being used by the Sea Defence Division to store materials and equipment.
- More than 10 people are engaged in the hunting of iguanas on a weekly basis along the shoreline in Scottsburg.
- There are fewer than 30 cows grazing along the shoreline in the NDC. According to the bylaws of the TC, there should be no livestock farming in the town.
- There are approximately five tour operators who provide trips down the Corentyne River. Sometimes regattas and other events like pageants are held in communities in the river, such as Orealla.
- Approximately 30 households squat along the sea dam in Line Path, Dukestown, and No. 78 and No. 79 Villages.
- Approximately 35 people are engaged in cultivation of cash crops and fruits along the shore and sea dams of Line Path, Scottsburg, Dukestown, and No. 75 Village.

Other Data Collected

- The NDC population is approximately 17,000 to 18,000 people in the municipality.

- The closure of the Skeldon Sugar Estate has resulted in increased fishing, crop cultivation, livestock farming, and hire car services operating on the municipality.
- The municipality has received a request to construct a Hindu temple on the No. 79 village seashore.
- There is significant dumping of garbage along the seashore of the municipality and there are certain areas where depressions in the ground cause garbage to accumulate.

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ATTACHMENT A: REGISTRATION SHEETS

Attachment A1: Region 5

Name	Designation	Contact Information
Woodlands/ Farm NDC		
Wainright Henry	Businessman/Chairman	On file
Shawndell Bristol	Overseer	On file
Roxanne Abrams	Vice Chairperson	On file
Hamlet/ Chance NDC		
Marlon McRae	Chairman	On file
Gloria Vaux	Councillor	On file
Lewis Bourne	CEI worker	On file
Cheryl Mingo		On file
Coritta Richmond		On file
Stacey Abel		
Carolyn Nedd		On file
Shundell Robertson	Overseer	On file
Marcie Richmond	Vice Chairwoman	On file
Maxine Halley	Farmer	On file
Mahaicony/ Abary NDC		
Gafeth Williams		On file
Marsha Pereira Tappin	Housewife	On file
Vibert Sealey	Pensioner	On file
Deonarine Dindayal	Pensioner	On file
Wilbert Inniss	Farming	On file
Mohini Singh	Shop Keeper	On file
Charles Gibbons	Pensioner	On file
Andrea Moriah	Overseer	On file
Tamica John	Sanitary/ E.H.A	On file
Profit/ Rising Sun NDC		
Debris David		On file
Cassandra Pellord		On file
Shanneta Bisnauth	Overseer	On file
Andrea Noble	Asst. Overseer	On file
Toiwana Reynolds	Environmental Health Asst.	On file
Gloria Fraser	Asst. Chairperson	On file
Marwa Belgrave	Housewife	On file

Name	Designation	Contact Information
David Ross	Farmer	On file
Eon V. Warde		On file
Joseph Rooplall	Farmer	On file
Seafield/ Tempie NDC		
Desirey Mentore	Dentex	On file
Oneca Sam	Overseer	On file
Delon Crawford	Councillor	On file
Bradley Downer	Environmental Health Asst.	On file
Carol Inniss	Councillor	On file
Michelle McPherson	C.E.T.L	On file
Leticia Kissoonchand	E.H.A	On file
Union/ Naarstigheid NDC		
Rameshwar Samaroo	Nurse	On file
Vinceroy Jordan	Engineer	On file
Trevor Gravl	Businessman	On file
Suvaeh Ramlochan	Business/ Farmer	On file
Seonaid Richmond Welch	Pastor	On file
Myrtle Christian	Overseer	On file
Lolita Chesney	Nurse	On file
Bath/ Woodley Park NDC		
Annesia Ramchand	Asst. Overseer	On file
Dinesh Gossai	Student/ Councillor	On file
Krishna Sewlall	Farmer	On file
Adrian Singh	Field Supervisor (Blairmont Estate GUYSUCO)	On file
Sudesh Persaud	Self Employed	On file
W. Isahack	Driver	On file
Candacia Jacobs	Crop Extension Officer	On file
Kamini Amantram	Clerk	On file
Mohanlall Chandlall	Councillor	On file
Woodlands/ Bel Air NDC		
M. Heeralall	Overseer	On file
Letitia Blackman	E.H.A	On file
Joycelyn Braithwaite	Vice Chairperson	On file
Shanti Seenarine	Councillor	On file
Fiona Reynolds	Chairperson	On file
Surujdai Ramdin	Councillor	On file
Shermon B. Vyphuis	Team Leader	On file

Name	Designation	Contact Information
Zeelugt/ Rosignol NDC		
Olanda O Donoghue	E.H.A	On file
Sheniza Noble	E.H.A	On file
Kamine Anthonio	Assistant Overseer	On file
Joseph Jageshwar	Councillor	On file
Samuel Gagnandan	Councillor	On file
Choutar Dewan	Pensioner	On file
Eshwarnath Singh	Councillor	On file
Agnes Karamchand	Councillor	On file
Iqbal Alli	Councillor	On file
Andrea Cummings	E.H.O	On file
Shellon Peters	Councillor	On file

Attachment A2: Region 6

Name	Designation	Contact Information
Ordinance/ Fort Lands NDC		
Haimwattie Clifford	Nursing Assistant	On file
Karmanand Ramash	Pastor	On file
Tessie Ramnauth	Overseer (ag)	On file
Subhaschan Beer	Shop Keeper	
Kintyre/ No.37 NDC		
V. Totaram	Security	On file
Benawattie Gulcharran	Charwoman	On file
Basant Persaud	Vice Chairman	On file
Chandroutie Paul	Housewife	On file
Vijay Persaud	Typist/ Clerk	On file
Gibraltar/ Fyrish NDC		
Joshua P. Sewdat	Overseer	On file
Kilcoy/ Hampshire NDC		
Pittamdai Tamradwagh	Housewife	On file
L. Harcharran	Housewife	On file
R. Ramson		On file
U. Gowkarran		On file

Name	Designation	Contact Information
P. Kisten	Pensioner	On file
Arjuna Veerasamy	Cane Harvestor	On file
Ashook Balcharran	Truck Driver	On file
Chrismadat Noel	Overseer	On file
D. Kasinath	Pump Operator	On file
Shamal Sugrim	Sales Manager	On file
Rose Hall Town Council		
Chatergoon Ramnauth		On file
Natasha Griffith		On file
Vedwat Ramnarain	Councillor	On file
Sandra Chisholm	Councillor	On file
S. Ramdhail	M/Treasurer	On file
Winston Hope	Councillor	On file
Sharon Mc Allistor	ag Sgt	On file
Quacey Cort	Councillor	On file
Gaitree Sheonarain	Councillor	On file
Shelly Clarke	Clerk of Market (ag)	On file
Port Mourant/John NDC		
Ramdat Isar	Farmer	On file
Maipaul Persaud	C. Leader	On file
Satie Hussain	Councillor	On file
Narainsamy	Chairman	On file
Reshma Roopram	Rates Collector	On file
Budwatty Ramnarine	Overseer	On file
Anmal K. Mohan	Councillor	On file
O. Mc Daipall	Councillor	On file
Bloomfield/Whim NDC		
DonnieTony		On file
KC Harilall		On file
J. Baijnath		On file
C. Pooran		On file
S. Ishmael		On file
Khemraj Permaul		On file
Lalchand Rupchand	Overseer	On file

Name	Designation	Contact Information
K. Tejram	Revenue Collector	On file
Kamalda Singh	Councillor	On file
H. LaPelimar		On file
Omadevi Ramnarine	Office Assistant	On file
Lancaster/ Hogstye NDC		
Leroy Smith	Small Business Owner	On file
Intikak Ali	Businessman	On file
Chandani Drejodhan	Assistant Overseer	On file
Lorna Hope	Chairwoman	On file
Bonita Leitch	Team Leader	On file
Arnold Clinton	Farmer	On file
Kim Rambarose	Housewife	On file
Bridget Chichester	Supervisor	On file
Bushlot/ Adventure NDC		
Collin E. Moore	Chairman	On file
Gillian Bennett	Overseer	On file
Preya Mohanlal	Rates Collector	On file
Maida/ Tarlogie NDC		
Tenisha Williams	Asst. Overseer	On file
Davyani Karim Basil	Overseer	On file
Bebe Khedaroo	Councillor	On file
Annie Pestano	Councillor	On file
Macedonia/ Joppa NDC		
Aticha Persaud	Overseer	On file
Valsha Lomash	Councillor	On file
Lennox Haynes	Councillor	On file
Patricia Lewis	Councillor	On file
Vera France	Councillor	On file
Good Hope/ No.51 NDC		
Swarsate Devi Sharif	Housewife- Chairperson	On file
Coleen North	Housewife- Councillor	On file
Sharron Davis	Housewife- Councillor	On file
Kamaldeo	Labourer	On file
Letika E. Cornelius	Student	On file

Name	Designation	Contact Information
G. Samuels	Overseer	On file
Lelo Murrid		On file
No.52/ No.74 NDC		
Jaichand Ramraj	No. 64 Village	On file
V. Ramsaywack	No.52 Village	On file
Alvin Singh	Student	On file
Teneisha Smartt	Student	On file
Lakhram Singh	Councillor	On file
Jailall Tahal	Councillor	On file
Roslyn Hawker	Asst. Overseer	On file
Ravindra Dass	Overseer	On file
Anil Ramgahan	Chairman	On file
Shanaaz Ram	Councillor	On file
H. Ghansham	Councillor	On file
Jason Gravesande	Vice Chairman	On file
Nella Jaundoo	Charwoman	On file
S. Narine		On file
P. Bholanath	Councillor	On file
Denzil Lewis	PHI	On file
Shakuntalla Bhoj	Social Worker	On file
Corriverton Town Council		
Winston Roberts	Mayor	On file
Imran Amin	D/Mayor	On file
Mahendra Sukhram	Town Clerk	On file
D. Singh	Councillor	On file

ATTACHMENT B: IMAGES

Attachment B1: Region 5

Woodlands-Farm NDC

Hamlet-Chance NDC

Mahaicony-Abary NDC

Profit-Rising Sun NDC

Seafield-Tempie NDC

Union-Naarstigheid NDC

Bath-Woodley Park NDC

Woodlands-Bel Air NDC

Zeelugt-Rosignol NDC

Attachment B2: Region 6

Ordinance-Fort Lands NDC

Kintyre-No.37 NDC

Gibraltar-Fyrish NDC

Kilcoy-Hampshire NDC

Rose Hall Town Council

Port Mourant-John NDC

Bloomfield-Whim NDC

Lancaster-Hogstye NDC

Bushlot-Adventure NDC

Maida-Tarlogie NDC

Macedonia-Joppa NDC

Good Hope-No.51 NDC

No.52-No.74 NDC

Corriverton Town Council

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APPENDIX T

Traffic Impact Assessment

Resubmitted without changes

March 2022

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Traffic Impact Assessment

ESSO EXPLORATION AND PRODUCTION GUYANA LIMITED

GUYANA, **Yellowtail Development Project** 2021

CARITRANS

AUGUST, 2021

Executive Summary

Caribbean Transportation Consultancy Services (CARITRANS) Company Limited was contracted by Environmental Resources Management (ERM) on behalf of Esso Exploration and Production Guyana Limited (EEPGL) to undertake a Traffic Impact Assessment (TIA) for 47 intersections around six key locations in the Georgetown area.

To conduct a TIA, base data are needed to calibrate a model of existing conditions from which the assessment can be made. Turning Movement Counts (TMCs) at intersections that were deemed to potentially be affected by EEPGL-related vehicle trips were collected between May 9 and 12, 2019. The road network was then analysed for 2026, selected to represent a time when EEPGL's proposed Yellowtail development is planned to be in production operations, with continued development well drilling. The scenarios analysed for this year included "with development" (i.e., "with EEPGL-related vehicle movements") and "without development." VISSIM microsimulation software was used to develop and analyse these scenarios through simulation.

Future base traffic volumes for the 2026 scenario were obtained by "growing" the May 2019 measured base model volumes using an annual growth rate of 5%. Outputs from the VISSIM model included predicted traffic queues and delays, the latter used to determine the Level of Service (LOS) for each approach at the study intersections.

Generally, the bulk of the existing intersections were found to be operating at **LOS A** (free-flowing of operations) under base traffic conditions. However, of the 47 intersections for which base condition LOS modelling was conducted, it was found that some individual approaches and, in most instances, individual movements (right, left, or through) were found to be experiencing unsatisfactory LOS (i.e., an **LOS E** or **LOS F**) under base conditions. Specifically, of the 355 approaches analysed across all the intersections, 70 (approximately 20%) were found to be operating at unsatisfactory LOS in the AM peak period under base conditions, and 57 (approximately 16%) were found to operate at unsatisfactory LOS in the PM peak period under base conditions. These typically occurred at signalized intersections, those with high intercity connectors, and around minibus stands.

The additional EEPGL-related vehicle trips predicted for 2026 are relatively low compared to current base and projected future traffic, resulting in a projected overall minimal impact on the existing road network from the addition of EEPGL-related traffic.

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Introduction

Caribbean Transportation Consultancy Services (CARITRANS) Company Limited was contracted by Environmental Resources Management (ERM) on behalf of Esso Exploration and Production Guyana Limited (EEPGL) to undertake a Traffic Impact Assessment (TIA) for 47 intersections around six key locations in the Georgetown area. The TIA was conducted to support an Environmental Impact Assessment (EIA) for EEGPL's proposed Yellowtail Development Project and involved assessment of the potential impacts from future projected EEPGL-related traffic at intersections that were deemed to potentially be affected by EEPGL-related vehicle trips (inclusive of traffic related to the Yellowtail Development Project and other projected EEPGL-related activities; collectively referred to herein as "the development"). The intersections studied were generally clustered around six key locations in the Georgetown area (Figure 1).

The TIA involved the analysis and assessment of conditions for the surrounding road network with the existing 2019 measured "base" traffic, and assessment of the potential impacts the proposed development would have on projected traffic conditions in 2026.

Methodology

In order to assess the impact of the proposed development on the existing road network, the base or current year operating conditions were established. Base data were collected via Turning Movement Counts (TMCs) at forty-seven (47) intersections, grouped around six (6) key locations:

- *Marriott*
- *EEPGL Office Complex / Ogle*
- *Contractor Commercial Port A*
- *Contractor Inland Storage Yard*
- *Contractor Shorebase B*
- *Ramada Intersection*

A growth factor of five percent (5%) per annum was used to take the base year data and project it to 2026. This year was selected to represent a time when EEPGL's proposed Yellowtail development is planned to be in production operations, with continued development well drilling.

The trips generated by the proposed development were provided by ERM as daily volumes. The directional design hourly volume (DDHV) formula with general ranges of the 'K' (the proportion of daily traffic in the peak hour) and 'D' (the proportion of peak hour traffic travelling in the peak direction of flow) values were taken from the Institute of Transportation Engineers (ITE) Traffic Engineering Handbook 6th Edition, 2008 and used to calculate the volume of trips that occurred specifically during the morning and afternoon peak hours.

The analyses have been undertaken to assess traffic conditions for the noted future year for "without development" and "with development" scenarios. VISSIM microsimulation software was used to develop and analyse these models through simulation.

Capacity and Level of Service Analysis

Level of Service (LOS) is a key performance factor that is used to evaluate the operation of an intersection and is measured on a scale of A to F, A being the least congested and F being the most congested. It is a measure of the level of road-user comfort in traversing a roadway facility, usually taken as a measure of the delay experienced on/at the facility. Generally, LOS A-D is considered acceptable while LOS E-F is considered unacceptable.

The results of the TIA, presented by key location, are discussed below. The tables provided below (Tables 1-10) show the delays and queues calculated by the VISSIM analysis and the corresponding LOS for each approach at each study intersection.

For each of the key locations' associated study intersections, separate tables are provided presenting results for the following analyses:

- *LOS for Base Model – AM Peak (2019)*
- *LOS for Projected Model - AM Peak (2026 without projected development trips and 2026 with projected development trips)*
- *LOS for Base Model - PM Peak (2019)*
- *LOS for Projected Model - PM Peak (2026 without projected development trips and 2026 with projected development trips)*

Marriott

Figure 2: Marriott location and corresponding study intersections

- *M2 - Battery Street at Fort Street*
- *M3 - Battery Road at High Street*
- *M4 - High Street at Wights Lane*
- *M5 - High Street at Young Street*
- *M6 - Fort Street at Wights Lane*
- *M7 - Barrack Street at High Street*
- *M8 - Fort Street at Barrack Street*
- *M9 - Water Street at Barrack Street*
- *M10 - Camp Street at Seawall Road*
- *M11 - Camp Street at Carifesta Avenue and Young Street*

Base Model - 2019

Figure 2 shows the intersections modelled at the Marriott location. For the intersections around this location, the morning peak generally indicates an acceptable **LOS**. However, at the M11 intersection, the high delays indicate high congestion at the signalized intersections, as it was observed to have lengthy queues that, at times, spilled over to upstream intersections. This was because of traffic demand heading into Georgetown; the reverse was seen to occur in the afternoon peak, as cars were leaving Georgetown. Police presence was commonplace at peak hours at the M11 intersection to manage traffic operations.

Projected Model - 2026

The demand is greater than the capacity of several intersections in 2026 and as such the LOS at several intersections is seen to move from acceptable in 2019 to unacceptable in 2026. This was the case for M3, M7, M10 and M11 in the AM Peak and M5, M7 and M11 in the PM Peak. These intersections are either signalised (M11) or these are the intercity connections where most vehicles pass to access Georgetown. The signalized intersections have not been optimised to service the additional volumes projected in 2026.

LOS delay analysis indicates that there are minor impacts on capacity at the Marriott location due to the additional projected development trips in 2026. The minor impacts are due to a road network that is already performing at an unsatisfactory LOS at several intersections. Overall, the trips projected to be generated by the development are relatively small compared to the existing traffic volumes and generally do not result in substantial further deterioration of performance at the associated intersections. The results for the Marriott location are provided in Tables 1 and 2.

Table 1: Level of Service for Base Model - Marriott AM Peak (2019) and Projected Model - Marriott AM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
M1	SB	Right	1	9	10	6	16	17	LOS_A	LOS_C	LOS_C
		Left	1	9	10	7	4	7	LOS_A	LOS_A	LOS_A
		Through	1	9	10	5	15	16	LOS_A	LOS_C	LOS_C
	EB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	2	5	6	LOS_A	LOS_A	LOS_A
		Right	0	0	0	4	8	7	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	1	1	2	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Right	0	1	1	1	1	4	LOS_A	LOS_A	LOS_A
		Through	0	1	1	1	3	3	LOS_A	LOS_A	LOS_A
		Left	0	1	1	1	1	1	LOS_A	LOS_A	LOS_A
M2	EB	Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	WB	Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	NB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
M3	EB	Through	5	21	32	7	34	35	LOS_A	LOS_E	LOS_E
		Right	5	21	32	11	35	40	LOS_B	LOS_E	LOS_E
	WB	Through	17	424	424	25	133	133	LOS_C	LOS_F	LOS_F
		Left	14	423	423	17	104	107	LOS_C	LOS_F	LOS_F
	NB	Left	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
M4	SB	Through	2	3	3	10	10	10	LOS_A	LOS_B	LOS_A
		Left	6	6	6	5	7	9	LOS_A	LOS_A	LOS_A
	NB	Through	2	3	3	1	3	3	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Right	5	5	5	4	6	7	LOS_A	LOS_A	LOS_A
	WB	Right	10	11	17	19	20	25	LOS_C	LOS_C	LOS_C
		Left	10	11	17	17	16	22	LOS_C	LOS_C	LOS_C
M5	SB	Right	3	3	3	2	2	3	LOS_A	LOS_A	LOS_A
		Through	2	2	2	1	1	2	LOS_A	LOS_A	LOS_A
	NB	Through	9	34	36	9	17	19	LOS_A	LOS_C	LOS_C
		Left	9	34	36	13	20	20	LOS_B	LOS_C	LOS_C
M6	NB	Through	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
	WB	Right	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
M7	NB	U-Turn	1	13	13	0	0	0	LOS_A	LOS_A	LOS_A
		Right	1	13	13	1	2	7	LOS_A	LOS_A	LOS_A
		Left	1	13	13	1	2	3	LOS_A	LOS_A	LOS_A
		Through	1	13	13	1	2	5	LOS_A	LOS_A	LOS_A
	WB	Left	9	108	107	17	167	184	LOS_C	LOS_F	LOS_F
		Through	9	107	107	23	172	175	LOS_C	LOS_F	LOS_F
		Right	9	107	107	25	165	179	LOS_D	LOS_F	LOS_F
	EB	Right	1	3	9	12	35	48	LOS_B	LOS_D	LOS_D
		Through	1	3	9	16	29	43	LOS_C	LOS_D	LOS_D
		Left	1	3	9	8	17	27	LOS_A	LOS_C	LOS_D
	SB	Through	0	3	4	2	4	5	LOS_A	LOS_A	LOS_A
		Left	0	3	4	0	2	3	LOS_A	LOS_A	LOS_A
		Right	0	3	4	3	9	12	LOS_A	LOS_A	LOS_B
		U-Turn	0	3	4	0	0	0	LOS_A	LOS_A	LOS_A
M8	NB	Through	0	0	0	1	3	3	LOS_A	LOS_A	LOS_A
		Right	0	0	0	2	2	3	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	SB	Through	0	0	0	2	2	2	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	3	5	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	3	3	5	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		U-Turn	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	EB	Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
M9	NB	Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	SB	Through	0	1	1	3	4	4	LOS_A	LOS_A	LOS_A
		Left	0	1	1	1	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	2	2	2	LOS_A	LOS_A	LOS_A
M10	WB	Through	0	327	323	3	78	77	LOS_A	LOS_F	LOS_F
		Left	0	327	323	1	65	65	LOS_A	LOS_F	LOS_F
	EB	Through	0	4	5	2	5	6	LOS_A	LOS_A	LOS_A
		Right	0	4	5	2	6	6	LOS_A	LOS_A	LOS_A
	NB	Right	1	5	6	5	16	19	LOS_A	LOS_C	LOS_C
		Left	1	5	6	4	23	28	LOS_A	LOS_C	LOS_D
M11	NB	Right	11	29	29	50	80	82	LOS_D	LOS_F	LOS_F
		Through	11	29	29	50	81	81	LOS_D	LOS_F	LOS_F
		Left	2	20	21	11	34	35	LOS_B	LOS_C	LOS_D
	WB	Left	407	452	452	114	124	125	LOS_F	LOS_F	LOS_F
		Right	407	452	452	143	151	151	LOS_F	LOS_F	LOS_F
		Through	407	452	452	141	142	144	LOS_F	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	SB	Through	6	13	24	43	61	73	LOS_D	LOS_E	LOS_E
		Left	6	15	23	60	120	134	LOS_E	LOS_F	LOS_F
		Right	6	13	24	43	55	60	LOS_D	LOS_D	LOS_E
	EB	Right	5	6	6	38	37	42	LOS_D	LOS_D	LOS_D
		Through	5	6	6	11	9	9	LOS_B	LOS_A	LOS_A
		Left	5	6	6	10	11	13	LOS_A	LOS_B	LOS_B

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 2: Level of Service for Base Model - Marriott PM Peak (2019) and Projected Model - Marriott PM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
M1	SB	Right	0	1	1	3	15	16	LOS_A	LOS_B	LOS_C
		Left	0	1	1	4	5	7	LOS_A	LOS_A	LOS_A
		Through	0	1	1	4	8	9	LOS_A	LOS_A	LOS_A
	EB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	1	1	3	6	6	LOS_A	LOS_A	LOS_A
		Right	0	0	0	2	5	5	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	1	1	3	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	3	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Right	0	2	1	2	3	4	LOS_A	LOS_A	LOS_A
		Through	0	2	1	1	4	6	LOS_A	LOS_A	LOS_A
		Left	0	1	1	1	1	1	LOS_A	LOS_A	LOS_A
M2	EB	Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	WB	Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	NB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
M3	EB	Through	2	10	18	3	10	17	LOS_A	LOS_B	LOS_C
		Right	2	10	18	3	10	16	LOS_A	LOS_B	LOS_C
	WB	Through	0	2	3	12	30	34	LOS_B	LOS_D	LOS_D
		Left	0	1	2	1	10	11	LOS_A	LOS_A	LOS_B
	NB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
M4	SB	Through	0	1	1	4	8	8	LOS_A	LOS_A	LOS_A
		Left	0	2	3	1	1	3	LOS_A	LOS_A	LOS_A
	NB	Through	1	4	4	2	4	4	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Right	2	7	7	3	6	6	LOS_A	LOS_A	LOS_A
	WB	Right	2	17	24	9	24	27	LOS_A	LOS_C	LOS_D
		Left	2	17	24	6	19	23	LOS_A	LOS_C	LOS_C
M5	SB	Right	1	3	3	3	8	9	LOS_A	LOS_A	LOS_A
		Through	0	2	2	0	1	3	LOS_A	LOS_A	LOS_A
	NB	Through	3	144	150	3	37	41	LOS_A	LOS_E	LOS_E
		Left	3	144	150	4	42	43	LOS_A	LOS_E	LOS_E
M6	NB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
M7	NB	U-Turn	0	110	116	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	110	116	0	30	34	LOS_A	LOS_D	LOS_D
		Left	0	110	116	2	30	35	LOS_A	LOS_D	LOS_D
		Through	0	110	116	0	30	33	LOS_A	LOS_D	LOS_D
	WB	Left	2	82	104	8	228	235	LOS_A	LOS_F	LOS_F
		Through	2	82	104	17	220	224	LOS_C	LOS_F	LOS_F
		Right	2	82	103	13	367	376	LOS_B	LOS_F	LOS_F
	EB	Right	1	9	15	17	49	59	LOS_C	LOS_E	LOS_F
		Through	1	9	15	9	50	58	LOS_A	LOS_F	LOS_F
		Left	1	9	15	7	63	64	LOS_A	LOS_F	LOS_F
	SB	Through	0	8	9	2	9	10	LOS_A	LOS_A	LOS_A
		Left	0	8	9	0	8	10	LOS_A	LOS_A	LOS_A
		Right	0	8	9	6	22	26	LOS_A	LOS_C	LOS_D
		U-Turn	0	8	9	0	0	0	LOS_A	LOS_A	LOS_A
M8	NB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	SB	Through	0	0	0	2	2	2	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	3	3	3	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	2	LOS_A	LOS_A	LOS_A
		U-Turn	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	EB	Right	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
M9	NB	Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	SB	Through	0	0	0	3	3	3	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	3	3	LOS_A	LOS_A	LOS_A
M10	WB	Through	0	0	0	2	2	2	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	EB	Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	NB	Right	0	1	1	3	5	5	LOS_A	LOS_A	LOS_A
		Left	0	1	1	1	3	3	LOS_A	LOS_A	LOS_A
M11	NB	Right	5	10	9	44	55	62	LOS_D	LOS_E	LOS_E
		Through	5	10	9	44	59	60	LOS_D	LOS_E	LOS_E
		Left	1	6	4	6	10	11	LOS_A	LOS_B	LOS_B
	WB	Left	12	98	177	9	85	90	LOS_A	LOS_F	LOS_F
		Right	12	97	176	53	105	110	LOS_D	LOS_F	LOS_F
		Through	12	97	176	36	100	104	LOS_D	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	SB	Through	8	11	11	61	60	67	LOS_E	LOS_E	LOS_E
		Left	4	8	8	37	53	54	LOS_D	LOS_D	LOS_D
		Right	8	11	11	58	55	51	LOS_E	LOS_D	LOS_D
	EB	Right	7	7	8	33	36	37	LOS_C	LOS_D	LOS_D
		Through	7	7	8	5	6	7	LOS_A	LOS_A	LOS_A
		Left	7	8	8	5	7	7	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

EEPGL Office Complex / Ogle

Figure 3: EEPGL Office Complex / Ogle location and corresponding study intersections

- *OGL 1 - Ogle Airstrip Road at unnamed Street*
- *OGL 2 - Ogle Airstrip Road at Railway Embankment Road*
- *OGL 3 - Ogle Airstrip Road at Rupert Craig Highway*
- *OGL 5 - unnamed streets*
- *OGL 6 - Railway Embankment Road at unnamed street*
- *GC 1 - Grand Coastal Intersection at Rupert Craig Highway*

Base Model - 2019

The LOS observed at 3 out of the 6 intersections for both the AM and PM peak are acceptable. However, this location's operations are characterized by heavy east-west peak volumes, as it is one of the major conduits for traffic into and out of Georgetown from communities to the east. As such, OGL 2 and OGL 6 typically experience high delays. Police presence was commonplace at peak hours at the signalized intersection (OGL 3) to aid operations.

Projected Model - 2026

The demand is greater than the capacity of several intersections in 2026 and as such the LOS is seen to move from acceptable in 2019 to unacceptable in 2026 for approaches in several intersections. This was the case for OGL 2, OGL 3, and OGL 6 in the AM Peak and OGL 2, OGL 3, OGL 5 and OGL 6 in the PM Peak. These intersections are either signalised (OGL 3) or these are the intercity connections where most vehicles pass to access Georgetown. The signalized intersections have not been optimised to service the additional volumes projected in 2026.

LOS delay analysis indicates that there are minor impacts on capacity due to the additional projected development trips in 2026. The minor impacts are due to a road network that is already performing at an unsatisfactory LOS at several intersections. The trips projected to be generated by the development are relatively small compared to the existing traffic volumes and generally do not result in substantial further deterioration of performance at the associated intersections. The results for the EEPGL Office Complex / Ogle location are provided in Tables 3 and 4.

Table 3: Level of Service for Base Model – EEPGL Office Complex / Ogle AM Peak (2019) and Projected Model – EEPGL Office Complex / Ogle AM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
Ogle1	NB	Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	3	5	LOS_A	LOS_A	LOS_A
	WB	Left	0	4	0	0	0	1	LOS_A	LOS_A	LOS_A
		Right	0	3	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	4	0	0	4	0	LOS_A	LOS_A	LOS_A
	SB	Through	0	30	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	30	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	30	0	1	2	2	LOS_A	LOS_A	LOS_A
	EB	Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	1	0	LOS_A	LOS_A	LOS_A
Ogle2	WB	Right	144	267	257	21	90	96	LOS_C	LOS_F	LOS_F
		Through	144	267	257	10	48	55	LOS_B	LOS_E	LOS_F
		Left	144	267	257	7	77	80	LOS_A	LOS_F	LOS_F
	SB	Left	309	319	335	>500	>500	>500	LOS_F	LOS_F	LOS_F
		Right	308	318	334	900+	800+	900+	LOS_F	LOS_F	LOS_F
		Through	309	319	336	>500	>500	>500	LOS_F	LOS_F	LOS_F
	EB	Through	1	20	35	2	5	6	LOS_A	LOS_A	LOS_A
		Left	1	20	35	2	4	5	LOS_A	LOS_A	LOS_A
		Right	1	20	35	2	5	5	LOS_A	LOS_A	LOS_A
	NB	Right	10	27	17	237	360	375	LOS_F	LOS_F	LOS_F
		Through	10	27	17	98	261	271	LOS_F	LOS_F	LOS_F
		Left	10	27	17	38	200	213	LOS_E	LOS_F	LOS_F
Ogle3	SB	Right	104	109	109	323	339	341	LOS_F	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	104	109	109	374	382	401	LOS_F	LOS_F	LOS_F
		Left	104	109	109	285	322	322	LOS_F	LOS_F	LOS_F
	NB	Through	29	27	38	75	68	80	LOS_E	LOS_E	LOS_F
		Left	29	27	38	55	42	58	LOS_E	LOS_D	LOS_E
		Right	29	27	38	0	0	0	LOS_A	LOS_A	LOS_A
	EB	Left	61	421	421	50	76	77	LOS_D	LOS_E	LOS_E
		Right	61	421	421	53	73	83	LOS_D	LOS_E	LOS_F
		Through	61	421	421	61	83	83	LOS_E	LOS_F	LOS_F
	WB	Right	10	14	14	27	27	27	LOS_C	LOS_C	LOS_C
		Through	10	15	14	28	30	30	LOS_C	LOS_C	LOS_C
		Left	9	14	14	20	24	25	LOS_D	LOS_C	LOS_C
Ogle5	NB	Left	0	2	0	0	1	0	LOS_A	LOS_A	LOS_A
		Right	0	2	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	2	0	1	3	2	LOS_A	LOS_A	LOS_A
	EB	Right	0	5	0	1	3	3	LOS_A	LOS_A	LOS_A
		Through	0	5	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	6	0	0	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	1	1	3	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	1	5	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	2	6	LOS_A	LOS_A	LOS_A
	SB	Through	0	0	0	0	2	6	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
Ogle6	SB	Right	3	4	2	90	115	113	LOS_F	LOS_F	LOS_F
		Left	3	5	3	58	70	75	LOS_F	LOS_F	LOS_F
		Through	3	5	2	133	60	64	LOS_F	LOS_F	LOS_F
	EB	Left	0	116	134	0	0	10	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	0	116	134	1	6	7	LOS_A	LOS_A	LOS_A
		Right	0	116	134	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Right	1	20	29	0	50	60	LOS_A	LOS_F	LOS_F
		Through	22	211	50	1	1	5	LOS_A	LOS_A	LOS_A
		Left	6	121	159	0	0	0	LOS_A	LOS_A	LOS_A
	NB	Through	16	20	25	71	90	97	LOS_F	LOS_F	LOS_F
		Left	16	20	25	96	55	59	LOS_F	LOS_F	LOS_F
		Right	16	20	25	95	83	85	LOS_F	LOS_F	LOS_F
GC	SB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	6	7	10	LOS_A	LOS_A	LOS_B
	NB	Through	0	0	0	2	9	9	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	2	1	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	2	1	LOS_A	LOS_A	LOS_A
	WB	Right	0	1	1	4	4	4	LOS_A	LOS_A	LOS_A
		Left	1	1	1	2	3	4	LOS_A	LOS_A	LOS_A
		U-Turn	0	1	1	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	1	1	1	2	2	LOS_A	LOS_A	LOS_A
	EB	Left	3	4	5	8	13	9	LOS_A	LOS_B	LOS_A
		Right	3	4	5	6	11	12	LOS_A	LOS_B	LOS_B
		Through	3	4	5	4	5	6	LOS_A	LOS_A	LOS_A
		U-Turn	3	4	5	0	0	0	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 4: Level of Service for Base Model – EEPGL Office Complex / OGL PM Peak (2019) and Projected Model – EEPGL Office Complex / OGL PM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
Ogle1	NB	Right	0	14	14	1	1	3	LOS_A	LOS_A	LOS_A
		Through	0	14	14	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	15	15	1	20	25	LOS_A	LOS_C	LOS_C
	WB	Left	0	12	15	1	1	10	LOS_A	LOS_A	LOS_A
		Right	0	12	12	0	8	9	LOS_A	LOS_A	LOS_A
		Through	0	12	12	0	5	10	LOS_A	LOS_A	LOS_A
	SB	Through	1	75	81	0	0	0	LOS_A	LOS_A	LOS_A
		Left	1	75	81	0	0	0	LOS_A	LOS_A	LOS_A
		Right	1	75	81	0	0	0	LOS_A	LOS_A	LOS_A
	EB	Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
Ogle2	WB	Right	218	308	290	44	164	167	LOS_E	LOS_F	LOS_F
		Through	218	308	290	27	85	95	LOS_D	LOS_F	LOS_F
		Left	218	308	290	31	105	108	LOS_D	LOS_F	LOS_F
	SB	Left	283	336	327	490	600+	600+	LOS_F	LOS_F	LOS_F
		Right	282	335	326	700+	700+	900+	LOS_F	LOS_F	LOS_F
		Through	284	336	327	500+	600+	700+	LOS_F	LOS_F	LOS_F
	EB	Through	2	153	84	3	6	10	LOS_A	LOS_A	LOS_A
		Left	2	153	84	3	5	6	LOS_A	LOS_A	LOS_A
		Right	2	153	84	3	6	10	LOS_A	LOS_A	LOS_A
	NB	Right	21	51	66	415	447	500+	LOS_F	LOS_F	LOS_F
		Through	22	52	66	365	600+	600+	LOS_F	LOS_F	LOS_F
		Left	21	51	66	288	500+	600+	LOS_F	LOS_F	LOS_F
Ogle3	SB	Right	104	110	109	205	297	300	LOS_F	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	104	110	109	359	377	385	LOS_F	LOS_F	LOS_F
		Left	104	110	109	315	323	324	LOS_F	LOS_F	LOS_F
	NB	Through	57	32	59	106	111	108	LOS_F	LOS_F	LOS_F
		Left	57	32	59	91	53	93	LOS_F	LOS_D	LOS_F
		Right	57	32	59	0	0	358	LOS_A	LOS_A	LOS_F
	EB	Left	231	437	436	67	75	75	LOS_E	LOS_E	LOS_E
		Right	231	437	436	114	111	220	LOS_F	LOS_F	LOS_F
		Through	231	437	436	80	84	86	LOS_E	LOS_F	LOS_F
	WB	Right	8	13	12	22	32	32	LOS_C	LOS_C	LOS_C
		Through	8	13	12	29	29	30	LOS_C	LOS_C	LOS_D
		Left	8	13	12	27	28	36	LOS_C	LOS_C	LOS_D
Ogle5	NB	Left	0	2	0	5	7	10	LOS_A	LOS_A	LOS_A
		Right	0	2	0	1	4	10	LOS_A	LOS_A	LOS_A
		Through	0	2	0	0	1	2	LOS_A	LOS_A	LOS_A
	EB	Right	0	5	9	2	28	42	LOS_A	LOS_D	LOS_E
		Through	0	5	9	0	5	13	LOS_A	LOS_A	LOS_B
		Left	0	5	9	0	87	95	LOS_A	LOS_F	LOS_F
	WB	Left	0	251	168	1	79	80	LOS_A	LOS_F	LOS_F
		Through	0	251	168	1	25	28	LOS_A	LOS_D	LOS_D
		Right	0	251	168	1	23	28	LOS_A	LOS_C	LOS_D
	SB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	4	9	10	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
Ogle6	SB	Right	0	0	0	46	55	58	LOS_F	LOS_F	LOS_F
		Left	0	0	1	16	50	69	LOS_C	LOS_E	LOS_F
		Through	0	0	1	81	85	92	LOS_F	LOS_F	LOS_F
	EB	Left	0	186	190	0	0	0	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	0	186	190	1	6	8	LOS_A	LOS_A	LOS_A
		Right	0	186	190	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Right	0	30	35	7	75	79	LOS_A	LOS_F	LOS_F
		Through	13	251	260	1	3	10	LOS_A	LOS_A	LOS_A
		Left	1	196	198	0	0	0	LOS_A	LOS_A	LOS_A
	NB	Through	12	213	249	33	300	313	LOS_D	LOS_F	LOS_F
		Left	11	213	248	33	323	326	LOS_D	LOS_F	LOS_F
		Right	12	213	248	46	345	355	LOS_E	LOS_F	LOS_F
GC	SB	Through	0	0	0	3	5	8	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	1	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	3	7	10	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	WB	Right	0	0	1	3	5	3	LOS_A	LOS_A	LOS_A
		Left	1	0	0	2	3	5	LOS_A	LOS_A	LOS_A
		U-Turn	0	0	1	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	1	1	1	2	LOS_A	LOS_A	LOS_A
	EB	Left	5	5	5	10	11	13	LOS_B	LOS_B	LOS_B
		Right	5	5	5	10	12	12	LOS_A	LOS_B	LOS_B
		Through	5	5	6	6	6	6	LOS_A	LOS_A	LOS_A
		U-Turn	5	5	6	0	0	0	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Contractor Commercial Port A and Contractor Inland Storage Yard

Figure 4: Contractor Commercial Port and Contractor Inland Storage Yard locations and corresponding study intersections

Contractor Commercial Port A

- *JFL 1 - Saffon Street at Mandela Avenue*
- *JFL 2 - Saffon Street at First Street*
- *JFL 3 - Saffon Street at unnamed street*
- *JFL 4 - Saffon Street at Trench Street*

Contractor Inland Storage Yard

- *JF 1 - Mandela Avenue at Hunter Street*
- *JF 2 - Mandela Avenue at John Fernandes Container Terminal Road*
- *JF 3 - Mandela Avenue at Plumbago Street*
- *JF 4 - Mandela Avenue at Vessegen Road*
- *JF 6 - Unnamed Street intersection*
- *JF 7 - Unnamed Street intersection*

Base Model - 2019

This location has one of the major connector roads for vehicles coming from the East Bank Demerara Road into Georgetown. Consequently, the road is characterized by high traffic volumes and queues at the Mandela signalized intersection that spill over into the nearby intersections, particularly during peak hours. Police presence was noted during both the morning and afternoon peaks to assist with operations. The LOS at the JF1 intersection was unacceptable for both AM and PM peaks. The LOS at JFL1 to JFL4 was acceptable for both the AM and PM Peaks. JF2 – JF7 generally experience acceptable LOS in the AM peak except for the approaches attempting to traverse the intersection that already has minimum gaps because of the high volumes on the main roads. The LOS for JF2 – JF7 is acceptable for the PM Peak.

Projected Model - 2026

The demand is greater than the capacity of several intersections in 2026 and as such the LOS is seen to move from acceptable in 2019 to unacceptable in 2026 for approaches in several intersections. While some approaches remained acceptable, a number of the approaches went to unacceptable. The signalised intersection (JF1) was already performing at unacceptable service levels and with the increased demand the spill over to the surrounding intersections is greater. The signalized intersections have not been optimised to service the additional volumes projected in 2026.

LOS delay analysis indicates that there are minor impacts on capacity due to the additional projected development trips in 2026. The minor impacts are due to a road network that is already performing at unsatisfactory LOS at several intersections. The trips projected to be generated by the development are relatively small compared to the existing traffic volumes and generally do not result in substantial further deterioration of performance at the associated intersections. The results for the Contractor Commercial Port A and Contractor Inland Storage Yard locations are provided in Tables 5 and 6.

Table 5: Level of Service for Base Model – Contractor Commercial Port A and Contractor Inland Storage Yard - AM Peak (2019) and Projected Model - Contractor Commercial Port A and Contractor Inland Storage Yard AM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
JFL1	NB	Through	0	289	289	0	40	41	LOS_A	LOS_E	LOS_E
		Right	0	297	297	0	36	39	LOS_A	LOS_E	LOS_E
		Left	0	306	306	1	25	35	LOS_A	LOS_D	LOS_D
	SB	Left	0	22	36	0	9	14	LOS_A	LOS_A	LOS_B
		Right	0	306	306	0	6	6	LOS_A	LOS_A	LOS_A
	WB	Right	0	0	0	0	13	15	LOS_A	LOS_B	LOS_B
		Through	0	0	0	5	11	12	LOS_A	LOS_B	LOS_B
	EB	Left	0	0	0	0	9	6	LOS_A	LOS_A	LOS_A
		Through	0	0	1	12	16	17	LOS_B	LOS_C	LOS_C
JFL2	WB	Right	0	0	0	3	20	25	LOS_A	LOS_C	LOS_C
		Left	0	0	0	0	1	0	LOS_A	LOS_A	LOS_A
	SB	Left	0	287	286	0	1	3	LOS_A	LOS_A	LOS_A
		Through	0	0	4	0	0	3	LOS_A	LOS_A	LOS_A
	NB	Right	0	279	280	3	66	68	LOS_A	LOS_F	LOS_F
		Through	0	276	275	0	42	43	LOS_A	LOS_E	LOS_E
JFL3	WB	Left	3	127	86	4	75	78	LOS_A	LOS_F	LOS_F
		Right	3	127	86	10	89	93	LOS_A	LOS_F	LOS_F
	NB	Right	2	68	81	0	0	0	LOS_A	LOS_A	LOS_A
		Through	2	68	81	2	29	31	LOS_A	LOS_D	LOS_D
	SB	Left	0	0	2	0	0	2	LOS_A	LOS_A	LOS_A
		Through	0	0	2	0	0	2	LOS_A	LOS_A	LOS_A
JFL4	SB	Left	0	1	2	8	8	9	LOS_A	LOS_A	LOS_A
		Through	0	1	2	10	10	11	LOS_B	LOS_B	LOS_B
	NB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
JF1	SB	Through	78	95	95	496	600+	600+	LOS_F	LOS_F	LOS_F
		Right	78	95	95	0	0	0	LOS_A	LOS_A	LOS_A
		Left	78	95	95	422	500+	500+	LOS_F	LOS_F	LOS_F
	NB	Through	268	335	334	271	368	375	LOS_F	LOS_F	LOS_F
		Left	268	335	334	392	420	435	LOS_F	LOS_F	LOS_F
		Right	268	335	334	295	326	355	LOS_F	LOS_F	LOS_F
	EB	Left	73	273	288	37	71	71	LOS_D	LOS_E	LOS_E
		Right	73	273	288	37	57	58	LOS_D	LOS_E	LOS_E
		Through	73	273	288	45	63	66	LOS_D	LOS_E	LOS_E
	WB	Right	64	430	433	73	88	92	LOS_E	LOS_F	LOS_F
		Left	64	430	433	57	80	89	LOS_E	LOS_F	LOS_E
		Through	64	430	433	57	77	79	LOS_E	LOS_E	LOS_E
JF2	NB	Left	0	0	0	0	13	13	LOS_A	LOS_B	LOS_B
		Through	0	0	0	100	101	110	LOS_F	LOS_F	LOS_F
		Right	0	0	0	3	0	0	LOS_A	LOS_A	LOS_A
	SB	Through	0	1	1	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	1	1	0	24	28	LOS_A	LOS_C	LOS_D
		Left	0	0	0	1	3	6	LOS_A	LOS_A	LOS_A
	WB	Left	0	168	173	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	168	173	0	65	66	LOS_A	LOS_F	LOS_F
		Right	0	158	163	31	84	86	LOS_D	LOS_F	LOS_F
	EB	Right	5	5	9	4	9	10	LOS_A	LOS_A	LOS_A
		Left	6	6	8	3	1	0	LOS_A	LOS_A	LOS_A
		Through	6	6	8	3	3	3	LOS_A	LOS_A	LOS_A
JF3	SB	Left	4	3	3	95	100	111	LOS_F	LOS_F	LOS_F
		Right	3	3	3	27	47	48	LOS_D	LOS_E	LOS_E
	WB	Left	0	192	202	1	30	34	LOS_A	LOS_E	LOS_E

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	0	192	202	0	41	43	LOS_A	LOS_E	LOS_E
	EB	Right	35	19	22	6	9	10	LOS_A	LOS_A	LOS_A
		Through	35	19	22	3	4	4	LOS_A	LOS_A	LOS_A
JF4	WB	Right	1	130	129	2	29	29	LOS_A	LOS_D	LOS_D
		Through	2	138	138	3	34	36	LOS_A	LOS_D	LOS_D
		Left	1	130	129	3	17	20	LOS_A	LOS_C	LOS_C
	EB	Left	14	8	12	8	8	8	LOS_A	LOS_A	LOS_A
		Through	14	8	12	5	9	9	LOS_A	LOS_A	LOS_A
		Right	14	8	13	17	18	20	LOS_C	LOS_C	LOS_C
	NB	Through	31	38	38	107	114	122	LOS_F	LOS_F	LOS_F
		Right	30	37	37	52	101	110	LOS_F	LOS_F	LOS_F
		Left	24	30	31	70	100	104	LOS_F	LOS_F	LOS_F
JF6	NB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
	SB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	0	0	LOS_A	LOS_A	LOS_A
JF7	NB	Right	2	6	8	0	0	0	LOS_A	LOS_A	LOS_A
		Left	2	6	8	66	290	295	LOS_F	LOS_F	LOS_F
		Through	2	7	8	47	228	230	LOS_E	LOS_F	LOS_F
	WB	Left	65	192	180	0	0	0	LOS_A	LOS_A	LOS_A
		Through	65	192	180	118	228	242	LOS_F	LOS_F	LOS_F
		Right	65	192	180	163	257	260	LOS_F	LOS_F	LOS_F
	EB	Right	1	1	1	1	2	3	LOS_A	LOS_A	LOS_A
		Through	1	1	1	1	2	5	LOS_A	LOS_A	LOS_A
		Left	1	0	1	37	40	41	LOS_E	LOS_E	LOS_E

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	SB	Through	0	0	0	2	4	6	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 6: Level of Service for Base Model – Contractor Commercial Port A and Contractor Inland Storage Yard - PM Peak (2019) and Projected Model - Contractor Commercial Port A and Contractor Inland Storage Yard PM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
JFL1	NB	Through	0	55	55	0	0	12	LOS_A	LOS_A	LOS_B
		Right	0	58	58	0	40	45	LOS_A	LOS_E	LOS_E
		Left	0	62	62	1	1	1	LOS_A	LOS_A	LOS_A
	SB	Left	0	186	207	0	107	140	LOS_A	LOS_F	LOS_F
		Right	0	56	62	0	40	41	LOS_A	LOS_E	LOS_E
	WB	Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	2	3	9	LOS_A	LOS_A	LOS_A
	EB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	2	7	10	101	110	LOS_B	LOS_F	LOS_F
JFL2	WB	Right	2	107	145	9	97	111	LOS_A	LOS_F	LOS_F
		Left	1	102	139	3	115	120	LOS_A	LOS_F	LOS_F
	SB	Left	0	46	84	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	38	46	0	63	82	LOS_A	LOS_F	LOS_F
	NB	Right	1	50	58	7	35	40	LOS_A	LOS_D	LOS_E
		Through	1	50	57	1	15	17	LOS_A	LOS_C	LOS_C
JFL3	WB	Left	0	1	3	0	10	15	LOS_A	LOS_B	LOS_B
		Right	0	0	3	5	5	16	LOS_A	LOS_A	LOS_B
	NB	Right	0	3	21	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	3	21	1	2	10	LOS_A	LOS_A	LOS_A
	SB	Left	0	93	114	0	73	79	LOS_A	LOS_F	LOS_F
		Through	0	93	114	0	44	57	LOS_A	LOS_E	LOS_F
JFL4	SB	Left	0	38	51	8	27	37	LOS_A	LOS_D	LOS_E
		Through	0	38	51	10	30	44	LOS_B	LOS_D	LOS_E
	NB	Through	0	1	2	0	1	1	LOS_A	LOS_A	LOS_A
		Right	0	1	2	0	0	0	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
JF1	SB	Through	94	99	99	500+	700+	700+	LOS_F	LOS_F	LOS_F
		Right	94	99	99	500+	700+	700+	LOS_F	LOS_F	LOS_F
		Left	94	99	99	600+	700+	700+	LOS_F	LOS_F	LOS_F
	NB	Through	84	294	283	155	404	441	LOS_F	LOS_F	LOS_F
		Left	84	294	283	155	340	355	LOS_F	LOS_F	LOS_F
		Right	84	294	283	193	471	475	LOS_F	LOS_F	LOS_F
	EB	Left	39	371	379	33	80	83	LOS_C	LOS_F	LOS_F
		Right	39	371	379	30	130	135	LOS_C	LOS_F	LOS_F
		Through	39	371	379	31	185	190	LOS_C	LOS_F	LOS_F
	WB	Right	165	438	438	68	80	80	LOS_E	LOS_E	LOS_F
		Left	165	438	438	70	80	80	LOS_E	LOS_F	LOS_F
		Through	165	438	438	71	76	77	LOS_E	LOS_E	LOS_E
JF2	NB	Left	0	4	6	0	13	13	LOS_A	LOS_B	LOS_B
		Through	0	4	6	0	10	10	LOS_A	LOS_A	LOS_A
		Right	0	4	6	2	28	28	LOS_A	LOS_D	LOS_D
	SB	Through	0	18	18	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	18	18	3	314	320	LOS_A	LOS_F	LOS_F
		Left	0	18	18	0	122	125	LOS_A	LOS_F	LOS_F
	WB	Left	0	183	184	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	183	184	0	68	68	LOS_A	LOS_F	LOS_F
		Right	0	173	173	0	122	130	LOS_A	LOS_F	LOS_F
	EB	Right	1	372	394	3	79	86	LOS_A	LOS_F	LOS_F
		Left	2	374	385	2	76	78	LOS_A	LOS_F	LOS_F
		Through	2	374	385	5	60	63	LOS_A	LOS_F	LOS_F
JF3	SB	Left	0	1	1	9	38	40	LOS_A	LOS_E	LOS_E
		Right	0	1	1	3	20	20	LOS_A	LOS_C	LOS_C
	WB	Left	0	211	213	1	42	44	LOS_A	LOS_E	LOS_E

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	0	211	213	0	45	46	LOS_A	LOS_E	LOS_E
	EB	Right	0	12	9	4	17	20	LOS_A	LOS_C	LOS_C
		Through	0	12	9	1	6	8	LOS_A	LOS_A	LOS_A
JF4	WB	Right	0	144	145	1	29	32	LOS_A	LOS_D	LOS_D
		Through	0	144	145	0	35	35	LOS_A	LOS_E	LOS_E
		Left	0	144	145	1	11	20	LOS_A	LOS_B	LOS_C
	EB	Left	0	0	0	1	4	5	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	4	4	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	13	14	LOS_A	LOS_B	LOS_B
	NB	Through	0	28	29	4	80	82	LOS_A	LOS_F	LOS_F
		Right	0	27	28	11	120	120	LOS_B	LOS_F	LOS_F
		Left	0	27	28	3	94	100	LOS_A	LOS_F	LOS_F
JF6	NB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	6	LOS_A	LOS_A	LOS_A
	SB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
JF7	NB	Right	0	1	2	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	1	2	2	55	69	LOS_A	LOS_F	LOS_F
		Through	0	1	2	1	26	48	LOS_A	LOS_D	LOS_E
	WB	Left	0	20	48	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	20	48	1	51	63	LOS_A	LOS_F	LOS_F
		Right	0	20	48	1	58	65	LOS_A	LOS_F	LOS_F
	EB	Right	0	2	0	1	0	0	LOS_A	LOS_A	LOS_A
		Through	0	2	0	0	5	8	LOS_A	LOS_A	LOS_A
		Left	0	2	0	1	65	66	LOS_A	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	SB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Contractor Shorebase B

Figure 5: Contractor Shorebase B location and corresponding study intersections

- *JFS 1 - Water Street at Hadfield Street*
- *JFS 2 - Lombad Street at Hadfield Street*
- *JFS 3 - Water Street at Brickdam*
- *JFS 4 - Lombard/Cornhill at Brickdam*
- *JFS 5 - Avenue of the Republic at Brickdam*
- *JFS 6 - Croal Street at Water Street*
- *JFS 7 - Croal Street at London Street*
- *JFS 8 - Hinck Street at Commerce Street*
- *JFS 9 - Avenue of the Republic at Croal Street*
- *JFS 10 - Water Street at Commerce Street*
- *JFS 11 - London Street and Hinck Street at Commerce Street*
- *JFS 12 - Avenue of the Republic at Commerce Street*
- *JFS 13 - Water Street at Robb Street*
- *JFS 14 - Robb Street*
- *JFS 15 - Robb Street at Avenue of the Republic*

Base Model - 2019

This location includes the Stabroek Market as well as a concentration of government buildings and business places. It is therefore characterized by the following:

- High pedestrian volumes and movements that hinder vehicular traffic flows.
- Roadside vending and commercial activity that restrict capacity of the sidewalk and hinder traffic flows.
- Multiple minibus and taxi stand operations that interrupt the free flow of traffic.

Due to these activities, a few intersections in the immediate vicinity of the market experience high delays. In the AM Peak, 2 out of the 15 study intersections and 5 out of the 15 study intersections in the PM peak experience at least one turning movement with an unacceptable LOS. These approaches are characterized by long queues, standstill traffic and high delays. Aside from these intersections the intersections outside of the immediate market are predicted to operate at acceptable LOS for both the AM and PM peak. Traffic police officers are frequently required to control operations at the signalised intersections.

Projected Model - 2026

The demand is greater in 2026 but the LOS is seen to generally remain the same. The intersections closest to the market show consistent, unacceptable LOS while the areas outside of the immediate market area generally remain at an acceptable LOS. The signalised intersections (JFS56 and JFS9) were already performing at unacceptable service levels and with the increased demand, the spill over to the surrounding intersections is greater. The signalized intersections have not been optimised to service the additional volumes projected in 2026.

LOS delay analysis indicates that there are minor impacts on capacity at the Contractor Shorebase B location due to the additional projected development trips in 2026. The minor impacts are due to a road network that is already performing at unsatisfactory LOS at several intersections. The trips projected to be generated by the development are relatively small compared to the existing traffic volumes and generally do not result in substantial further deterioration of performance at the associated intersections. The results for the Contractor Shorebase B location are provided in Tables 7 and 8.

Table 7: Level of Service for Base Model – Contractor Shorebase B AM Peak (2019) and Projected Model - Contractor Shorebase B AM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
JFS1	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	2	1	LOS_A	LOS_A	LOS_A
JFS2	NB	Right	1	17	16	3	12	15	LOS_A	LOS_B	LOS_B
		Left	2	20	20	4	15	17	LOS_A	LOS_C	LOS_C
	SB	Left	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
		Right	0	0	0	2	3	2	LOS_A	LOS_A	LOS_A
JFS3	EB	Through	12	27	30	18	39	40	LOS_C	LOS_E	LOS_E
		Left	14	32	36	16	26	29	LOS_C	LOS_D	LOS_D
	NB	Right	0	0	0	3	21	23	LOS_A	LOS_C	LOS_C
		Through	0	0	0	6	6	8	LOS_A	LOS_A	LOS_A
	WB	Right	0	0	0	3	3	4	LOS_A	LOS_A	LOS_A
JFS4	EB	Right	19	32	34	13	18	19	LOS_B	LOS_C	LOS_C
		Through	15	27	27	18	33	33	LOS_C	LOS_D	LOS_D
	WB	Left	0	0	0	2	3	3	LOS_A	LOS_A	LOS_A
	SB	Left	1	1	3	10	15	16	LOS_A	LOS_B	LOS_B
		Through	19	32	34	10	13	20	LOS_B	LOS_B	LOS_C
		Right	18	32	32	18	19	20	LOS_C	LOS_C	LOS_C
JFS5	NB	Right	201	204	206	107	110	114	LOS_F	LOS_F	LOS_F
		Left	201	204	206	372	328	343	LOS_F	LOS_F	LOS_F
		Through	201	204	206	238	251	258	LOS_F	LOS_F	LOS_F
	WB	Left	141	143	143	248	263	268	LOS_F	LOS_F	LOS_F
		U-Turn	141	143	143	486	493	498	LOS_F	LOS_F	LOS_F
		Through	141	143	143	319	378	379	LOS_F	LOS_F	LOS_F
		Right	141	143	143	353	413	423	LOS_F	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	EB	Right	85	95	95	141	154	165	LOS_F	LOS_F	LOS_F
		Through	85	95	95	142	154	168	LOS_F	LOS_F	LOS_F
		Left	85	95	95	47	53	59	LOS_D	LOS_D	LOS_E
	SB	Through	22	24	26	64	65	67	LOS_E	LOS_E	LOS_E
		Left	22	24	26	50	53	57	LOS_D	LOS_D	LOS_E
		Right	22	24	26	52	63	65	LOS_E	LOS_E	LOS_E
JFS6	NB	Through	3	3	4	8	7	11	LOS_A	LOS_A	LOS_B
	WB	Right	10	18	18	15	21	25	LOS_B	LOS_C	LOS_C
JFS7	WB	Left	59	65	81	32	34	50	LOS_D	LOS_D	LOS_F
		Through	59	65	81	34	39	48	LOS_D	LOS_E	LOS_E
	SB	Through	0	1	2	3	4	7	LOS_A	LOS_A	LOS_A
		Right	0	1	2	2	4	7	LOS_A	LOS_A	LOS_A
JFS8	EB	Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
JFS9	SB	Left	236	264	266	159	160	171	LOS_F	LOS_F	LOS_F
		Through	236	264	266	186	189	191	LOS_F	LOS_F	LOS_F
		Right	236	264	266	181	236	242	LOS_F	LOS_F	LOS_F
		U-Turn	236	264	266	0	0	0	LOS_A	LOS_A	LOS_A
	WB	U-Turn	100	115	119	106	221	234	LOS_F	LOS_F	LOS_F
		Left	100	115	119	228	270	272	LOS_F	LOS_F	LOS_F
		Through	100	115	119	128	211	215	LOS_F	LOS_F	LOS_F
		Right	100	115	119	117	202	205	LOS_F	LOS_F	LOS_F
	NB	Right	72	69	76	179	186	188	LOS_F	LOS_F	LOS_F
		Left	72	69	76	117	111	120	LOS_F	LOS_F	LOS_F
		Through	72	69	76	145	159	184	LOS_F	LOS_F	LOS_F
JFS10	NB	Left	3	3	6	1	2	3	LOS_A	LOS_A	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	SB	Right	3	4	7	3	5	7	LOS_A	LOS_A	LOS_A
		Through	3	3	6	1	2	3	LOS_A	LOS_A	LOS_A
		Right	1	4	8	11	12	20	LOS_B	LOS_B	LOS_C
		Left	1	3	7	3	5	9	LOS_A	LOS_A	LOS_A
JFS11	EB	Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
JFS12	EB	Left	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
JFS13	SB	Right	0	0	0	2	2	3	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	EB	Left	0	0	0	2	1	2	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	3	5	5	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
JFS14	EB	Left	0	0	0	2	3	3	LOS_A	LOS_A	LOS_A
		Through	0	0	0	1	2	3	LOS_A	LOS_A	LOS_A
JFS15	EB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 8: Level of Service for Base Model – Contractor Shorebase B PM Peak (2019) and Projected Model - Contractor Shorebase B PM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
JFS1	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
JFS2	NB	Right	0	5	5	2	6	7	LOS_A	LOS_A	LOS_A
		Left	0	6	6	2	8	8	LOS_A	LOS_A	LOS_A
	SB	Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	2	2	2	LOS_A	LOS_A	LOS_A
JFS3	EB	Through	34	36	37	88	89	92	LOS_F	LOS_F	LOS_F
		Left	39	41	44	20	25	26	LOS_D	LOS_D	LOS_D
	NB	Right	0	1	2	22	33	47	LOS_C	LOS_D	LOS_E
		Through	0	0	1	3	5	6	LOS_A	LOS_A	LOS_A
	WB	Right	0	0	1	3	7	14	LOS_A	LOS_A	LOS_B
JFS4	EB	Right	40	43	46	36	34	41	LOS_E	LOS_D	LOS_E
		Through	36	37	39	63	58	61	LOS_F	LOS_F	LOS_F
	WB	Left	0	0	0	3	3	2	LOS_A	LOS_A	LOS_A
	SB	Left	1	2	4	4	8	8	LOS_A	LOS_A	LOS_A
		Through	40	43	46	8	13	14	LOS_D	LOS_B	LOS_B
		Right	41	42	44	16	18	19	LOS_C	LOS_C	LOS_C
JFS5	NB	Right	196	199	198	123	124	128	LOS_F	LOS_F	LOS_F
		Left	196	199	198	199	201	208	LOS_F	LOS_F	LOS_F
		Through	196	199	198	146	148	15	LOS_F	LOS_F	LOS_F
	WB	Left	143	143	143	261	295	299	LOS_F	LOS_F	LOS_F
		U-Turn	143	143	143	0	0	0	LOS_A	LOS_A	LOS_A
		Through	143	143	143	348	356	375	LOS_F	LOS_F	LOS_F
		Right	143	143	143	323	340	360	LOS_F	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
	EB	Right	102	102	103	107	142	156	LOS_F	LOS_F	LOS_F
		Through	102	102	103	118	130	131	LOS_F	LOS_F	LOS_F
		Left	102	102	103	17	29	20	LOS_C	LOS_C	LOS_C
	SB	Through	54	56	59	900	97	99	LOS_F	LOS_F	LOS_E
		Left	54	56	59	83	88	90	LOS_F	LOS_F	LOS_F
		Right	54	56	59	110	110	115	LOS_F	LOS_F	LOS_F
JFS6	NB	Through	0	0	0	2	3	3	LOS_A	LOS_A	LOS_A
	WB	Right	5	5	5	3	4	5	LOS_A	LOS_A	LOS_A
JFS7	WB	Left	18	29	29	18	19	20	LOS_C	LOS_C	LOS_C
		Through	18	29	29	14	16	18	LOS_B	LOS_C	LOS_C
	SB	Through	0	0	0	0	3	3	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	2	LOS_A	LOS_A	LOS_A
JFS11	EB	Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
JFS9	SB	Left	249	266	267	180	191	200	LOS_F	LOS_F	LOS_F
		Through	249	266	267	205	220	232	LOS_F	LOS_F	LOS_F
		Right	249	266	267	193	194	198	LOS_F	LOS_F	LOS_F
		U-Turn	249	266	267	0	0	0	LOS_A	LOS_A	LOS_A
	WB	U-Turn	105	120	120	67	217	219	LOS_E	LOS_F	LOS_F
		Left	105	120	120	255	352	359	LOS_F	LOS_F	LOS_F
		Through	105	120	120	123	185	190	LOS_F	LOS_F	LOS_F
		Right	105	120	120	144	199	205	LOS_F	LOS_F	LOS_F
	NB	Right	105	120	120	181	240	245	LOS_F	LOS_F	LOS_F
		Left	44	45	46	49	57	60	LOS_D	LOS_E	LOS_E
		Through	44	45	46	57	57	60	LOS_E	LOS_E	LOS_E
JFS10	NB	Left	133	144	146	145	158	160	LOS_F	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Right	0	0	2	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	0	2	1	2	6	LOS_A	LOS_A	LOS_A
	SB	Right	0	0	2	1	1	1	LOS_A	LOS_A	LOS_A
		Left	1	1	2	7	8	12	LOS_A	LOS_A	LOS_B
JFS11	EB	Right	0	1	2	1	2	3	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	WB	Left	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
JFS12	EB	Left	0	0	0	0	1	0	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
JFS13	SB	Right	0	0	0	1	2	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	2	2	2	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	2	2	LOS_A	LOS_A	LOS_A
	EB	Left	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	2	2	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	2	5	4	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
JFS14	EB	Left	0	0	0	1	1	1	LOS_A	LOS_A	LOS_A
		Through	0	1	0	1	3	2	LOS_A	LOS_A	LOS_A
JFS15	EB	Left	0	1	0	2	4	3	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	NB	Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
		Right	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Ramada Intersection

Figure 6: Ramada Intersection location and corresponding study intersections

- *LP2 Point-Houston - East Bank Public Road at Houston Split*
- *LP2 Point-Eccles - East Bank Public Road at Eccles Intersection*
- *LP2 Point-DH Bridge - East Bank Public Road at the Demerara Harbour Bridge*
- *LP2 Point-Nandy Park - East Bank Public Road at Nandy Park Intersection*
- *LP2 Point-Massy - East Bank Public Road at Massy Intersection*

Base Model - 2019

At the Ramada Intersection location, the morning peak is characterized by vehicles heading into Georgetown as the dominant movement, with increasing delays as motorists approach Georgetown. The exception is LP2 Point - Nandy Park, which is a signalized intersection immediately downstream of another signalized intersection, Eccles. The low delays experienced at LP2 Point - Nandy Park, however, appear to be due to traffic metering by the signals at LP2 Point - Eccles, reducing the demand approaching LP2 Point - Nandy Park. Northbound vehicles soon re-join queues as they continue into Georgetown at LP2 Point - Houston. In essence, northbound movements experience queuing spillbacks and delays originating in Georgetown and reaching as far south as the Demerara Harbour Bridge in the morning peak period. This is reversed in the afternoon peak with southbound movements experiencing high delays from the Harbour Bridge, spilling back towards Georgetown.

Projected Model - 2026

The demand is greater than the capacity of several intersections in 2026 and as such the LOS is seen to move from acceptable in 2019 to unacceptable in 2026 for the majority of approaches at all study intersections, in both the AM and PM peak. The signalized intersections have not been optimised to service the additional volumes projected in 2026.

LOS delay analysis indicates that there are minor impacts on capacity at the Ramada Intersection due to the additional projected development trips in 2026. The minor impacts are due to a road network that is already performing at unsatisfactory LOS. The trips projected to be generated by the development are relatively small compared to the existing traffic volumes and generally do not result in substantial further deterioration of performance at the associated intersections.

Table 9: Level of Service for Base Model - Ramada Intersection AM Peak (2019) and Projected Model - Ramada Intersection AM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
Houston	SB	Through	60	497	500	8	173	152	LOS_A	LOS_F	LOS_F
	NB	Through (Ln3)	252	480	473	125	269	268	LOS_F	LOS_F	LOS_F
		Through	487	486	486	74	74	82	LOS_F	LOS_F	LOS_F
		Left	488	486	486	90	94	100	LOS_F	LOS_F	LOS_F
Eccles	NB	Through (Ln3)	27	37	301	25	28	72	LOS_C	LOS_C	LOS_E
		Right	27	37	301	60	48	77	LOS_E	LOS_D	LOS_E
	WB	Right	27	491	487	51	221	199	LOS_D	LOS_F	LOS_F
		Left	27	491	487	50	236	221	LOS_D	LOS_F	LOS_F
	NB	Through (Ln3)	49	433	449	34	84	96	LOS_C	LOS_F	LOS_F
		Through	56	427	441	30	86	95	LOS_C	LOS_F	LOS_F
	SB	Left	0	0	0	50	198	109	LOS_D	LOS_F	LOS_F
		Through	460	491	480	89	355	189	LOS_F	LOS_F	LOS_F
HB	EB	Right	29	496	472	53	227	239	LOS_F	LOS_F	LOS_F
		Left	28	496	472	14	100	114	LOS_B	LOS_F	LOS_F
	NB	U-Turn	1	495	447	0	0	0	LOS_A	LOS_A	LOS_A
		Through (Ln3)	11	155	141	13	35	39	LOS_B	LOS_E	LOS_E
		Left	8	144	144	5	46	51	LOS_A	LOS_E	LOS_F
		Through	5	319	295	4	52	51	LOS_A	LOS_F	LOS_F
	SB	Through	468	494	485	74	192	113	LOS_F	LOS_F	LOS_F
		Right	468	495	485	108	286	195	LOS_F	LOS_F	LOS_F
		U-Turn	468	495	485	133	284	219	LOS_F	LOS_F	LOS_F
Nandy Park	NB	Through	0	337	346	1	43	48	LOS_A	LOS_E	LOS_E
		U-Turn	1	356	365	0	0	0	LOS_A	LOS_A	LOS_A
		Right	1	355	365	3	35	44	LOS_A	LOS_D	LOS_E
	SB	U-Turn	0	1	0	2	14	10	LOS_A	LOS_B	LOS_A

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	1	1	2	LOS_A	LOS_A	LOS_A
	WB	Right	0	1	3	4	40	44	LOS_A	LOS_E	LOS_E
		Left	0	0	3	1	2	15	LOS_A	LOS_A	LOS_C
Massy	NB	Through	0	214	262	0	30	27	LOS_A	LOS_D	LOS_D
		Right	0	216	265	1	10	28	LOS_A	LOS_B	LOS_D
		U-Turn	0	216	266	2	43	34	LOS_A	LOS_E	LOS_D
	SB	U-Turn	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	2	3	5	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	1	1	LOS_A	LOS_A	LOS_A
	WB	Right	0	13	6	5	74	37	LOS_A	LOS_F	LOS_E
		U-Turn	0	7	2	0	75	10	LOS_A	LOS_F	LOS_A
		Left	0	13	6	1	47	16	LOS_A	LOS_E	LOS_C

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 10: Level of Service for Base Model - Ramada Intersection PM Peak (2019) and Projected Model - Ramada Intersection PM Peak (2026 without projected development trips and 2026 with projected development trips)

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
Houston	SB	Through	0	339	332	0	69	78	LOS_A	LOS_F	LOS_F
	NB	Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
		Left	0	0	0	0	0	1	LOS_A	LOS_A	LOS_A
Eccles	WB	Right	13	63	139	36	72	93	LOS_D	LOS_E	LOS_F
		Left	13	63	139	36	98	143	LOS_D	LOS_F	LOS_F
	NB	Right	321	378	385	44	45	45	LOS_D	LOS_D	LOS_D
		Through	321	377	386	17	17	16	LOS_B	LOS_B	LOS_B
	SB	Left	159	488	488	19	114	120	LOS_B	LOS_F	LOS_F
		Through	188	488	488	73	186	199	LOS_E	LOS_F	LOS_F
HB	EB	Right	433	377	371	36	195	230	LOS_E	LOS_F	LOS_F
		Left	427	370	364	1	42	42	LOS_A	LOS_E	LOS_E
	NB	Left	36	220	221	21	79	81	LOS_C	LOS_F	LOS_F
		Through	36	220	221	25	100	104	LOS_C	LOS_F	LOS_F
	SB	Through	403	496	491	39	46	54	LOS_E	LOS_E	LOS_F
		Right	408	497	492	247	264	271	LOS_F	LOS_F	LOS_F
Nandy Park	NB	Through	0	428	428	1	134	139	LOS_A	LOS_F	LOS_F
		U-Turn	0	448	448	0	0	0	LOS_A	LOS_A	LOS_A
		Right	0	448	448	6	133	135	LOS_A	LOS_F	LOS_F
	SB	U-Turn	1	33	52	3	53	101	LOS_A	LOS_F	LOS_F
		Through	0	26	46	1	16	27	LOS_A	LOS_C	LOS_D
		Left	0	33	52	1	5	31	LOS_A	LOS_A	LOS_D
	WB	Right	1	48	52	9	230	388	LOS_A	LOS_F	LOS_F
		Left	1	48	52	13	186	303	LOS_B	LOS_F	LOS_F
Massy	NB	Through	0	416	414	0	121	122	LOS_A	LOS_F	LOS_F
		Right	0	418	417	7	125	118	LOS_A	LOS_F	LOS_F

Site	Direction	Movement	Queue Length			Delay			LOS		
			2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips	2019 Base	2026	2026 + Trips
		U-Turn	0	419	418	2	109	119	LOS_A	LOS_F	LOS_F
	SB	U-Turn	0	0	0	6	10	0	LOS_A	LOS_B	LOS_A
		Left	0	0	0	1	0	1	LOS_A	LOS_A	LOS_A
		Through	0	0	0	0	0	0	LOS_A	LOS_A	LOS_A
	WB	Right	1	164	199	9	311	430	LOS_A	LOS_F	LOS_F
		U-Turn	0	154	189	0	310	488	LOS_A	LOS_F	LOS_F
		Left	1	163	198	4	302	475	LOS_A	LOS_F	LOS_F

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2026 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2026 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Discussion

Comparison of modelled LOS values between the "without development" and "with development" scenarios indicated that the additional projected development trips in 2026 will generally result in minimal changes to conditions on the existing road networks. This is due to the low percentage increase (relative to projected "without development" conditions) associated with the additional projected development trips.

Projecting the increased "without development" volumes to 2026 using a 5% growth factor results in an increase in demand and oversaturation of the road network at many intersections. This is seen in the deterioration of LOS at many intersections, particularly the signalised intersections with traffic signal timing that hasn't been optimised to efficiently service the extended queues. The prominence of high delays and extended queues at many intersections has a domino effect on the surrounding intersections, resulting in spillbacks, making it difficult for vehicles to traverse consecutive intersections uninterrupted. The analysis with the projected development trips in 2026 appears to show unsatisfactory LOS at a number of intersections. However, the assumed growth in non-development traffic volume on its own, appears to be the primary driver for the poor LOS in the majority of cases.

The growth rate utilized in this, and previous analyses has been 5%. This was the expected growth rate prior to the current pandemic and so can be considered the upper limit of what the estimated growth rate should be. Assuming that pre-pandemic conditions will exist by 2026 and that growth may spike considerably during the period, the upper limit may be considered practical for estimating purposes. The most important consideration in this analysis is, therefore, the state of current (pre-pandemic) traffic conditions of the network and the natural growth progression to 2026. In this context, it is predicted that the development will contribute minimally to the already unsatisfactory conditions in many intersections around Georgetown. EEPGL must then seek to adopt internal operational policies to facilitate the most efficient movements for its vehicles at the respective locations.

When undertaking analysis of a network of intersections where heavy flows occur in one main direction, it is expected that users of minor roads will experience poor LOS and high delays in attempting to traverse a common intersection. This is more so the case when dealing with unsignalised intersections. However, additional traffic on the major road segment may result in a reduction in vehicle flows and a slowing down of traffic at the intersection. There comes a point where the increased congestion creates more gaps in the traffic stream, allowing a greater volume of minor road users to access or cross the major road. Model

analysis results of queue length, delay, and LOS may therefore in some cases appear to show improved flows for minor roads with the addition of vehicles to the intersection. However, this is to be taken into context of the entire intersection, where overall delay is increased.

This concept also applies to a dense, connected network of intersections, where vehicles spilling back into upstream intersections create gaps in the minor and/or opposite directions, giving the appearance of improved operations.

Some of the existing road networks observed were characterised by less-than-ideal conditions, in particular the signalised intersections. It was observed that at all the signalised intersections included in the study, police officers were present during peak periods to regulate traffic and alleviate congestion at the intersections. The high delays and unacceptable **LOS** ratings for these intersections indicate a need to optimise signal timings to allow for more efficient operations at the intersection and network levels. The following is therefore noted:

- The Contractor Shorebase B location is in an area where there is a high level of activity that directly affects traffic flows, resulting in substantial delays on the surrounding streets and spill over congestion into several major intersections.
- The Ramada Intersection location features high levels of northbound traffic into Georgetown in the morning and the reverse in the afternoon, resulting in significant delay and congestion (i.e., unacceptable **LOS**).
- The EEPGL Office Complex / OGL location shows high volumes of east-west traffic as vehicles go to and from Georgetown. The signalized intersection is observed to not efficiently handle the elevated volumes.
- Some of the high volumes from the EEPGL Office Complex / Ogle location lead into the Marriott location and result in excessive delay, especially at the signalized M11 intersection. The spillbacks from M11 then affect M3, M7 and M10 in the AM Peak and M7 in the PM Peak.

Conclusion

The additional projected development trips are not predicted to significantly alter the traffic congestion conditions at the study intersections.

In general, the numbers of additional projected development trips at the study intersections are relatively small compared to projected non-development base traffic volumes (assuming a 5 percent annual growth rate in non-development traffic volumes). The road network in the vicinity of some of the study intersections is characterized by high levels of base congestion due to limited road capacity, sub-optimal signal timing, and/or excessive vehicle demand. It is noted, however, that even in these areas, the additional projected development trips are generally not predicted to contribute significantly to worsening congestion. It is also noted that the analysis was based on an upper-limit assumption of projected traffic growth to 2026 and as such, represents a reasonable "worst-case scenario" for traffic operations in 2026. Further, for the purpose of modelling, the additional development trips were assumed to occur during peak periods. Given the likelihood that a portion of these trips may occur outside of peak hours, further reduction of the already minimal projected impacts is expected.

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APPENDIX U

Stakeholder Comments

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Table 1: Responses to Consultants Comments on Yellowtail EIA Review (18 February 2022)

Comment	Date	Stakeholder	Comment	Response	EIA Edit?	EPA Response	Consultant Response	Page Numbers with EIA Edit
1	09-Dec-2021	EPA	**General Comments** Please note in the EIA Section 3 is assigned to both Administrative Framework and Project Impacts. Additionally, the table of contents has Section 3 Administrative Framework with no reference to Project Impacts. Conversely, the executive Summary has Section 3 labelled as Project Impacts with no mention of Administrative Framework. Kindly review and provide clarity.	While the Environmental Impact Statement (EIS) provides a summary of the Environmental Impact Assessment (EIA), the sections of the EIS and the chapters in the EIA do not align numerically. For example, EIS Section 3 summarizes Project impacts, and Project impacts are addressed in Chapters 6 through 10 of the EIA. Chapter 3 of the EIA describes the Administrative Framework applicable to the Project.	No	Accepted	N/A	N/A
2	09-Dec-2021	EPA	What will be done with the sulphate removed from the sea water in the sea water treatment? What/how are the residues resulting from the treatment of seawater e.g sulphates managed or disposed	Sulfates removed from seawater prior to injection of seawater into the reservoir would be contained in the Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines effluent stream that would be discharged from the Floating Production, Storage, and Offloading (FPSO) vessel. Sulfate removal is discussed in Section 2.18.3.6, Seawater Treatment, and explained in detail in Sections 2.13.3., Discharges, and 2.18.3.6. Modeling of this discharge stream (documented in Appendix C, Water Quality Modeling Report, in Volume II of the EIA) predicts that this effluent stream would decrease in concentration by more than 98 percent within 100 meters (328.1 feet) of the discharge point.	No	Accepted	N/A	N/A
3	09-Dec-2021	EPA	**Section 2: Project Description** **2.3. Project Workforce. Page 119** There was no mention of Protected Species Observers as a part of the workforce.? Is this expected as part of the full-time work force? Or only for specific activities e.g seismic.	Section 2.3, Project Workforce, has been edited to reflect the fact that Protected Species Observers (PSOs) would provide support to the Project.	Yes	Accepted	N/A	p. 2-10
4	09-Dec-2021	EPA	**2.5.4. Well Control. Page 131** The EIA mentions personnel training and proficiency drills are to be conducted. Kindly provide more details. Kindly provide more details on specific training, requirements and frequency?	EEPGL conducts well-control training and drills to build drilling crew proficiency, specifically as it relates to detecting and efficiently responding to a potential influx. Drilling-crew leadership positions (e.g., toolpusher, driller, assistant driller) complete accredited classroom-based well control training commensurate with industry standards and drilling contractor internal requirements. Well-control drills are held on each drill ship with each drilling crew to reinforce training and build operational proficiency. With respect to EEPGL operations in Guyana, well-control drills include, but are not necessarily limited to, pit drills, trip drills, power choke drills, and emergency disconnect / hang-off drills. These drills are performed at regular intervals over the course of operations. Pit drills are conducted to reduce the time required for the drilling crew to detect and respond to a potential influx while drilling. Trip drills are conducted to reduce the time required for the drilling crew to detect and respond to a potential influx while running or retrieving pipe from the well. Power choke drills are conducted to provide drilling crew members practice in operating the rig chokes, as would be used during an influx circulation. Emergency disconnect / hang-off drills are conducted to provide the drillers practice in simulating the rig-specific emergency	Yes	Accepted	N/A	p. 2-22

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				disconnect sequence procedure, as would be implemented during an emergency disconnect event.				
5	09-Dec-2021	EPA	**2.7.1. General Description. Page 141** There was no mention of a safe limit for daily production. The EIA must also clearly identify the maximum production capacity of the rig within the prescribed safety limits for the vessel.	The FPSO design rates described in Table 2.7-1: FPSO Key Design Rates are annual averages, and daily peak rates could be higher during the lifetime of the Project, depending on multiple factors (e.g., reservoir pressure, number of wells, equipment reliability). Currently, the FPSO basic design has an upper production limit of 263,000 barrels per day (BPD) (42,080 cubic meters [m^3] per day) peak oil production rate, and the FPSO would be able to operate safely at this limit. The current production profile forecasts that the peak annual average rate for oil production would occur in approximately 2027. As the wells are drilled and early production is assessed, the production would continue to be optimized, and the timing to achieve peak production levels may vary from the current estimate. If during the detailed design stage or during production operations an opportunity to expand the upper production limit arises, the Project would document the evaluation and justification and an updated upper production limit would be available. This evaluation would include assessment of the potential for changes to the conclusions of the EIA.	Yes	Accepted	N/A	p. 2-33
6	09-Dec-2021	EPA	**Section 2.10.2 Hydrogen Sulfide Management. Page 177** There was mention made regarding training for handling Hydrogen Sulfide. What is the validity period for training? Is it a one-off session or will it be a continuous training regime that needs to be updated at increments?	The concentration of hydrogen sulfide (H_2S) would be negligible for the initial stage (i.e., 1 to 5 years) of production operations. H_2S would be monitored at various points throughout the facility to detect any increase in H_2S concentration. This would be outlined in sampling programs before field start-up. The monitoring program would be detailed in a written procedure. In the event that H_2S concentrations would increase to a level that could represent potential health or safety concerns for the Project's offshore workforce, H_2S initial training would be conducted for potentially affected workers, and refresher training would be conducted on an annual basis. The H_2S monitoring plans would be included in the facilities surveillance and operational manuals for chemical vendors. Both of these surveillance plans would be finalized before production start-up.	Yes	Accepted However, upon completion the H2S management plan should be made available to the Agency.	N/A	p. 2-69
7	09-Dec-2021	EPA	**Section 2.13-5 Estimated Annual Atmospheric Emissions Summary Table Footnote Page: 196** Does the current preliminary schedule take in to account all other projects that are in operation? If no, why not?	Table 2.13-5 provides estimated annual atmospheric emissions for only the Yellowtail Development Project. Estimated annual atmospheric emissions for the full suite of EEPGL activities reflected in the cumulative air dispersion modeling scenario (i.e., Liza Phase 1, Liza Phase 2, Payara, Yellowtail, FPSO #5, FPSO #6, and exploration drilling) are summarized in Table 2-4 of the Emissions Inventory and Air Quality Modeling Report (included as Appendix G in Volume II of the EIA).	No	Accepted	N/A	N/A
8	09-Dec-2021	EPA	**2.13.1. Materials Inventory. Page 189** The EIA makes multiple reference to international best practices and standards that will be utilize in the operations. However, the list provided seems to be limited. As such please state/list all the environmental standards and international best practices that will be utilised.	Table 2.4-1 in the Environmental and Socioeconomic Management Plan (ESMP)—included in Volume III of the EIA—provides a summary of key environmental and socioeconomic performance criteria the Project would utilize. These performance criteria are consistent with good international oilfield practice.	No	Accepted	N/A	N/A

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9	09-Dec-2021	EPA	**Section 2.13.5. Radiation Emission Sources. Page 202.** The section highlighted that the project will follow good international oilfield practices…. to NORM or radiography sources. The section further discussed NORM, however there was no indication of EEPGL's role in the event of failed operation procedures. Failed operational procedures including breakage of source assembly, inadequate monitoring and failure to connect safety systems.	EEPGL and its contractors would adhere to a number of procedures that are in place to manage radioactive sources such as the use of multiphase flow meters, etc. These procedures would include the following: • API 17S Recommended Practice for the Design, Testing, and Operation of Subsea Multiphase Flow Meters • IAEA TS-R-1 Regulations for the Safe Transport of Radioactive Material • BSI BS EN ISO 361 Basic Ionizing Radiation Symbol • EP-HSE-PMS-SAF-SAF.GRP.INS.0059.ENG, Radiation Management Each FPSO has a Radiation Safety Officer, who is responsible for overseeing implementation of the above procedures. The information above has been added to EIA Section 2.13.5, Radiation Emission Sources.	Yes	Accepted	N/A	p. 2-99
10	09-Dec-2021	EPA	**2.18.2.4. Associated Gas Management Alternatives** Please specify what is meant by the gas compression required is considerable. Could it be quantified? If so, please state the quantities.	Gas re-injection pressure for the Yellowtail field would be expected to be no more than 8,200 pounds per square inch gauge (psig), as measured at the top of the gas injection risers on the FPSO. This pressure would be similar to that required for prior Guyana development projects. This information has been added to Section 2.18.2.4, Associated Gas Management Alternatives.	Yes	Accepted	N/A	p. 2-118
11	09-Dec-2021	EPA	**Section 5.2 Resources/Receptors Assessed in the EIA.** **Section 5.2.2. Assessment of Potential for Acoustic Impacts from Vessel Noise in Georgetown Harbour. Page 340.** Consultants conducted a screening level analysis and literature review. The EIA should indicate possible long-term noise exposure (irreversible). The section did not provide details of noise levels which can lead to annoyance and sleep disturbance. These effects are considered stressors and should be researched.	The predicted noise levels associated with the Project at the nearest residential portion of Vreed-en-Hoop are provided in Table 5.2-3. These noise levels were compared against recently adopted day/night noise guidelines and were estimated to be below these guidelines. Two additional noise recommendations that have been developed by other organizations to be protective of residential uses (including sleep disturbance and annoyance) are 55 dBA (A-weighted decibels) L_{dn} (day-night sound level), which is the noise level recommended by the U.S. Environmental Protection Agency (USEPA) for environmental noise to be protective of residential and other noise sensitive land uses, and 45 dBA L_{eq} (equivalent sound level), which is the most protective nighttime noise level recommended by the International Finance Corporation (IFC) for residential, institutional, and educational uses. The predicted Project noise levels in Table 5.2-3 are more than 10 decibels lower than the USEPA and IFC noise level recommendations, meaning that the predicted noise levels are less than half the applicable thresholds recommended by the USEPA and IFC (because decibels are calculated on a logarithmic scale). Therefore, noise levels associated with vessel traffic would not be anticipated to lead to annoyance or sleep disturbance or long-term/irreversible detrimental effects. EIA Section 5.2.2, Assessment of Potential for Acoustic Impacts from Vessel Noise in Georgetown Harbour, has been updated to include this information.	Yes	Accepted	N/A	p. 5-27
12	09-Dec-2021	EPA	**Section: Project Impacts** **Specific Comments** **3.1.1. Air Quality, Climate, and Climate Change. Page 63.** • Reference is made to "applicable guidelines", these "guidelines should be specified within the text.	1. The applicable guidelines referenced in EIS Section 3.1.1, Air Quality, Climate, and Climate Change, refer to the combined set of guidelines established by the World Health Organization (WHO) and the USEPA that are presented in EIA Section 6.1.1, Administrative Framework—Air Quality, Climate, and Climate Change. 2. Based on published corporate plans, EEPGL and its affiliates support the goals of the 2015 Paris Agreement and efforts of global Nationally Determined Contributions to achieve net-zero emissions, and have made meaningful progress, globally, in reducing greenhouse gas (GHG)	1. No 2. Yes 3. Yes 4. No	1 Accepted 2 Please specify the section 3 Accepted	2. A reference to the subject information has been added to the EIA in Section 6.1.4.	2. p. 6-45 3. p. 2-33

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			• Given the outcomes of the recent COP 26 will EEPGL establish specific GHG targets in the absence of national regulatory criteria as part of their Corporate Social Responsibility? • The EIA highlighted that "non-routine flaring will be used to combust associated gas when not consumed as fuel gas on the FPSO or injected back into the reservoir." Provide projections of the quantity or percentage (min-max range) of gas that will be consumed as fuel gas or injected into the reservoir. • The assessment indicated that "*the Project has applied technologies aligned with good international oilfield practice to reduce GHG emissions*." Clearly outline the applied technologies to be implemented with this project.	emissions. In this regard, ExxonMobil affiliates are reported to be on track, collectively, to meet the 2025 GHG emission-reduction plans announced by ExxonMobil in December 2020, and ExxonMobil anticipates year-end 2021 results to show a reduction of 15 to 20% in GHG intensity from its upstream operations, as compared to 2016 levels - four years ahead of schedule. This is supported by an anticipated reduction of 40 to 50% in methane intensity and 35 to 45% in flaring intensity compared to 2016. ExxonMobil's recently announced GHG reduction plans for 2030 are consistent with Paris Agreement-aligned pathways and include reductions in Scope 1 and Scope 2 GHG emissions from assets operated by ExxonMobil affiliates by the end of 2030, as compared to 2016 levels. ExxonMobil has also reaffirmed plans to achieve the goals of the World Bank for Zero Routine Flaring by 2030. A reference to this information has been added to the EIA. The Yellowtail Project has been designed to incorporate a number of embedded controls that would serve to reduce GHG emissions from Project sources, and EEPGL would leverage its expertise to identify potential opportunities to optimize operations and further lower GHG emissions. As with previous developments, EEPGL has indicated its willingness to continue to engage with governmental stakeholders regarding GHG emissions in keeping with its corporate commitment to minimizing environmental impacts. 3. The gas injection rate is approximately the gas production rate minus the estimated fuel gas demand. A fuel gas consumption estimate of 35 million standard cubic feet per day (MMscfd) (0.99 million standard cubic meters per day [MMsm^3/d]) is used in the current forecast. This estimate may be adjusted during detailed design, and may vary over the Project life cycle. As detailed in EIA Table 2.7-1 (FPSO Key Design Rates), the design maximum annual average gas production rate would be 450 MMscfd (12.7 MMsm^3/d); accordingly, the design maximum annual average gas injection design rate would be 415 MMscfd (11.8 MMsm^3/d) (i.e., when the estimated 35 MMscfd (0.99 MMsm^3/d) fuel gas consumption is subtracted). Table 2.7-1 has been edited to reflect this additional detail, and additional text has been added to the EIA explaining the conditions that could lead to a different consumption of fuel gas rate compared to that provided in the EIA. Currently, the FPSO basic design has an upper gas injection limit of 439 MMscfd (12.4 MMsm^3/d) as a peak gas injection rate and a peak gas production of 474 MMscfd (13.4 MMsm^3/d) as peak gas production. If during the detailed design stage or during production operations an opportunity to expand the upper production limit arises, the Project would document the evaluation and justification and an updated upper production limit and gas injection would be available. This would include assessment of the potential for changes to the conclusions of the EIA. 4. The Project has been inherently designed to incorporate a number of embedded controls and mitigation measures that would serve to reduce GHG emissions, as well as criteria air pollutant emissions, from Project sources. EIA Tables 6.1-14 and 6.1-15 include a summary of these embedded controls and mitigation measures, respectively.				
13	09-Dec-2021	EPA	**Section 3.1.3. Marine Geology/Sediments and Marine Benthos. Page 22.** The document states that the significance of potential impacts on	Age-dating of sediments was conducted for the neighboring Liza field, and this indicated that localized small-scale failures likely occurred intermittently up until approximately 4,000 years ago. The age-dating indicated that large-scale failures along sediment transport pathways likely occurred up until approximately 25,000 years ago, and are unlikely to occur again due to the	Yes	Accepted	N/A	p. 2-112

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			marine benthos and sediment from FPSO and Surf installation will be negligible. However, there is little to no mention of how the drilling of wells, and the placement of various subsea equipment will be impacted by the already naturally changing seabed, and changes from sediment accumulation of metals found within the seabed from discharged drill cuttings. Please state if there is potential for these activities to impact the above mention activities? Also, what mitigation / alternative measures will be put in place to address the potential impacts of the changing seafloor on the drilling of wells, and the placement of various subsea equipment?	absence of major failure triggering mechanisms. Similar age-dating is planned in the Yellowtail field prior to installation of subsea infrastructure. It is expected that the chronological event timing for small-scale and large-scale failures in the Yellowtail field, to the extent these are identified, would be similar to that of the Liza field; this would indicate such failures would also be unlikely in the Yellowtail field. Additionally, potential seafloor instabilities, such as slope instability, have already been mapped in the Yellowtail field based on geophysical studies, and the results of this mapping have been incorporated in the Yellowtail design process for subsea infrastructure. The primary mitigation strategy based on these data has been adjustment of the subsea infrastructure layout to avoid features with slope stability concerns where possible. Interpretation of additional geotechnical study data (ongoing as of the time of the EIA) will provide further data regarding potential slope stability concerns, and the subsea infrastructure would be further adjusted, as needed, based on the review of these data. EEPGL is in the process of collecting these additional data to corroborate the current expectation that the last movement occurred sufficiently long ago that further movement of the seabed is not anticipated within the design life of the Project. Additional detail on slope stability analysis and strategies to address related concerns has been added to EIA Section 2.18.1, Location Alternatives. Drill cuttings deposition would not pose a risk to the structural integrity of the Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment. In the case that there would be slight accumulations of cuttings in the vicinity of the SURF, remotely-operated vehicles (ROVs) with high-pressure pumps could be used to jet the cuttings away from the equipment, if needed.				
14	09-Dec-2021	EPA	**Section 3.1.6: Marine Mammals (including Status Species), page 23:** Please indicate: • What would be the duration and level of noise these marine mammals be exposed to? • Has there been any research/baseline done on the maximum limits and duration of sound/noise these marine mammals can be exposed to?	The duration and level of noise to which marine mammals would be exposed depends on the duration and nature of the noise-generating activity. Marine mammals could potentially be exposed to impulsive (instantaneous) noise on a short-term periodic basis during the drilling and installation phase and to comparatively low levels of non-impulsive (continuous) noise during all phases of the Project. Impulsive noise to which mammals could be exposed would not exceed 220 dB re 1 µPa². Non-impulsive noise exposure would not exceed 180 dB re 1 µPa². These maxima have been added to the text in EIA Section 7.5.3, Impact Assessment—Marine Mammals. Please refer to Section 7.5.3 for an explanation of the appropriate exposure thresholds for marine mammals. The Southall et al. (2007) and Finneran (2015) thresholds referenced in Figures 7.5-8 and 7.5-9 and subsequent discussions in that section represent widely accepted thresholds for acoustic injury.	Yes	Accepted	N/A	p. 7-120
15	09-Dec-2021	EPA	**Section 3.2.3: Discharge of Untreated Wastewater from FPSO. Page 30**: "*While there will be a number of controls to prevent a discharge of untreated black water to the ocean, an upset to this treatment system lasting for an extended period could result in untreated black water being*	EIA Section 9.1.11, Discharge of Untreated Wastewater from the FPSO, states that the FPSO design includes a large storage tank with capacity to store up to 7 days of sewage in the event of an upset to the treatment system and that, in the unlikely event of an upset to this treatment system lasting more than 7 days, this could result in untreated black water being discharged overboard for a short period. Section 9.1.11 has been edited to reflect that, in the event it is determined that the sewage treatment plant is not operating properly and wastewater is temporarily discharged outside of specification limits, the wastewater stream would be redirected to the black water holding tank and, if the treatment system could not be repaired within 7 days, alternative means of managing	Yes	Accepted	N/A	p. 9-99

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			discharged overboard for a short period of time." Please indicate: What is the course of action to be taken in the event that there is an accidental discharge of untreated wastewater?	black water would be implemented, including the option of re-directing the black water to the oily bilge tank for subsequent offload to a supply vessel or the option of pumping the black water directly to a supply vessel. The black water would be temporarily stored on the supply vessel and transferred back to the FPSO treatment system after it is repaired.				
16	09-Dec-2021	EPA	**Section 3.4. Cumulative Impacts. Page 84** The document indicates that EEPGL plans to develop a flare minimization plan for the Yellowtail Development Project. Please indicate whether the document will include provision for a detailed inventory of flaring activities which will aid in the reduction of methane emission.	As described in EIA Section 6.1.3.2, Emissions of Air Quality Pollutants, the purpose of the flaring minimization plan would be to document the design elements and operational practices that will serve to minimize non-routine flaring. As part of such documentation, EEPGL would identify various activities and scenarios that could result in flaring and how the FPSO's design was intended to minimize the potential for such flaring events. For each identified activity or scenario, the plan would also identify measures that can be applied, including potentially in some cases a series of actions, to reduce the frequency, duration, and/or volume of flaring. Flaring minimization would aid in the reduction of GHG emissions as a general matter, including methane. A flaring minimization plan would be developed once final design and equipment plans are complete.	No	Accepted	N/A	N/A
17	09-Dec-2021	EPA	**Section 6: Air Quality, Climate and Climate Change and Sound.** **General Comments** Given that the project activities will include support from onshore locations including but not limited to waste treatment facilities, mud plants, etc., justify why no modelling was done from these operations and their impacts were not assessed.	As discussed in EIA Section 5.1, The Area of Influence, while they would be used by the Project, the referenced ancillary facilities such as waste treatment facilities and mud plants are not components of the Project. EEPGL would use these existing onshore facilities, which are owned and operated by others and were assessed and authorized separately from the Project. For this reason, these facilities were not included in the air dispersion modeling completed for the Yellowtail Project EIA. Where EEPGL would have obligations to ensure its contractors were working within regulatory requirements and the measures established in the EIA and related Environmental Permit conditions, the EIA discusses measures to verify conformance with these requirements.	No	Accepted	N/A	N/A
18	09-Dec-2021	EPA	**Section 6.1.2 –Existing Conditions—Onshore Air Quality. Page 346 - Figure 6.1-1: Onshore Ambient Air Quality Monitoring Sites** • Why are those particular sites chosen to do air quality readings i.e. what was the site selection criteria used? • Why weren't other sites further downwind selected or other Regions along the coast e.g. Region 1, 2, 3 or 5? • Is there a system in place to capture/ model emissions data from land use vehicles?	1, 2. Onshore ambient air monitoring locations were selected in the Georgetown area to assess existing air quality where emissions sources are most heavily concentrated (i.e., in the most heavily populated area). This allows for conservative estimations of future air quality that incorporate impacts from the Project in the area where the highest concentrations of existing air pollutants are expected. EEPGL is in the process of developing a scope for additional ambient monitoring along the coast. Additional text explaining this rationale has been added to EIA Section 6.1.2.1, Existing Conditions—Air Quality. 3. Ambient air monitoring captured existing air quality from all emissions sources, in the vicinity of / downwind of monitoring sites, including existing vehicle emissions. As documented in EIA Section 8.5.3, Impact Assessment—Social Infrastructure and Services, anticipated additional vehicle trips associated with the EEPGL's activities in 2026 would not be expected to meaningfully change overall traffic conditions across the intersections studied in the Georgetown area. Accordingly, the additional air emissions from EEPGL-related vehicles would not represent a significant increase and were not included in air dispersion modeling.	Yes	1,2 see comment With the current location (Carifesta Ave), the majority of the area in a 3 mile diameter circle falls on uninhabited zones. A greater representation of the heavily populated areas would arise if the central location was shifted 1 km on an East South East bearing 3. Accepted	1,2. The Consultants acknowledge the comment, noting that the Carifesta location was a prior data monitoring location, for which data collection ended in March 2019. As described in Section 6.1.2.1 of the EIA, additional data were collected further to the south in the Georgetown urbanized area from April to August 2019 (New Guyana School site).	p. 6-8

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19	09-Dec-2021	EPA	**Section 6.1.3.2. Emissions of Air Quality Pollutants - Embedded Controls. Page 360.** Air Quality Data was taken sporadically via campaigns during 2016, 2018 & 2019. It was noted that with time, BTEX increased, though below regulations, however, with the increased activity of Yellowtail, it is recommended that there be consistent AQ monitoring of non-methane VOCs & other WHO AQ parameters 3 proposed sites.	In support of the Gas to Energy Project, EEPGL is in the process of deploying the ambient air quality monitoring system at a fourth location. Independent of the Yellowtail Project assessment and authorization process, EEPGL has indicated its willingness to engage with the Guyana Environmental Protection Agency (EPA) and other government agencies as necessary with a view to progressing appropriate environmental initiatives such as air quality monitoring in keeping with its commitment to minimizing environmental impacts.	Yes	Accepted	N/A	p. 6-19
20	09-Dec-2021	EPA	**Table 6.1-14: Embedded Controls Contributing to Reductions in Atmospheric Emissions** There is no mention of heat recovery systems. Will there be usage of high efficient combustion equipment that utilizes a heat recovery system?	Table 6.1-14 includes an embedded control for the Project to install waste heat recovery units (WHRUs) on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption. The WHRUs would be installed in a 4 x 33% configuration.	No	Accepted	N/A	N/A
21	09-Dec-2021	EPA	**Section 6.1.3.2. Emissions of Air Quality Pollutants. Page 362.** It is highlighted in the document that non-routine flaring is used to combust produced gas when not consumed as fuel gas on the FPSO or injected back into the reservoir, and vents. Please indicate the methodology that would be used for the temporary non-routine flaring.	EIA Section 2.7.4.3, Flare and Blowdown System) describes the flare and blowdown system, including situations where non-routine flaring may occur. The methodologies used to estimate the emissions of air pollutants coming from temporary non-routine flaring are based on the publication AP-42: Compilation of Air Pollutant Emission Factors (USEPA Undated).	No	Accepted	N/A	N/A
22	09-Dec-2021	EPA	**Section 6.1.3.3. Characterization of Potential Impacts—Air Quality – Figure Page 369. 6.1-2: Air Quality Modeling Domain** For point source emission modelling, does the data take into account pollutants from other sources (CGX, Repsol etc) in the near vicinity? Will there be a cumulative impact study that shows modeling data gathered from other sources?	The scope and timing of these non-Project sources, and therefore the emissions from these sources, have too much uncertainty associated with them for accurate quantitative modeling at this time. However, it is the understanding of the Consultants that current plans for these projects involve only a limited number of wells, with an associated short duration of drilling. As such, it is anticipated that the contribution of these sources to onshore air quality impacts in the Area of Influence (AOI) would be negligible. EIA Chapter 10, Cumulative Impact Assessment, addresses cumulative impacts to air quality from other operators' activities on a qualitative basis.	No	Accepted	N/A	N/A
23	09-Dec-2021	EPA	**Section 6.1.3.3. Characterization of Potential Impacts—Air Quality – Table 6.1-17: Summary of Modelling Results – Maximum Predicted Impact at Onshore Locations.**	Potential air quality-related health impacts for Project workers would be addressed through standard occupational exposure guidelines. The relevant occupational health and safety guidelines have been referenced in EIA Section 6.1.3, Impact Assessment—Air Quality, Climate, and Climate Change. Potential exposures to non-Project-related offshore receptors (i.e., on non-Project vessels) would be limited due to the distance of the Project	Yes	Accepted	N/A	p. 6-18

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			Justify why there were no modeled cases to predict the maximum offshore concentration of pollutants and their effects.	from areas of high non-Project vessel use (i.e., near shore). ExxonMobil, and its affiliates, generally follow the American Conference of Governmental Industrial Hygienist's Threshold Limit Values to set the exposure limits for chemical, physical, and biological substances.				
24	09-Dec-2021	EPA	**Section 6.1.3.1. Relevant Project Activities and Potential Impacts - Table 6.1-16: Annual Air Pollutant Emissions Summary—Yellowtail Project.** • Footnote (a) the annual estimated totals generally reflect the current preliminary Project schedule and production profile and remain subject to adjustment. Source category-specific sub-totals are rounded up to the next 5 tonnes and the totals reflect the sum of the rounded sub-totals. • Can you state what conditions may cause it to deviate from these readings on either side (positive and negative).	The air pollutant emissions summary provided in Chapter 6 was developed based on the current design of the Yellowtail Project and reflects the best available estimates of the components and activities of the Project that would generate air pollutant emissions. Actual pollutant emissions could differ from these estimates (either upward or downward) as a function of changes such as shorter or longer drilling duration, more or less oil and associated gas production, more or less upset or maintenance scenarios, more or less support vessel or helicopter trips, among others. Where appropriate, a degree of conservatism was reflected in the estimates. As an example, emissions estimates are provided for two cases designated as the "Design Case" and "Modeled Case." The Design Case emissions are based on estimated annual flaring, including an estimate of non-routine flaring in accordance with design basis assumptions for the Project. The Modeled Case emissions include an additional contingency for non-routine flaring volumes and are considered to reflect a credible worst case for non-routine flaring. Recognizing that range, a "low side" and "high side" estimation has been included to demonstrate the potential range for experience. For the purposes of modeling (on which assessment of potential air quality impacts is based), only the Modeled Case (i.e., "high side") emissions estimates are assessed. Examples of changes that could cause actual emissions to differ from those presented in EIA Table 6.1-16 have been added as a footnote to the table.	Yes	Accepted	N/A	p. 6-27
25	09-Dec-2021	EPA	**Section 6.2. Sound 6.2.2.2. Characterizing Existing Conditions in the PDA** Has there been any other (more recent) under water sound study conducted other than (Hildebrand (2009))? Current baseline in relation to marine mammals/fauna data. Can Hildebrand (2009) study be appropriate for these current conditions? If so, how?	EIA Section 6.2.2.2, Characterizing Existing Conditions in the PDA, discusses ambient noise in open ocean environments and notes that criteria associated with potential acoustic injury to marine fauna are much higher than existing ambient sound levels. Furthermore, ambient noise levels are inconsequential since sound levels add logarithmically, and a local noise source would be the controlling factor for any short-term noise. Several more recent studies including Wiggins et al. (2016), Hildebrand et al. (2021), and Haver et al. (2021) have been added to EIA Section 6.2, Sound.	Yes	Accepted	N/A	p. 6-50
26	09-Dec-2021	EPA	**Marine Water Quality, Marine Geology and Sediments, Biological Resources** **General Comment** • Was any updated EBS survey or ROV surveys conducted for the Stabroek Block for the period 2020-2021 as it pertains to obtaining benthic imagery? EIA makes reference to surveys conducted for the period 2014, 2016, 2017, 2018, 2019 and 2020.	1. As described in Appendix I, Recent Environmental Baseline Survey Reports (Volume II of the EIA), the Hammerhead Environmental Baseline Survey (EBS) was conducted in 2020 within the Stabroek Block, approximately 44 kilometers (approximately 27 miles) west of the Yellowtail Project Development Area (PDA), and included seabed video and still photography at 15 sample locations. As described in EIA Section 7.9, Marine Benthos, multiple EBSs have been conducted in the Stabroek Block, and as depicted in Figure 7.9-1 the 2019 EBS included one sample along the northern boundary of the Yellowtail PDA. While no other EBS data have been collected specifically within the Yellowtail PDA, as described in EIA Section 7.9, after more than 60 samples taken across several years in the Stabroek Block the weight of evidence suggests that benthic communities in the Stabroek Block are relatively homogeneous and typical of deep-sea sedimentary habitats. This supports the concept that	1. Yes 2. Yes 3. Yes 4. No 5. No.	1. Accepted 2. Accepted 3. Accepted 4. Accepted 5. Accepted	N/A	1. p. 7-261 2. p. 7-67, p. 7-91, p. 7-143, p. 7-165 3. p. 7-193 4. N/A 5. N/A

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			• With the absence of updated benthic information and imagery, how can it be ascertained that those conditions remain the same from periods of past surveys? Further it is noted that updated EBS information was provided for the Hammerhead for 2020, does this fall within the Yellowtail development area? • It has been noted that there is a lot of baseline information (with exception of marine mammals and fish) with respect sighting periods that were conducted up to the year 2000. However, limited information is available for the year 2021. A list of all baseline work conducted must be provided for the year 2021 with regards biological surveys and how it was taken into consideration in the EIA. • Based on the conduct of marine fish surveys from 2017 to 2020, did you observe any trends and if yes, what was the trend? • Was any marine fish survey conducted in the year 2021 and would the conduct of marine fish survey be ongoing? • With regards to designing water intakes to prevent the entrainment of fish, was any thought given to the entrainment of fish eggs?	the deep sea environment within the Stabroek Block is a relatively stable environment and EBS data collected within the last several years would be expected to remain relevant to present day conditions. A conclusory statement with supporting rationale indicating why the existing benthic information is sufficient has been added to EIA Section 7.9.2.3, Existing Conditions in the Project Development Area. 2. No biological baseline surveys were conducted in 2021; however, most of the biological receptors assessed in EIA Chapter 7 are supported by multiple EEPGL-sponsored biological baseline data studies that have been conducted within the last several years (e.g., PSO Surveys, Marine and Coastal Bird Studies, Enhanced Coastal Sensitivity Mapping, and Nearshore and Offshore Fisheries Study). The Consultants consider these baseline data as representative and appropriate for inclusion in the EIA, for the reasons discussed in Response #26. Statements regarding the applicability of recent historical data to the EIA have been added to the marine turtles, riverine mammals, seabirds, and coastal wildlife sections in Chapter 7. 3. Although two study years (2017–2018 and 2018–2019) constitute too short a timeframe to identify temporal trends across multiple years, the studies did identify several seasonal and spatial trends. These include increased fish biodiversity on the continental shelf relative to other areas (i.e., deepwater and nearshore/estuarine area), fluctuations in the fish abundance in the nearshore and inner continental shelf regions in response to seasonal influx of freshwater from rivers, and a potential seasonal trend in plankton abundance in response to seasonal peaks in spawning activity. These observations are discussed in more detail in Section 6 of Appendix M, Nearshore and Offshore Fisheries Study Summary (Volume II of the EIA). The Participatory Fish Survey also identified some trends to date, including seasonal increases in fishing effort from October to April, the increasing effect that fuel prices are having on fishing practices, a recent increase in the demand for (and effort directed to) swim bladders, and the increasing effect of sargassum incursions on catches. Discussions of these trends have been added to Section 7.8.2.2 of the EIA. 4. As a continuation of the participatory fish study initiated in 2019, additional data collection is underway. A third Nearshore and Offshore Fisheries Study is not currently underway, but is planned to begin in 2022. 5. EIA Section 7.8.3, Impact Assessment—Marine Fish, discusses the impacts of entrainment of juvenile life stages, including eggs.				
27	09-Dec-2021	EPA	**Specific Comment** Table EIS-4 (Coastal Resources Potentially Impacted by an Oil Spill) and Table EIS -5: Marine Resources Potentially Impacted by an Oil Spill: Further justification for the moderate to minor ratings is required since the severity of the consequences on coastal and marine resources was significant in oil spills that have occurred globally. Further marine fish has not been included in Table	As discussed in EIA Section 4.8.2.2, Evaluating Potential Impacts from Unplanned Events, assessing the risk of unplanned events, including oil spills, requires incorporating both the potential consequence/severity of the unplanned event if it were to occur and the likelihood of the unplanned event occurring. The Consultant team agrees that in the event of a Tier III spill event, the consequences for coastal and marine resources could be severe. The sensitivity of the ecosystem to such an event is the primary reason that several of the environmental resources received a Moderate risk rating for unplanned events. However, the likelihood of such an event would be exceedingly low. Even if a Tier III spill event—which is a very remote possibility—were to occur, the ocean area through which oil would move would be greatly reduced and the chances of oil reaching most of the	Yes	Accepted	N/A	p. EIS-37

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			EIS-5 (Marine Resources Potentially Impacted by an Oil Spill).	Guyana coast would be small given the mitigation measures included in the Oil Spill Response Plan (OSRP). As discussed in EIA Section 9.12.2, Marine Oil Spill, fish are generally only slightly impacted by oil spills because of their limited exposure to surface slicks (unlike marine mammals and reptiles they do not need to breathe at the surface), and the dispersed oil being rapidly diluted to very low concentrations in open water environments. Fish may also actively avoid oil, as they can detect hydrocarbons in the water. This unique combination of physiological attributes makes them more resilient to the effects of oil than the other biological resources listed in Table EIS-5. This explanation has been added to Section 3.3. of the EIS as a footnote.				
28	09-Dec-2021	EPA	**Section 7.5.3 Impact Assessment. Page 571. – Marine Mammals:** physical injury to marine mammals was not discussed as a potential impact and must be included in the impact assessment.	Vessel collisions with marine mammals are not a planned Project activity, and are therefore not addressed in Chapter 7. As a potential unplanned event, vessel collisions (of all types used by the Project) with marine mammals are addressed in Chapter 9, specifically in Sections 9.1.10.2, Vessel Collision with a Marine Mammal, and 9.9.4, Vessel Collision. Additional text has been added to Section 9.9.4 to address the probability of collisions with the FPSO and other project vessels specifically.	Yes	Accepted	N/A	p. 9-152
29	09-Dec-2021	EPA	**Section 7.8.3.3. Characterization of Impacts. Page 664.—Changes in the Distribution of Fish Due to Altered Water Quality:** What are the potential impacts on fish that may be found before that 100-meter range, given that increase food availability may result in fish moving closer toward the FPSO?	Most of the fish species that occur in the mixing zone are highly migratory open ocean species, and as such would be expected to briefly pass through the mixing zone rather than loiter within it. Fish that pass through the 100-meter (328-foot) mixing zone surrounding the FPSO would be temporarily exposed to elevated concentrations of various constituents in the routine FPSO discharges. The effects of these constituents on the fish could manifest in several ways such as elevated metabolic rates and/or gill or skin irritation, but these effects would generally be expected to be temporary and to abate once the fish exited the mixing zone. To the extent that increased forage availability could induce the fish to remain within the mixing zone longer than they otherwise would, the negative effects of increased exposure to discharges would be balanced by the energetic benefits of increased forage availability. EIA Section 7.8, Marine Fish, has been revised to include this discussion.	Yes	Accepted	N/A	p. 7-212
30	09-Dec-2021	EPA	**Section 7.10.3.2 Magnitude of Impact. Page 734. – Ecological Balance and Ecosystems, Impact on Gene Flow:** it is mentioned that the project is not predicted to have any impact on regional current patters that define the North Brazil Shelf LME nor site-specific reproductive activities that could be considered significant, however the specific reasons for this conclusion is not clearly outlined and thus needs to be addressed.	As described in Section 7.10.2, Existing Conditions—Ecological Balance and Ecosystems, the defining characteristic of the North Brazil Large Marine Ecosystem (LME) is the influence of freshwater inputs from the Amazon River. This influence gives rise to the Guiana Current, which extends north and west along the coast of northern South America past the Project to the Orinoco River delta in Venezuela. The Project would not change any of the fundamental hydrological characteristics of the Amazon River or the macro-scale oceanographic characteristics of the eastern North Brazil LME, which drive the Guiana Current at the Project site. The volume of the aqueous discharges from the Project would be insignificant compared to the volume of the Guiana Current as it flows past the Project, so the Project would not be expected to significantly influence the oceanographic environment west of the Project within the North Brazil LME (or the Guiana Current's effects on this area). Site-specific reproductive events (such as spawning aggregations or migrations) occur at locations where a specific combination of physio-chemical conditions is uniquely favorable to support them. As described in various sections in Chapter 6, the effects of the Project on physical and chemical oceanographic parameters would be expected to diminish to near-	Yes	Accepted	N/A	p. 7-285

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				background conditions within a few hundred meters of the FPSO. No spawning aggregations, migration pathways, or other unique reproduction-related habitat features are known to occur within this zone, so the Project would not be expected to affect site-specific reproductive activity. EIA Section 7.10.3.2, Magnitude of Impact—Ecological Balance and Ecosystems, has been revised to elaborate on the oceanographic and biological rationale described above.				
31	09-Dec-2021	EPA	**Section 9.1.5 Oil Spill Modelling Results. Page 1000:** Has the assessment of impacts been conducted with respect to oil spill modelling scenarios presented in the EIA? If yes, should the oil spill volumes go beyond the model, what implications that will have on the impact ratings provided?	A detailed assessment of potential impacts from various oil spill scenarios was discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events. These scenarios included two Worst Case Discharge (WCD) scenarios, a Most Credible WCD and a Maximum Case WCD, associated with a loss-of-well-control event. As described in EIA Section 9.1.1.9, Summary of Spill Scenarios Considered, the U.S. Department of Interior Bureau of Safety and Environmental Enforcement's regulations stipulate that each facility operator calculate its own WCD for each OSRP. According to this regulation, for an oil production platform facility, the size of the WCD scenario must be based on the daily production volume from an uncontrolled blowout of the highest capacity well associated with the facility. In determining the daily discharge rate, the operator must consider reservoir characteristics, casing/production tubing sizes, and historical production and reservoir pressure data (RPS 2021). This was done for the Yellowtail WCD calculations. In addition, these scenarios assume an uncontrolled release for a period of 30 days; however, the OSRP outlines provisions for shutting in the well with a capping stack or other technology 5.5 days after the event (assuming no debris removal is required and mobilization of the capping stack out of the United States). For these reasons, the Consultants consider the release volumes reflected in the oil spill modeling, and the assessment of risks related to these volumes, to be reasonably conservative.	No	Accepted	N/A	N/A
32	09-Dec-2021	EPA	**Section 9.1.1.8 Production-Related Spills. Page 990:** As seen with Liza 1, there was a breach in the hose due to puncture by a sword fish. Therefore, this should be mentioned in the EIA as a source of potential breach in the hose barrier.	EIA Section 9.1.1.8, Production-Related Spills, covers unplanned spill events associated with production, which includes an example of a release of crude oil due to a failure of an offloading hose. There could be different causes of a hose failure, including the one provided in the comment, which are accommodated by the scenario, and the specific cause would not change the level of impact or risk associated with this spill event. EIA Section 9.1.1.8 has been updated to include this information.	Yes	Accepted	N/A	p. 9-9
33	09-Dec-2021	EPA	**Section 10.5.3 Potential Impacts from other Projects. Page 1255, Table 10.5-3:** With regards to marine water quality, what are the potential impacts from produced water discharge from the development projects?	As indicated in Table 10.5-3, changes in water quality and temperature would be expected from liquid effluent discharges from other EEPGL development projects. Section 4 of the Water Quality Modeling Report, Appendix C of the EIA, presents the results of modeling discharges from the four EEPGL development projects, including the Yellowtail Project. None of the modeled plumes showed potential for overlap during simultaneous FPSO operations, and the individual produced water plumes experience rapid dilution and mixing. Embedded controls and mitigation measures proposed for the Project are considered to be sufficient to address potential cumulative impacts to marine water quality.	No	Accepted	N/A	N/A
34	09-Dec-2021	EPA	**Section 8:** Assessment and Mitigation of Potential Impacts from Planned Activities	Comment acknowledged. Responses to specific comments are provided in Comments #35 through #38 below.	No	Accepted	N/A	N/A

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			General Comment This section, Section 8 of the Yellowtail Development Project's EIA, is clear and informative in identifying social and economic aspects affected by the Yellowtail Development Project within and around the boundaries of the Project's area of interest in keeping with the Terms and Scope. Leading issues such as waste management, potential job opportunities, food security, especially agriculture and fishing, and land use in indigenous areas, etc. are addressed according to their magnitude of impact however, there were some concerns for the management /mitigation measures which needs to address in the revised document Please see below for specific comments:					
35	09-Dec-2021	EPA	Throughout section 8, several impacted areas were highlighted with the challenges they pose. However, no mitigation measures were listed.	In the course of the impact assessment, the Consultants considered potential mitigation measures for impacts with a pre-mitigation significance of at least "minor"; impacts with a pre-mitigation significance of "negligible" would not be expected to result in a noticeable change and were therefore not a focus for defined mitigation. However, the Consultants also recognize that not all potential impacts would be reasonably managed by EEPGL, particularly where there would be complex external influences on an impact or receptor (such as cost of living). In these rare cases, the impact is clearly identified to have no direct mitigation measures (although there may be relevant and useful measures identified as embedded controls), and the pre-mitigation significance and residual significance are identical. For example, in EIA Section 8.3, Community Health and Wellbeing, public anxiety impacts are addressed through embedded controls for ongoing stakeholder engagement (and the Stakeholder Engagement Plan [SEP]), as well as oil spill response training/awareness. In EIA Section 8.5, Social Infrastructure and Services, increased traffic congestion is recognized to be a pre-existing issue in Georgetown, and this is conservatively reflected as a higher sensitivity leading to an impact of minor significance. Given the Project's small contribution to vehicle congestion (2 to 4%), no specific mitigation measures are identified.	No	Accepted	N/A	N/A
36	09-Dec-2021	EPA	Page 8-1 (i.e., 741), the EIA makes reference to community-based studies via surveys or interviews for local community members, however there are no transcripts on the results of the activities conducted with local members, only the organizational entities.	To protect the privacy of individuals, the Consultants do not typically include transcripts or detailed results for community-level surveys and/or key informant interviews. However, EIA Section 4.7, Stakeholder Engagement, provides a high-level summary of engagement that has informed the EIA development. In addition, a more detailed synopsis of stakeholder engagement topics, by stakeholder, is provided in Attachment B of the SEP (available in Volume III of the EIA). The synopsis table provided in the SEP includes engagement directly related to the Yellowtail Project and 2021 socioeconomic baseline updates, as well as engagement from past development projects that has also informed the Yellowtail EIA. In addition, a	Yes	Please amend in keeping with comments provided during Redford Group Meeting	Detailed records of consultation made during the development of the EIA have been provided in Appendix W of the EIA. Together with the stakeholder consultation process	pp. 4-41 to 4-43, Appendix W (new), SEP p. 39

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				summary of the public comments received from, and revisions made to the EIA in response to, consultation conducted during the 60-day public disclosure period has been added to EIA Chapter 4 of the EIA, and detailed comments and responses are provided in Appendix U, Stakeholder Comments (Volume II of the EIA).			and summaries provided in Chapter 4 and the attached SEP and SEP Attachment A, these records include the manner in which the public was notified, the groups targeted, a description of the stakeholder consultation process, listing of all stakeholder groups included in the process, the number of meetings held, location of the meetings, dates held, and minutes of all meetings. Personal information including specific names of participants have been withheld to respect the privacy of those involved. No surveys were performed.	
37	09-Dec-2021	EPA	Section 8.5.3.2, EEPGL already identified suitable alternatives in the event that the new cell at HBL is not ready for use when the short-term, 2-3 years, use for cell 2 is up? If so, what are avenues that are being considered by the company?	If it becomes apparent that suitable additional capacity at Haags Bosch Landfill (HBL) would not be available to support EEPGL's needs, EEPGL would pursue plans to construct an alternative industrial landfill to meet anticipated needs.	No	Response should be included in the EIA document	The subject language has been added to Section 8.6.3.2 of the EIA.	p. 8-168
38	09-Dec-2021	EPA	Do the current timelines for the HBL for short-term (2-3 years) and long-term (up to 10 years) take into account the increase in other commercial and industrial activities that will begin concurrently with EEPGL's project lifecycle and which will also be using the HBL?	At current disposal rates, Cell 2 is expected to last for approximately 4 to 6 years. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next five years. There remains space for additional cell(s) at the HBL location to be developed in the future. The currently available landfill capacity appears sufficient to support the Project and other users for the near term based on Cell 2 having entered service in March 2021, even considering the forecasted growth in waste volumes from expanding industrial activity. Presuming additional cell(s) would be constructed on a timely basis, the future HBL landfill capacity also appears reasonable for the longer-term (up to 10 years).	No	Accepted	N/A	N/A

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39	09-Dec-2021	EPA	**Recommendations:** It is recommended that the Company highlights the applied technologies that they have indicated will be implemented to reduce GHG emissions.	The Project has been inherently designed to incorporate a number of embedded controls and mitigation measures that would serve to reduce GHG emissions, as well as criteria air pollutant emissions, from Project sources. Tables 6.1-14 and 6.1-15 include a summary of these embedded controls and mitigation measures, respectively.	No	Accepted	N/A	N/A
40	09-Dec-2021	EPA	**Volume II: Appendix D – Participatory Fishing Study Final Report January 2019 – March 2020.** The document seems to be more of a fish inventory and not a study, since it failed to identify the possible effects of the project on fish population and health (including bioaccumulation), nesting/spawning seasons and grounds, etc. This analysis must be included in the EIA.	The Participatory Fishing Study is a baseline study that provides information for use in the impact analysis, although in and of itself it does not, and is not intended to, provide an analysis of Project effects on fish and fishery resources. Additional baseline information used in the impact analysis is presented in various EIA appendices (e.g., Appendix M, Nearshore and Offshore Fisheries Study Summary; Appendix O, Coastal Sensitivity Maps; and Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Reports). Analyses of potential impacts on spawning, habitat, and general fish health are presented in Chapter 7 (protected areas and special status species, coastal habitats, and marine fish) and Chapter 8 (socioeconomic conditions, employment and livelihoods, and ecosystem services) of the EIA. The potential for bioaccumulation was considered but ultimately not assessed in the EIA because bioaccumulation is typically a long-term impact that occurs over time due to ongoing chronic exposure to a pollutant, and as described in the response to Comment #29, most of the fish species that occur in the mixing zone of operational effluent discharges would be expected to briefly pass through the mixing zone rather than remaining within it for any significant period of time.	No	Include explanation for not assessing bioaccumulation in the EIA document	The rationale provided in the Consultants' response has been added to Section 7.8.3.3 of the EIA as requested.	p. 7-213
41	09-Dec-2021	EPA	**Volume III: Esso Exploration and Production Guyana Limited (EEPGL) – Oil spill Response Plan for Guyana Operations** Why wasn't a strategy developed for the application, monitoring and evaluation of chemical dispersants at surface and subsea?	As a continuation of studies and activities related to the Payara Development Project approvals, EEPGL has been working with the EPA and other government agencies to refine OSRPs, including a strategy for application, monitoring, and evaluation of chemical dispersants, which is actively under development. The strategy is expected to be ready in the first half of 2022. Pending formal development of the strategy, good practices have been established by international groups such as International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Oil and Gas Producers to guide the application, monitoring, and evaluation of chemical dispersants applied at the surface and subsea. If in the unlikely event the use of dispersants was deemed favorable to reduce the impact of spilled oil to the environment, the responders, including those from EEPGL and those from oil spill response organizations, would follow this guidance.	No	Accepted	N/A	N/A
42	25-Oct-2021	Region 4: Umana Yana	What are the resources available for oil spill response?	Yellowtail Development Project EIA Volume III OSRP Chapter 6 Table 6-1 lists or otherwise describes the international, regional, and local resources available to EEPGL for each potential response strategy. OSRP Tables 6-2 through 6-7 provide a further summary of the representative oil spill response equipment in Guyana.	No	Accepted	N/A	N/A
43	25-Oct-2021	Region 4: Umana Yana	How many Guyanese will actually benefit from the operation?	As discussed in Section 12.1, Planned Project Activities, the EIA predicts that the Project would generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, an increase in employment, and in-country Project purchasing of goods and services from Guyanese businesses. While it is not possible at this stage to quantify the exact number of Guyanese that would benefit from the Project, as discussed	No	Accepted	N/A	N/A

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				in Section 2.3, Project Workforce, the Project is expected to employ up to 600 persons at peak employment.				
44	25-Oct-2021	Region 4: Umana Yana	Who pays compensation to fishermen if there is an oil spill? Is there a plan in place?	EIA Section 9.1.9, Claims and Livelihood Remediation Processes, describes claims and livelihood remediation processes. In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses; the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated as appropriate based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss. It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would establish an independent implementation entity, as needed depending on the circumstances, as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts were ongoing. Depending on the extent of losses, livelihood remediation efforts would potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as determined by the duration of spill impacts.	No	Accepted	N/A	N/A
45	25-Oct-2021	Region 4: Umana Yana	How will the fishery sector be impacted by the project?	EIA Section 7.8.3, Impact Assessment—Marine Fish, provides details on potential impacts on marine fish.	No	Accepted	N/A	N/A
46	25-Oct-2021	Region 4: Umana Yana	Was the marine survey a one-off study?	Biological resources were documented through a range of studies conducted over the last several years, in some cases going back to 2014. These included studies of seabirds, marine mammals, riverine mammals, marine turtles, marine fish, and marine benthos in the appropriate areas of the Guyana Exclusive Economic Zone (EEZ). These studies are described in Table 5.2-1, and are available to the public either in Volume II of the Yellowtail EIA, or for older studies, in technical appendices of prior development project EIAs (all of which are available on the EPA website). In most cases the studies were conducted in the Stabroek Block and adjacent continental shelf, but the riverine mammal study was conducted in the Demerara River. Monitoring of marine and riverine mammals is recommended in the ESMP, and EEPGL is currently considering the potential for additional biological data collection in the future.	No	Accepted	N/A	N/A

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47	25-Oct-2021	Region 4: Umana Yana	Will there be updated studies throughout the life of the project?	Monitoring of marine and riverine mammals is recommended in the ESMP, and EEPGL is currently considering the potential for additional biological data collection in the future.	No	Accepted	N/A	N/A
48	25-Oct-2021	Region 4: Umana Yana	The EIA does not show what the benefits to the developer are.	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
49	25-Oct-2021	Region 4: Umana Yana	What is the length, breadth, and depth of the project area?	Work would be performed in a subsea area within the PDA that could potentially cover an estimated 3,534 hectares (8,733 acres). Work performed on the surface of the ocean could potentially occur within an estimated 4,576 hectares (11,308 acres). The Project facilities would be installed in water ranging from approximately 1,700 to 1,900 meters (5,577 to 6,234 feet) in depth. This information is included in Chapter 2 of the EIA.	No	Accepted	N/A	N/A
50	25-Oct-2021	Region 4: Umana Yana	Will there be consistent engagement with the public throughout the project?	EEPGL conducts regular and ongoing engagement with fisherfolk, communities, Toshaos, and other stakeholders. Through this engagement, EEPGL provides updates about the company's activities in the marine and onshore areas, and opportunities to be involved in local programs and initiatives.	No	Accepted	N/A	N/A
51	25-Oct-2021	Region 4: Umana Yana	Will there be a certificate issued after decommissioning?	As indicated in Section 8 of the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects (included in Volume III of the EIA), the relevant Guyanese regulators would have access to the work site during the decommissioning activities to monitor and witness the final completion of the work. After the completion of well plugging and abandonment (P&A) and facilities decommissioning work, EEPGL would submit a final decommissioning report to the relevant Guyanese regulators that would include a description of the scope of work performed, work logs, final inspection reports, videos, and photos, as applicable. The relevant Guyanese regulators would be requested to review the submitted report and issue a certificate of completion of the decommissioning work as well as a certificate of release of liability within 60 days of completion of final inspection.	No	Accepted	N/A	N/A
52	25-Oct-2021	Region 4: Umana Yana	Who owns the information in the EIA?	The EIA and all the data contained within it is public information. Per the requirements of the Environmental Protection Act, EEPGL and the EPA will maintain copies of the EIA for the duration of the Project plus 5 years, and the public may request copies of these documents from the EPA at any time during this period.	No	Accepted	N/A	N/A
53	25-Oct-2021	Region 4: Umana Yana	Does EEPGL plan to provide insurance?	Insurance and financial security are addressed in EIA Table 4.7-4. The Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts. The co-venturers have the financial capacity to meet the responsibilities for an event including obligations under Guyanese law and the respective petroleum agreements. Regarding insurance, the Stabroek Block co-venturers have secured comprehensive insurance for petroleum activities as required by environmental permits. Under the existing legal framework and agreements with the government, there are extensive assurances of EEPGL's and co-venturers' commitments, including environmental protection measures to respond to operational incidents. The Government of Guyana has multiple mechanisms in place, including the Stabroek Block Petroleum Agreement and the environmental permits, to ensure that the companies would take responsibility for any adverse events.	No	Accepted	N/A	N/A

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				Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, should the Yellowtail Project receive necessary approvals, the co-venturers would have insurance coverage including Third Party Liability and the cost of regaining control of a well.				
54	25-Oct-2021	Region 4: Umana Yana	What data was used to inform the risk analysis?	Where there is uncertainty in the details of the Project design, the EIA uses conservative assumptions. However, it is noted that in addition to information obtained from the first 2 years of operations in Guyana, the EIA also draws on information from ExxonMobil affiliates' operations globally, so there is a strong foundation forming the basis of the assessment. The project description chapter (Chapter 2) establishes the basis for the EIA, inclusive of the technologies used to inform the assumptions.	No	Accepted	N/A	N/A
55	25-Oct-2021	Region 4: Umana Yana	What are the statutory requirements for hazard analysis?	The Environmental Protection Act does not require specific hazard assessment methodologies to be used to the support the EIA, but it does require the EIA to include basic Project design-related information and analysis of anticipated impacts on a number of specific environmental receptors.	No	Accepted	N/A	N/A
56	27-Oct-2021	Region 2: Regina	Some fishermen have noted the smell of diesel in the water that is unusual, can this be addressed?	The Consultants acknowledge the question. The question is beyond the scope of the EIA. However, the comment of potential odors in the water has been noted and communicated to EPA and EEPGL.	No	Accepted	N/A	N/A
57	27-Oct-2021	Region 2: Anna Regina	What treatment process is used on produced water?	EIA Section 2.7.4.5, Produced Water Treatment, provides an overview on how produced water would be treated.	No	Accepted	N/A	N/A
58	27-Oct-2021	Region 2: Anna Regina	Why isn't treated water injected back into the well?	Based on the many supporting factors described in the EIA and consistent with the produced water reinjection study conducted for the Payara Development Project, overboard discharge of treated produced water was recommended for the Project after taking into account the technical feasibility and economic evaluations, with a consideration of regulatory requirements and predicted environmental impact. This recommendation, subject to EPA review and approval, also is consistent with good international oilfield practice. More details can be found in EIA Section 2.18.2.5, Produced Water Management Alternatives.	No	Accepted	N/A	N/A
59	27-Oct-2021	Region 2: Anna Regina	Does Guyana have insurance? Partial, full coverage?	The question of whether the country of Guyana has an insurance policy is beyond the scope of the EIA. For information regarding insurance coverage for the Project, see the response to Comment #53.	No	Accepted	N/A	N/A
60	27-Oct-2021	Region 2: Anna Regina	Is there any financial security in place after decommissioning, specifically to address changes to the seafloor structure?	The subsea equipment would generally be laid on the seafloor, with a minimal degree of restructuring of the seafloor. Likewise, the process of decommissioning would not include any activities that would result in seafloor stability concerns. As stated in EIA Volume III, Preliminary End of Operations Decommissioning Plan for Guyana Development Projects, the relevant Guyanese regulators would have access to the work site during the decommissioning activities to monitor and witness the final completion of the work. After the completion of well P&A and facilities decommissioning work, EEPGL would submit a final decommissioning report to the relevant Guyanese regulators for review and	No	Accepted	N/A	N/A

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				approval, which would include a description of the scope of work performed, work logs, final inspection reports, videos, and photos, as applicable.				
61	27-Oct-2021	Region 2: Anna Regina	Are there any plans for compensation of fishermen?	EIA Section 9.1.9 describes claims and livelihood remediation processes. In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated as appropriate based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss. It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would establish an independent implementation entity, as needed depending on the circumstances, as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts would potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as defined by the duration of spill impacts.	No	Accepted	N/A	N/A
62	27-Oct-2021	Region 2: Anna Regina	How many Essequibians are employed by the company and how many can be employed by the project?	As of the first half of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more than 5,400, more than half of whom (more than 2,800 workers, or 53 percent of total) are Guyanese, representing all ten Regions of Guyana. Increases in total employment would be expected with the development of the Yellowtail Development Project, and, if the Project was approved, EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable, in alignment with its Local Content Plan. Onshore jobs would be based in the Georgetown area (Region 4) although employment applications would be welcome from residents of all regions. EEPGL and its contractors publicly advertise for job opportunities on a regular basis. Opportunities are available in a wide variety of disciplines. For more information, see the EEPGL website, Facebook page. EEPGL also posts opportunities in newspapers and through the Centre for Local Business Development (CLBD).	No	Accepted	N/A	N/A
63	27-Oct-2021	Region 2: Anna Regina	Under management measures for marine fish, specify which standards the company intends to use.	There are no national or international standards for managing the impacts of offshore oil and gas projects on marine fish. However, many of the predicted effects on marine fish would be indirect effects caused by changing water quality. Guyana has no national marine water quality standards, but applicable international water quality standards are available and are	No	Accepted	N/A	N/A

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				included in EIA Section 6.4.4.3, Characterization of Impacts—Changes to Water Quality and Temperature.				
64	27-Oct-2021	Region 2: Anna Regina	Will flaring be done on this project?	As per EIA Section 2.7.1, General Description, the FPSO would be designed to re-inject associated gas under routine conditions—except that which would be used as fuel gas, flare pilot gas, and background flare gas (e.g., purge, compressor seals) for FPSO operations and *de minimis* sources not captured by the Vapor Recovery Unit (VRU)—back into the reservoir except during times of injection / compression system unavailability, which would require temporary, non-routine flaring during maintenance/repair. Flaring of associated gas would occur on a non-routine basis during start-up and shutdown; equipment maintenance and process upsets scenarios; emergency pressure relieving scenarios; and other non-routine flaring events.	No	Accepted	N/A	N/A
65	27-Oct-2021	Region 2: Anna Regina	Was a Cumulative Impact Assessment of the burning of fossil fuels done?	Chapter 10, Cumulative Impact Assessment, and Appendix G, Emissions Inventory and Air Quality Modeling Report, discuss the assessment of cumulative air emissions.	No	Accepted	N/A	N/A
66	27-Oct-2021	Region 2: Anna Regina	What are the company's plans for monitoring emissions?	ESMP Table 3.6-1 includes quantification and reporting of direct emissions from Project offshore facilities and from offshore and onshore Project activities conducted by EEPGL and its dedicated contractors on an ongoing basis.	No	Accepted	N/A	N/A
67	27-Oct-2021	Region 2: Anna Regina	The EPA should monitor the conditions at Shell Beach	The question of whether the EPA should monitor Shell Beach generally is beyond the scope of the EIA; however, the monitoring component of the ESMP includes recommendations to monitor several types of marine wildlife within the PDA, and many of these species also occur at Shell Beach.	No	Accepted	N/A	N/A
68	27-Oct-2021	Region 2: Anna Regina	What considerations have been given to drill cuttings as litter on the ocean floor?	The EIA describes potential impacts to marine water quality, marine sediments, and marine life associated with drilling, including deposition of drill cuttings on the seafloor and temporary increases in suspended solids concentrations in the water column. The EIA includes computer modeling of these impacts, the results of which indicate the extent of minor impacts remains well offshore.	No	Accepted	N/A	N/A
69	27-Oct-2021	Region 2: Anna Regina	How will ballast water be managed?	Per the ESMP for the Yellowtail Development Project, the Project would comply with International Maritime Organization (IMO) guidelines for management of ballast water, which is the internationally recognized performance standard for managing potential environmental impacts associated with ballasting operations. Compliance with the relevant IMO requirements as recommended in the EIA should address potential impacts, and manage risks from ballast water discharges to the marine environment.	No	Accepted	N/A	N/A
70	27-Oct-2021	Region 2: Anna Regina	What is the quantity of ballast water that will be coming on the ships?	The FPSO would have a ballast capacity of up to 550,000 barrels (88,000 m^3). The market tankers that would accept the oil from the FPSO would have a maximum ballast water capacity of 629,000 barrels (100,000 m^3).	No	Accepted	N/A	N/A
71	27-Oct-2021	Region 2: Anna Regina	Are the drill cuttings responsible for the fish moving away?	As indicated in Chapter 7, deepwater fish would be expected to move away from disturbances at the sea floor during the drilling and installation stage of the Project. This effect would be expected to be temporary, and would not be expected to extend onto the continental shelf or the inshore zone where most fishing in Guyanese waters takes place. As a baseline matter, EIA Section 8.1, Socioeconomic Conditions, discusses the issue of declining fish catches. See additional information in the response to Comment #207.	No	Accepted	N/A	N/A

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72	27-Oct-2021	Region 2: Anna Regina	What replaces oil when it is extracted?	Associated gas and seawater would be injected into the reservoir. This water and gas would replace the oil and maintains reservoir pressure during production operations. This is typical of offshore production operations around the world.	No	Accepted	N/A	N/A
73	27-Oct-2021	Region 2: Anna Regina	What is the distance of the project from specific regions?	For the purposes of the public disclosure meetings, the distances between the FPSO and the Atlantic Ocean shoreline nearest the disclosure meeting locations in the six coastal regions are as follows: • Region 1: 232 kilometers (144 miles) • Region 2: 207 kilometers (129 miles) • Region 3: 206 kilometers (128 miles) • Region 4: 191 kilometers (119 miles) • Region 5: 191 kilometers (119 miles) • Region 6: 198 kilometers (123 miles)	No	Accepted	N/A	N/A
74	27-Oct-2021	Region 2: Anna Regina	What is EXXON doing for Guyana?	The question is not specific to a project or a resource and as such is too broad to be answered within the resource-specific scope of the EIA; however, with respect to the Yellowtail Development Project specifically, as discussed in Section 12.1, Planned Project Activities, the EIA predicts that Project would generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, an increase in employment, and in-country Project purchasing of goods and services from Guyanese businesses.	No	Accepted	N/A	N/A
75	27-Oct-2021	Region 2: Anna Regina	How is this project secured against piracy?	Marine safety is discussed in EIA Section 2.10.3. The Maritime Administration Department (MARAD) of the Ministry of Public Infrastructure is responsible for issuing notices to mariners concerning safety at sea. MARAD would be advised of the locations of drill ships during the drilling of the development wells and the performance of well workovers in the PDA so that mariners can be made aware of these activities. As shown on Figure 2.10-1, marine safety exclusion zones with a 500-meter (1,640-foot) radius would be established by MARAD around drill ships during drilling operations and around drill centers during well workovers, as well as around major installation vessels, in accordance with good international oilfield practice. Authorizations for major in-water activities would be obtained from MARAD and notices to mariners would be issued for all marine vessels, including the FPSO, supply and support vessels, tugs, and those vessels to be used during the installation, hook-up, and commissioning stage. As shown on Figure 2.10-1, MARAD would establish a 2-nautical mile-radius (2.7-kilometer-radius) marine safety exclusion zone centered on the FPSO during offloading activities, where marine support and tanker offloading would occur. No unauthorized vessels would be allowed to enter this approximately 4,310-hectare (10,650-acre) operational marine safety exclusion zone during offloading activities.	No	Accepted	N/A	N/A
76	27-Oct-2021	Region 2: Anna Regina	Will any oil spill affect international borders and how will this be addressed?	Chapter 9 includes an assessment of the potential risks of an oil spill on the various resources and receptors. Potential transboundary impacts from an oil spill are described in EIA Section 9.24.	No	Accepted	N/A	N/A
77	27-Oct-2021	Region 2: Anna Regina	What are the plans for monitoring wells?	As part of normal well tree installation on completed development wells, there is ROV support. At the conclusion of well tree installation, the ROVs survey the as-left condition and perform a visual survey of the location.	No	Accepted	N/A	N/A

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				EEPGL operations would have planned maintenance in place to have an ROV survey on a periodic basis to inspect wells / manifolds / subsea infrastructure. All of the trees would have the ability to monitor pressure, temperature, and flow rate. During normal operations, EEPGL would monitor flow rate, pressure, and temperature at different locations on the well tree and within the well, enabling it to identify any abnormal operating conditions.				
78	27-Oct-2021	Region 2: Anna Regina	How often will equipment be serviced?	The list of embedded controls for the Project (which are detailed in Chapter 2, Chapter 13, the ESMP, and the OSRP) includes a number of controls related to equipment maintenance and inspection. EEPGL would perform regular servicing and maintenance on equipment and, every few years, would complete a full overhaul. EEPGL would have dedicated teams who would manage these maintenance/servicing efforts as well as people on site who would monitor and test on a frequent basis. EEPGL would utilize a tracking system to manage its general equipment maintenance program.	No	Accepted	N/A	N/A
79	27-Oct-2021	Region 2: Anna Regina	If tankers moving fuel get into accidents in Guyana's waters, who is responsible for the cleanup?	EIA Section 2.10.4, Offloading Tankers, provides a summary of the operational procedures and controls (maritime navigation protocols, safety procedures, communication protocols, etc.) that would be implemented in relation to tanker activities, including tanker transit within Guyana waters and during offloading of oil from the FPSO to the tankers. In the event of a tanker accident in Guyanese waters, EEPGL would work with the tanker operator to assist with response.	No	Accepted	N/A	N/A
80	27-Oct-2021	Region 2: Anna Regina	Are there any plans to set up a refinery in Guyana?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
81	29-Oct-2021	Region 1: Santa Rosa	Would an oil spill affect our CARICOM neighbors?	Chapter 9 includes an assessment of the potential risks of an oil spill on the various resources and receptors. Potential transboundary impacts from an oil spill are described in EIA Section 9.24.	No	Accepted	N/A	N/A
82	29-Oct-2021	Region 1: Santa Rosa	Will oil spill response drills be conducted in villages?	EIA Volume III OSRP Table 7-3 provides information on oil spill exercises overview and schedule. Decisions on exercise locations would be determined during the exercise planning. Local communities would be offered the opportunity for involvement in oil spill exercises.	No	Accepted	N/A	N/A
83	29-Oct-2021	Region 1: Santa Rosa	Will there be compensation for villages, alternative livelihoods?	EIA Section 9.1.9 describes the claims and livelihood remediation processes. In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses; the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated as appropriate based on	No	Accepted	N/A	N/A

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				the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss. It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would establish an independent implementation entity, as needed depending on the circumstances, as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts would potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as defined by the duration of spill impacts.				
84	29-Oct-2021	Region 1: Santa Rosa	Did Liza Phase 1 EIA take flaring into account? If yes, how is there still flaring from the FPSO?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
85	29-Oct-2021	Region 1: Santa Rosa	How does EEPGL intend to deal with flaring in the context of the LCDS?	As described in EIA Section 6.1, Air Quality, Climate, and Climate Change, the Project would implement a flaring minimization plan. Instead of continuous flaring of gas produced during crude oil production, associated gas that would not be used as fuel gas on the FPSO—excluding *de minimis* sources not captured by the VRU—would be reinjected into the reservoir, to avoid routine flaring of associated gas. In addition, a series of measures would be implemented to minimize non-routine flaring of associated gas.	No	Accepted	N/A	N/A
86	29-Oct-2021	Region 1: Santa Rosa	Is the LCDS captured in the EIA?	The 2009 Draft Low Carbon Development Strategy, updated in 2013, was captured in EIA Section 3.3.1, National Policy Framework.	No	Accepted	N/A	N/A
87	29-Oct-2021	Region 1: Santa Rosa	Would the reservoir have the same density after the oil is extracted?	The reservoir is comprised of both sandstone rock as well as oil, gas, and water fluids. The oil, gas, and water fluids are contained within the pore space between the solid sandstone particles. As a part of the Yellowtail depletion plan, when fluids would be produced from the pore space, water and associated gas would be injected into the pore space to maintain the reservoir pressure near original conditions. At original conditions, the primary fluid would be oil. As the field would be developed and oil produced, water would become a greater percentage of the fluids in the pore space. The density of water is greater than the density of oil. Therefore, as the field would be produced, the density of the fluids in the reservoir would increase. The depletion plan would be approved by the Ministry of Natural Resources as part of any approval of the Field Development Plan for the Project.	No	Accepted	N/A	N/A
88	29-Oct-2021	Region 1: Santa Rosa	Did the Fish Study involve people of Region 1?	Yes. The Participatory Fish Study involved respondents from Smith's Creek and Morawhanna.	No	Accepted	N/A	N/A
89	29-Oct-2021	Region 1: Santa Rosa	Other than government revenue, is EEPGL willing to support small development projects if approached?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
90	29-Oct-2021	Region 1: Santa Rosa	The time for the distribution of the EIA and the meetings is too short given the distance of most villages and the length of the document. Can	The Consultants acknowledge the question. In accordance with the Environmental Protection Act, the public was provided 60 days after publication of the EIA to provide comments to the EPA. Opportunities to	No	Accepted	N/A	N/A

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			finance be provided to assist village leaders to distribute documents in a timely manner?	share information in advance would be considered when planning future community meetings.				
91	29-Oct-2021	Region 1: Santa Rosa	Can visits off shore be facilitated for village leaders?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
92	29-Oct-2021	Region 1: Santa Rosa	How will maintenance of the equipment be undertaken with respect to extraction rat e of oil and injection rate of water and gas?	The list of embedded controls for the Project (which are detailed in Chapter 2, Chapter 13, the ESMP, and the OSRP) includes a number of controls related to equipment maintenance and inspection. EEPGL would perform regular servicing and maintenance on equipment and, every few years, would complete a full overhaul. EEPGL would have dedicated teams to manage these maintenance/servicing efforts as well as people on site to monitor and test on a daily basis. EEPGL would utilize a tracking system to manage its general equipment maintenance program.	No	Accepted	N/A	N/A
93	01-Nov-2021	Region 3: Leonora Technical Institute	Are the standards used for treating produced water mandatory or voluntarily enforced by the developer?	Produced water discharge criteria identified in the EIA were adopted from international standards by the Project. If the Project receives an environmental authorization from the EPA, these criteria—if listed in the environmental authorization—would become mandatory.	No	What applicable international standard are you referring to? Comment relating to standard must be addressed in keeping with discussions following Redford Group Meeting	The produced water discharge criteria adopted by the Project (i.e., treat to achieve an oil in water content of 29 mg/L [monthly average] and 42 mg/L [daily maximum]) were sourced from the World Bank Group EHS Guidelines for Offshore Oil and Gas Development. This is stated in Table 2.4-1 of the Environmental and Socioeconomic Management Plan (Volume III).	N/A
94	01-Nov-2021	Region 3: Leonora Technical Institute	Is the produced water treated to international standards?	As described in the EIA Section 2.18.3.5, Produced Water Treatment, the World Bank Group has established Environmental, Health, and Safety Guidelines for offshore oil and gas development (World Bank 2015), which is a technical reference document with examples of good environmental practices. The offshore guideline has established an effluent guideline of oil and grease content in produced water of no more than 42 milligrams per liter (mg/L) daily maximum, and no more than 29 mg/L monthly average. The EEPGL produced water system design basis is consistent with the performance criteria of the above-referenced guidelines for oil and grease content.	No	Comment relating to standard must be addressed in keeping with discussions following Redford Group Meeting	Please see response to Comment #93.	N/A
95	01-Nov-2021	Region 3: Leonora Technical Institute	How will ballast water be managed?	Per the Yellowtail Development Project ESMP, the Project would comply with IMO guidelines for management of ballast water, which is the internationally recognized performance standard for managing potential environmental impacts associated with ballasting operations. Compliance with the relevant IMO requirements as recommended in the EIA should address potential	No	Accepted	N/A	N/A

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				impacts, and would manage risks from ballast water discharges to the marine environment.				
96	01-Nov-2021	Region 3: Leonora Technical Institute	Will there be compensation for loss of livelihood of fisherfolk?	EIA Section 9.1.9 describes the claims and livelihood remediation processes.	No	Accepted	N/A	N/A
97	01-Nov-2021	Region 3: Leonora Technical Institute	If there is an environmental disaster, what is in place for citizens?	In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated as appropriate based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss. It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would establish an independent implementation entity, as needed depending on the circumstances, as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts would potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as defined by the duration of spill impacts.	No	Accepted	N/A	N/A
98	01-Nov-2021	Region 3: Leonora Technical Institute	The key to the EIA is mitigation measures, who will monitor the company, and will operations be shut down if the permit is breached?	The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
99	01-Nov-2021	Region 3: Leonora Technical Institute	Medium and lower water columns will have minor impacts, there is no mention of the top water columns.	EIA Section 6.4.3, Impact Assessment—Water Quality, describes the impacts that would occur from discharges from Project vessels to the upper portion of the water column. During the drilling and installation phase, the upper portion of the water column would receive discharges of treated cuttings and operational discharges (e.g., grey water, black water) from drilling and installation vessels. During production operations, the upper portion of the water column would be exposed primarily to operational discharges from the FPSO (e.g., produced water, wash water) as well as grey and black water and ballast water from the export tankers and FPSO.	No	Section 6.4.3 refers to the Impact Assessment - Marine Water Quality	The Consultants acknowledge that the correct title of Section 6.4.3 is “Impact Assessment—Marine Water Quality.” The remainder of the comment response is correct as stated.	N/A

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.100	01-Nov-2021	Region 3: Leonora Technical Institute	Nitrous oxide levels are currently below the WHO standard; will these levels increase over the lifetime of the project?	Modeling of onshore nitrogen dioxide (NO_2) concentrations was based on the worst-case dispersion conditions (i.e., leading to the maximum predicted onshore concentrations) that would be expected at any time during the Project life cycle (at least 20 years) to calculate the maximum anticipated annual emissions for each source during each of three time periods over the Project life. For the Project-only modeling, maximum predicted NO_2 concentrations (without background) at any potential onshore receptor location would be no more than 6.3% of the applicable guideline for all pollutants and averaging periods. This indicates that, if the Yellowtail Development Project receives an Environmental Permit and it is executed, onshore NO_2 concentrations would not increase to more than 6.3% of the applicable guideline for all pollutants and averaging periods at any point in time over the life of the Project. For the cumulative scenario, this indicates that, if the Yellowtail Development Project receives an Environmental Permit and is executed, maximum predicted concentrations (without background) at any potential onshore receptor location would be no more than 28.4% of the applicable guideline for all averaging periods at any point in time over the life of the Project.	No	Accepted	N/A	N/A
101	01-Nov-2021	Region 3: Leonora Technical Institute	How dangerous will flaring be in combination with other projects undertaken by the company?	Flaring would be a safety measure that would be in place to keep people and the facility out of danger in an unexpected or emergency scenario in the process. The flare would be part of the safety system that relieves excess pressure in those scenarios. Without a flare, the same gases would be vented to the atmosphere, would have a greater impact on air quality, and would potentially form a gas cloud. A gas cloud would not be controlled and if contacted by a source of ignition, could result in an explosion, with potential impacts to people, facility, and the environment. The Liza Phase 1, Liza Phase 2, and Payara FPSOs would be located approximately 31 kilometers (19.2 miles), 22 kilometers (13.7 miles), and 41 kilometers (25 miles)—respectively—from the proposed location of the Yellowtail FPSO. Given these distances between the Yellowtail FPSO and other project FPSOs, flaring at the Yellowtail FPSO would not present safety hazards to other FPSOs.	No	Accepted	N/A	N/A
102	01-Nov-2021	Region 3: Leonora Technical Institute	Is there a plan for the restoration of plants and animals in the event of an oil spill?	Yes. EEPGL's OSRP Chapter 5, which is included in Volume III, contains measures to clean oil from affected shorelines and rehabilitate affected wildlife.	No	Accepted	N/A	N/A
103	01-Nov-2021	Region 3: Leonora Technical Institute	What are the tools used to remove crude oil? Will these tools affect the plants and animals?	OSRP Table 6-1 lists or otherwise describes the international, regional, and local resources available to EEPGL for each potential response strategy. OSRP Tables 6-2 through 6-7 provide a further summary of the representative oil spill response equipment in Guyana. The tools for a given spill would be selected using what is known as a Net Environmental Benefit Analysis (NEBA), which is a situation-specific analysis that would be conducted to result in the best overall outcome from an environmental perspective.	No	Accepted	N/A	N/A
104	01-Nov-2021	Region 3: Leonora Technical Institute	Is there a register of fisherfolk who participated in the study?	The identities of the individual fishermen that participated in the participatory fish study are kept confidential to ensure that business-sensitive information (e.g., personal fishing locations, financial information) is protected.	No	Accepted	N/A	N/A

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105	01-Nov-2021	Region 3: Leonora Technical Institute	Please share the company's insurance policy as a potential oil spill will not only impact Guyana's waters.	Insurance and financial security are addressed in EIA Table 4.7-4. Also, see the response to Comment #53 for additional information regarding insurance coverage maintained for the Project.	No	Accepted	N/A	N/A
106	01-Nov-2021	Region 3: Leonora Technical Institute	What taxes does EEPGL pay to the government?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
107	01-Nov-2021	Region 3: Leonora Technical Institute	Why doesn't the EPA report the findings of the EIA to the public?	Comment should be referred to the EPA.	No	Accepted	N/A	N/A
108	01-Nov-2021	Region 3: Leonora Technical Institute	Does the baseline survey take into account all the other oil wells being drilled?	Various baseline studies of physical, biological, and socioeconomic resources were conducted to inform the impact assessment for the Project, as described in Chapters 6, 7, and 8. These studies included effects from existing projects, including drilling of wells. The combined effects from the Yellowtail Project plus other existing, planned, or reasonably foreseeable projects, including future oil and gas development, were evaluated in the cumulative impact assessment, described in Chapter 10.	No	Accepted	N/A	N/A
109	02-Nov-2021	Region 5: Mahaicony Technical Institute	The language used in the EIA about oil spills and response is not very specific. There is no mention on specific time intervals for drills to be conducted.	Oil spill response exercises are described in OSRP Section 7.3.	No	Accepted	N/A	N/A
110	02-Nov-2021	Region 5: Mahaicony Technical Institute	There is no PDF version of the Oil Spill Response Plan for the EIA. Where can this be found?	The OSRP is an integral part of the Yellowtail EIA Volume III submitted to the EPA and it is available on the EPA website.	No	Accepted	N/A	N/A
111	02-Nov-2021	Region 5: Mahaicony Technical Institute	There is an increase in GHG levels from Liza Phase 1. According to the Liza Phase 1 EIA, the maximum storage capacity is 120, 000 barrels per day and the FPSO is currently storing 130, 000 barrels per day. What measures will be put in place to monitor the numbers for this and other FPSOs?	The Liza Phase 1 Project was evaluated in a separate, approved EIA. The Yellowtail Development Project would be a separate project with different storage capacity. As such, details of the Liza Phase 1 Project are not relevant to the Yellowtail Project EIA; however, the cumulative impact assessment includes emissions from prior approved projects, including Liza Phase 1. As it relates to the Yellowtail Project, the ESMP (Volume III of the EIA) includes quantification and reporting of direct GHG emissions from Project offshore facilities and from offshore and onshore Project activities conducted by EEPGL and its dedicated contractors on an annual basis, should the Project be approved. For the Yellowtail Project, the FPSO design rates described in EIA Table 2.7-1: FPSO Key Design Rates, would be annual averages and daily peak rates that could be higher during the lifetime of the Project, depending on multiple factors (e.g., reservoir pressure, number of wells, equipment reliability). Currently, the FPSO basic design has an upper production limit of 263,000 BPD (42,080 m^3) peak oil production rate. If during the detailed design stage or during production operations, an opportunity to expand the upper production limit would arise, the Project /EEPGL would document the evaluation and justification and an updated upper production limit would be available.	No	Accepted	N/A	N/A

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112	02-Nov-2021	Region 5: Latchmansingh Primary School	What is the anticipated volume of oil that can be spilled?	The EIA considers a range of potential oil spill scenarios, with varying assumed volumes. The EIA included modeling of two loss-of-well-control scenarios, both of which would be highly unlikely to occur. As described in EIA Section 9.1.1.9, Summary of Spill Scenarios Considered, two rates were modeled for a loss-of-well-control scenario: 88,728 BPD (14,196 m^3) (most credible worst-case discharge) and 177,157 BPD (28,345 m^3) (maximum worst-case discharge).	No	Accepted	N/A	N/A
113	02-Nov-2021	Region 5: Latchmansingh Primary School	Who pays for the cleanup of an oil spill?	The Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts. The co-venturers have the financial capacity to meet the responsibilities for an event including obligations under Guyanese law and the respective petroleum agreements. Regarding insurance, the Stabroek Block co-venturers have secured comprehensive insurance for petroleum activities as required by environmental permits. Under the existing legal framework and agreements with the government, there are extensive assurances of EEPGL's and co-venturers' commitments, including environmental protection measures to respond to operational incidents. The Government of Guyana has multiple mechanisms in place, including the Stabroek Block Petroleum Agreement and the environmental permits, to ensure that the companies would take responsibility for any adverse events. Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, should the Yellowtail Project receive necessary approvals, the co-venturers would have insurance coverage including Third Party Liability and the cost of regaining control of a well.	No	Accepted	N/A	N/A
114	02-Nov-2021	Region 5: Latchmansingh Primary School	Were fishermen in the region engaged in the fish study?	The Participatory Fishing Study included landing sites in all coastal regions, including Region 5, which was used to inform the existing conditions for the EIA. A profile on fishing in Region 5, including landings, fishing areas, targeted species, seasonal considerations, and biometrics, is included in EIA Volume II (Appendix D, Participatory Fishing Study Final Report January 2019–March 2020).	No	Accepted	N/A	N/A
115	02-Nov-2021	Region 5: Latchmansingh Primary School	Fish catch is low in the region, what can be done for them?	As a baseline matter, EIA Section 8.1, Socioeconomic Conditions, discusses the issue of declining fish catches. See additional information in the response to Comment #207.	No	Accepted	N/A	N/A
116	02-Nov-2021	Region 5: Latchmansingh Primary School	What compensation is in place for fishermen if fish stocks continue to decline?	As a baseline matter, EIA Section 8.1, Socioeconomic Conditions, discusses the issue of declining fish catches. See additional information in the response to Comment #207.	No	Accepted	N/A	N/A
117	02-Nov-2021	Region 5: Latchmansingh Primary School	Is the gas being released by the project playing a role in climate change?	Flaring results in GHG emissions, which contribute to cumulative global GHG emissions. As explained in EIA Section 6.1.3.4, Management Measures—Air Quality, Climate, and Climate Change, potential climate / climate change impacts are a global concern and stem from cumulative worldwide GHG concentrations. The Global Circulation Models used to predict climate impacts from global concentrations are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project such as the Yellowtail Development Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate	No	Accepted	N/A	N/A

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				using observed data, and can be used to estimate future local climate changes based on the results of Global Circulation Models. However, the reverse approach of predicting the impact of local GHG emissions, including those from flaring, on global (or local) climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions.				
118	02-Nov-2021	Region 5: Latchmansingh Primary School	Is flaring responsible for climate change?	See the response to Comment #117.	No	Accepted	N/A	N/A
119	02-Nov-2021	Region 5: Latchmansingh Primary School	Why doesn't EEPGL recycle some of its waste instead of taking it to the landfill?	There is limited recycling infrastructure in Guyana, and EEPGL and its contractors have implemented a number of steps to minimize the generation of waste that requires treatment and disposal. This includes waste minimization during development drilling and waste minimization during FPSO production which would apply to the Yellowtail Project.	No	Accepted	N/A	N/A
120	02-Nov-2021	Region 5: Latchmansingh Primary School	What will be done with the excess gas from the project?	As stated in the EIA Section 2.7.1, General Description, the FPSO would be designed to re-inject associated gas under routine conditions—except that which would be used as fuel gas, flare pilot gas, and background flare gas for FPSO operations and *de minimis* sources not captured by the VRU—back into the reservoir except during times of injection / compression system unavailability, which would require temporary, non-routine flaring during maintenance/repair. Gas re-injection would be used as needed to maintain reservoir pressure for optimal production over the life cycle of the Project.	No	Accepted	N/A	N/A
121	02-Nov-2021	Region 5: Latchmansingh Primary School	Employment outreaches are done in Georgetown alone, meaning that the opportunities for employment are only for those in Georgetown. These job fairs need to be taken to other regions as skilled people also reside outside of Georgetown.	As of the first half of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more than 5,400, more than half of whom (more than 2,800 workers, or 53% of total) are Guyanese representing all ten Regions of Guyana. Through the Greater Guyana Initiative, EEPGL and the other Stabroek Block co-venturers are working closely with the University of Guyana on a variety of educational initiatives and are supporting a pilot program at several technical and vocational education and training institutions in Guyana focused on safety, electrical, and welding programs. In addition, EEPGL's contributions programs provide support to a variety of education, training, development, and capacity-building initiatives across Guyana, including the New Amsterdam Technical Institute. Through the CLBD, EEPGL has conducted several regional outreaches to foster greater awareness of ExxonMobil's operations in Guyana and how Guyanese businesses can become suppliers to the oil and gas sector. EEPGL and its contractors publicly advertise for job opportunities on a regular basis. Opportunities are available in a wide variety of disciplines. For more information, visit the EEPGL website and Facebook page. EEPGL also posts opportunities in newspapers and through the CLBD.	No	Accepted	N/A	N/A
122	02-Nov-2021	Region 5: Latchmansingh Primary School	What measures are put in place to deal with potential vandalism of cables?	As the Yellowtail Development Project is within the EEZ of Guyana, the Guyana Defence Force Coast Guard has the responsibility to patrol the EEZ and to protect all activities within. EEPGL would maintain a security protocol to monitor for potential threats to the offshore infrastructure, working in coordination with the Guyana Defence Force, as appropriate.	No	Accepted	N/A	N/A

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123	02-Nov-2021	Region 5: Latchmansingh Primary School	Who is paying for the EIA?	Consistent with the requirements of the Environmental Protection Act, EEPGL is paying for the Consultants' time.	No	Accepted	N/A	N/A
124	02-Nov-2021	Region 5: Latchmansingh Primary School	Has ERM done any other studies for EXXON around the world?	ERM is a global consultancy that has been conducting EIAs for 50 years around the world for numerous oil and gas companies, including ExxonMobil.	No	Accepted	N/A	N/A
125	03-Nov-2021	Region 6: #66 Fishport Complex	The location chosen for the drills were not practical.	EIA Volume III OSRP Table 7-3 provides information on oil spill exercises overview and schedule. A decision on exercise location would be determined during the exercise planning.	No	Accepted	N/A	N/A
126	03-Nov-2021	Region 6: #66 Fishport Complex	What are the names of the dispersants to be used in the event of an oil spill?	In alignment with the Guyana National Oil Spill Contingency Plan, the oil spill dispersants that have been cited in the OSRP for Guyana Operations (Volume III) are the following: • Corexit 9500 • Corexit 9527 • Dasic Slickgone • Finasol OSR 52 EPA approval would be required before dispersants could be applied in the field. Safety Data Sheets for all of the above-mentioned products have been provided in Appendix D of the OSRP (Volume III).	No	Accepted	N/A	N/A
127	03-Nov-2021	Region 6: #66 Fishport Complex	Is the time indicated to bring the well cap from Brazil practical?	As per Volume III OSRP Section 6.3.7, Subsea Well Response: • Capping stack mobilization time would depend on the availability of capping stack at the primary location and would potentially take from 5–21 days. • The primary resource would be the Boots & Coots Global Rapid Intervention Package (GRIP) capping stack from Houston, which would be mobilized by air/sea. The GRIP system, utilizing current logistics strategies, estimates that the capping stack deployment would be possible within 5 days, assuming no debris removal activities would be required. • Additionally, the Oil Spill Response Limited (OSRL) capping stacks located in Norway and Brazil could be deployed in approximately 9 and 21 days, respectively. The Norway capping stack would be air-freightable (via transport skid configured for transport by an Antonov AN124 aircraft) and its capability was demonstrated with a test flight out of the Solo Airport in late 2018. The Brazil capping stack would be transported to well location by vessel. OSRL, with Company involvement, conducted a major mobilization exercise (Guyana simulation) in November 2017 which evaluated the ability to export the Brazil capping stack outside of Brazil within 3 days.	No	Accepted	N/A	N/A
128	03-Nov-2021	Region 6: #66 Fishport Complex	Will any spill affect our CARICOM neighbours, and should they not be a part of the drills?	Impacts to other countries from an oil spill, if one occurs, would be a function of the size of the spill, but would be mitigated by the response tools and resources EEPGL has in place for such an event. As described in EIA Chapter 9, EEPGL would work with the Government of Guyana and other countries as appropriate to coordinate such a response and determine the need for such countries to participate in drills.	No	Accepted	N/A	N/A

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				Potential transboundary impacts from an oil spill are described in EIA Section 9.24.				
129	03-Nov-2021	Region 6: #66 Fishport Complex	What is the level of preparation of the company in the event of an oil spill?	EIA Volume III OSRP Chapter 6 Table 6-1 lists or otherwise describes the international, regional, and local resources available to EEPGL for each potential response strategy. OSRP Tables 6-2 through 6-7 in the OSRP provide a further summary of the representative oil spill response equipment in Guyana.	No	Accepted	N/A	N/A
130	03-Nov-2021	Region 6: #66 Fishport Complex	Compensation should be done prior to any anticipated oil spill since the fish industry is already on the decline. Additionally, fishermen should be among the first to benefit from the Sovereign Wealth Fund.	See the response to Comment #116 regarding potential compensation. The Consultants acknowledge the question related to benefits from the Sovereign Wealth Fund. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
131	03-Nov-2021	Region 6: #66 Fishport Complex	Will EXXON really provide compensation? The contract does not indicate this.	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
132	03-Nov-2021	Region 6: #66 Fishport Complex	How efficient is the boom in the case of high tides and rough waters?	In rough water, booms may not be very effective as per EIA Volume III OSRP Appendix G Table G-1.	No	Accepted	N/A	N/A
133	03-Nov-2021	Region 6: #66 Fishport Complex	How quickly can the booms be replaced if damaged?	Trained oil spill responders are able to identify booms that are in need of replacement. Depending on the type of boom (inflatable, self-inflatable, or rigid), this can be done in a matter of hours.	No	Accepted	N/A	N/A
134	03-Nov-2021	Region 6: #66 Fishport Complex	No baseline study on plankton was done prior to drilling.	Baseline data were collected on plankton in 2018 and 2019. Plankton were abundant in the 2018 (dry season) samples but much less abundant in the 2019 (wet season) samples. These data are discussed in EIA Volume II, Appendix M, Nearshore and Offshore Fisheries Study Summary. This trend is consistent with traditional knowledge concerning the timing of most marine species' spawning behavior.	No	Accepted	N/A	N/A
135	03-Nov-2021	Region 6: #66 Fishport Complex	How will the project deal with flaring?	As noted in EIA Table 6.1-14, several of the embedded controls for the Project relate to minimization of flaring from the Project's FPSO production operations. These controls would include providing installed spares on compressors for the Flash Gas Compression, Main Gas Compression, and Re-Injection Gas Compression systems, such that when one compressor trips, the spare (backup) unit could be started, reducing non-routine flaring frequency and volume/duration. To support these embedded controls, EEPGL would develop a flaring minimization plan to document the design measures and operational practices that would minimize flaring during Project FPSO operations. See the responses to Comment #190 and Comment #191 for additional information related to the flaring minimization plan.	No	Accepted	N/A	N/A
136	03-Nov-2021	Region 6: #66 Fishport Complex	Mr. Orwin Abdulla requested collaboration with EEPGL to refine a nature reserve that he established at #66	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
137	03-Nov-2021	Region 6: #66 Fishport Complex	There is no feedback from EEPGL on the fish studies.	The report for the first year of the marine fish study was made public in Volume II of the Payara EIA. The report for the second year of the marine fish study and the report for the Participatory Fish Study are both included in	No	Accepted	N/A	N/A

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				Volume II of the Yellowtail EIA (Appendix D, Participatory Fishing Study Final Report January 2019–March 2020).				
138	03-Nov-2021	Region 6: #66 Fishport Complex	What are the health and safety protocols on the ships?	ESMP Section 2.3 describes EEPGL's general health and safety policies. As described in ESMP Section 2.6, personnel would receive specialized health and safety training modules that are specifically tailored to each individual's designation.	No	Accepted	N/A	N/A
139	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	What job opportunities are available for the people of Region 01?	The Consultants acknowledge the question. The question is beyond the scope of the EIA. However, for informational purposes, as of the first half of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more than 5,400, more than half of whom (more than 2,800 workers, or 53% of total) are Guyanese representing all ten regions of Guyana. Modest increases in total employment would be expected with the development of the Yellowtail Development Project, and if the Project is approved EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable, in alignment with its Local Content Plan. Onshore jobs would be based in the Georgetown area (Region 4) although employment applications would be welcome from residents of all regions. EEPGL and its contractors publicly advertise for job opportunities on a regular basis. Opportunities are available in a wide variety of disciplines. For more information, visit the EEPGL website and Facebook page. EEPGL also posts opportunities in newspapers and through the CLBD.	No	Accepted	N/A	N/A
140	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	What opportunities are available for structured training? For example, those related to oil spill response.	As described in EIA Section 2.3, Project Workforce, EEPGL is committed to exploring various training formats that may include, but are not limited to, on-the-job training, mentoring, classroom training, e-learning, and self-taught programs. In addition, contractors and subcontractors are evaluating other training options in collaboration with local institutions to build capacity of potential candidates prior to the start of the work, should the Project be approved. These institutions include existing vocational and technical education institutions and centers, Aeronautical Institute, and the University of Guyana.	No	Accepted	N/A	N/A
141	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	What plans are there with regards to provision of resources to agricultural activities and sports-related activities for the people of Region 01?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
142	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	What investment opportunities are there to support infrastructure in Region 01?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
143	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	Two species of birds have been listed for the first time and identified as vulnerable species. How is this being addressed in the EIA?	The EIA applies a higher sensitivity rating to listed (i.e., special status) species to account for their special conservation needs. This is explained in EIA Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species.	No	Accepted	N/A	N/A
144	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	What are the impacts to aquatic animals from the operations, in more particular sound and vibrations	The EIA discusses the predicted impacts of sound individually for each taxonomic group (e.g., marine mammals, marine fish, etc.) as appropriate in several locations in Chapter 7. Generally, impacts were rated from Negligible to Minor depending on the type of sound, sensitivity of a particular taxonomic group to auditory impacts, and availability of appropriate management	No	Accepted	N/A	N/A

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			generated by various activities associated with the project?	measures. These ratings were based in part on a re-analysis of underwater noise modeling that was originally conducted for the Liza Phase 1 Project and re-assessed using Yellowtail-specific inputs, as described in EIA Section 7.5.3, Impact Assessment—Marine Mammals.				
145	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	How will turtles be affected from the increase in marine traffic?	As described in EIA Section 7.7, Marine Turtles, the Project would not be expected to impact sea turtle migration patterns or behavior, primarily because marine turtles are transient in the PDA and are relatively resilient to auditory impacts, and the PDA would be too far away from sensitive habitat (i.e., nesting beaches) to significantly affect nesting behavior.	No	Accepted	N/A	N/A
146	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	Are there any impacts to tourism activities in the region from the proposed development? One of the areas identified was the Mora Passage.	The EIA did not identify any impacts to tourism in Region 1 due to the limited onshore impact from the Project. Impacts on ecosystems and biodiversity are described in Chapter 7; impacts on ecotourism would not be anticipated.	No	Accepted	N/A	N/A
147	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	Sensitization campaigns for young people of Region 01 regarding avoidance of teenage pregnancies, rape and other social crimes.	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
148	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	Are there any opportunities for the provision of scholarships?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
149	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	Reference was made to the 2014 air study conducted and thus the question was posed what has happened with respect to air quality since the conduct of that study. What are the cumulative air impacts?	To characterize existing offshore air quality conditions in the vicinity of the PDA, the Consultants drew from four offshore ambient air monitoring campaigns completed in the Stabroek Block in 2016, 2018, and 2019. The 2019 campaign included PM_{10} (particulate matter with an aerodynamic diameter of less than 10 micrometers), $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 micrometers), carbon monoxide, sulfur dioxide, H_2S, NO_2, total non-methane volatile organic compounds (VOCs), and selected speciated VOCs. The offshore monitoring data were presented in prior EIAs. To characterize existing onshore air quality, the Consultants drew from four ambient air monitoring campaigns completed at onshore locations in 2018 and 2019. The air quality monitoring report documenting the onshore ambient air quality monitoring conducted to date is included in Appendix E, Ambient Onshore Air Quality Monitoring Report (EIA Volume II). These data were used in the modeling of predicted cumulative air pollution impacts for the Project combined with other planned projects.	No	Accepted	N/A	N/A
150	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	Would reinjection of gas contribute to seismic activities within the geological structures in the reservoir?	Associated gas and seawater would be injected into the reservoir to maintain reservoir pressure during production operations. This would be typical of offshore production operations around the world and would not be expected to pose a risk of seismic activity. Potential Project effects on seismic risk are evaluated in EIA Section 5.2.1, Assessment of Potential for Geological/Seismic Impacts.	No	Accepted	N/A	N/A
151	05-Nov-2021	Region 1: Mabaruma Rdc Boardroom	What is the equipment efficiency with respect to reliability, environmental safety and operations?	There is no one specific “efficiency” number applicable to the various pieces of equipment involved in the Project. However, as explained in EIA Section 2.8, Installation, Hook-up, and Commissioning, EEPGL would use the most appropriate industry-proven technologies in developing the Project. Technology selection includes consideration for equipment reliability and performance (e.g., proven vendor references in similar conditions as the Yellowtail Development Project). See EIA Section 2.18.3, Technology	No	Accepted	N/A	N/A

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				Alternatives, for additional information regarding technology selection, including best available technologies.				
152	11-Nov-2021	Virtual Meeting	Where does the waste go after the hydrocyclone and other treatment of the produced water?	As described in Chapter 2, the produced water treatment system would be comprised of a flash vessel, hydrocyclones, and induced gas flotation units. Hydrocarbons recovered from this process would be recycled back into the oil processing system. Gas streams would be recovered/recycled to the Flash Gas Compression system and reject oil streams would be cycled back to the Intermediate Pressure Separator.	No	Accepted	N/A	N/A
153	11-Nov-2021	Virtual Meeting	Why will you be drilling wells to re-inject produced water?	As discussed in EIA Section 2.18.3.5, the alternative selected by EEPGL for produced water treatment for the Project, subject to EPA review and approval, is to treat it prior to discharge overboard, and not to re-inject it. Associated gas would be re-injected into the reservoir, along with treated seawater, to help maintain reservoir pressure.	No	Accepted	N/A	N/A
154	11-Nov-2021	Virtual Meeting	When the water is treated to remove the contaminants, where do the contaminants go?	As discussed in EIA Section 2.7.4.5, the produced water treatment system would be operated to maximize oil recovery from the produced water prior to discharge, and the recovered oil would be routed to the oil processing system.	No	Accepted	N/A	N/A
155	11-Nov-2021	Virtual Meeting	After these repeated cycles of treatment, what happens to the residues?	Any residual wastes generated from treatment of produced water would be managed onshore using permitted waste treatment and disposal facilities in accordance with the approved Comprehensive Waste Management Plan (CWMP).	No	Accepted	N/A	N/A
156	11-Nov-2021	Virtual Meeting	Where would the currents carry the oil to, and who will those countries sue? Will they sue Guyana or oil operators?	Mitigated oil spills from each of the two loss-of-well-control scenarios would have the potential to reach Venezuela and Trinidad and Tobago. Effects on other countries from an oil spill, if one occurs, would be a function of the size of the spill, but would be mitigated by the response tools and resources EEPGL has in place for such an event. As described in Chapter 9, EEPGL would work with the Government of Guyana and other countries as appropriate to coordinate such a response. As described in EIA Section 9.1.9, Claims and Livelihood Remediation Processes, in the event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses; the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner.	No	Accepted	N/A	N/A
157	11-Nov-2021	Virtual Meeting	Trinidad, and the DR, and Haiti and all those other countries which stand to be affected. Where is the map showing this?	The Yellowtail Development Project EIA includes the following figures showing an impact from unmitigated oil spill: • Figure 9.1-22a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (28,345 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Trinidad and Tobago • Figure 9.1-22b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Trinidad and Tobago	No	Accepted	N/A	N/A

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				• Figure 9.1-29a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Dominican Republic • Figure 9.1-29b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Dominican Republic • Figure 9.1-30a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Haiti • Figure 9.1-30b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Haiti Mitigated oil spills from each of the two loss-of-well-control scenarios would only have the potential to reach Venezuela and Trinidad and Tobago, and would reduce the extent of shoreline oiling associated with spills under both scenarios relative to the corresponding unmitigated spill.				
158	11-Nov-2021	Virtual Meeting	Have the countries that are likely to be impacted by a spill, such as Jamaica, been consulted and informed of the extent of this project?	EIA Section 9.24 discusses potential transboundary impacts, including an identification of other countries that could be affected by a loss-of-well-control event. As described in Chapter 9, EEPGL would work with the Government of Guyana and other countries as appropriate to coordinate a response to an oil spill with the potential to affect other countries. The Yellowtail EIA process did not include consultation with stakeholders outside Guyana, but the EIA was available for review on the EPA's website and any comments from persons outside of Guyana could have been submitted to the EPA during the 60-day review period.	No	Accepted	N/A	N/A
159	11-Nov-2021	Virtual Meeting	An oil spill will affect many CARICOM countries, but do they know this?	The question relates to inter-government communications and is beyond the scope of the EIA. However, the EIA was available for review on the EPA's website and any comments from persons outside of Guyana could have been submitted to the EPA during the 60-day review period.	No	Accepted	N/A	N/A
160	11-Nov-2021	Virtual Meeting	What is the expected flow rate in the uncontrolled model in the event of an oil spill?	As described in the EIA Section 9.1.1.9, Summary of Spill Scenarios Considered, two rates were modeled for a loss-of-well-control scenario: 88,728 BPD (14,196 m^3) (most credible worst-case discharge) and 177,157 BPD (28,345 m^3) (maximum worst-case discharge). Both of these scenarios were run for uncontrolled release durations of 30 days.	No	Accepted	N/A	N/A
161	11-Nov-2021	Virtual Meeting	The impact on the Caribbean Sea was emphasized since the Lisa 1 ESIA process. At that time the consultants did not address the question.	Section 9.24 discusses potential transboundary impacts, including an identification of other countries that could be affected by a loss-of-well-control event.	No	Accepted	N/A	N/A
162	11-Nov-2021	Virtual Meeting	If an oil spill occurs what systems are in place to help with this?	If an oil spill occurs, EEPGL would respond to such a spill in accordance with the OSRP included in Volume III of the EIA as well as the National Oil Spill Contingency Plan.	No	Accepted	N/A	N/A

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163	11-Nov-2021	Virtual Meeting	Does the EPA consider the proposed deposit of US $2B adequate for cleanup cost?	The Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts. The co-venturers have the financial capacity to meet the responsibilities for an event including obligations under Guyanese law and the respective petroleum agreements. Regarding insurance, the Stabroek Block co-venturers have secured comprehensive insurance for petroleum activities as required by environmental permits. Under the existing legal framework and agreements with the government, there are extensive assurances of EEPGL's and co-venturers' commitments, including environmental protection measures to respond to operational incidents. The Government of Guyana has multiple mechanisms in place, including the Stabroek Block Petroleum Agreement and the environmental permits, to ensure that the companies would take responsibility for any adverse events. Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, should the Yellowtail Project receive necessary approvals, the co-venturers would have insurance coverage including Third Party Liability and the cost of regaining control of a well.	No	Accepted	N/A	N/A
164	11-Nov-2021	Virtual Meeting	How do you valuate the potential impact of a spill without consulting other Caribbean countries that will potentially be impacted?	Impact of an oil spill was determined in accordance with methodology described in the EIA Chapter 4, Methodology for Preparing the Environmental Impact Assessment. The EIA was available for review on the EPA's website and any comments from persons outside of Guyana could have been submitted to the EPA during the 60-day review period.	No	The potential impacts mentioned in section 4.1 does not include impacts for an oil spill.	The specific section in Chapter 4 to which the response is referring is Section 4.8.2.2, Evaluating Potential Impacts from Unplanned Events. This section describes the methodology used to evaluate risks to resources from unplanned events, including potential oil spills.	N/A
165	11-Nov-2021	Virtual Meeting	Whose responsibility will it be to pay compensation to Caribbean countries for damage to their economies – tourism, shipping, and fishing sectors in the event of a well blowout? Will Esso or the Guyanese people be responsible?	See the response to Comment #163.	No	Accepted	N/A	N/A
166	11-Nov-2021	Virtual Meeting	I don't see mention of formal monitoring programme, operated by XOM or by a contractor(s) on behalf of XOM, covering all aspects of the oil field development/operation/decommissioning/safe closure. Section 11(4)(a) of the EP Act specifies areas that should at least be covered in such a monitoring exercise. What is EEPGL	To the extent that the comment is not related to the Yellowtail Project, it is beyond the scope of the EIA. However, ESMP Table 3.6-1 (included in Volume III of the EIA) presents the monitoring measures recommended by the Consultants for the Yellowtail Project. EEPGL is also in the process of developing a framework for enhanced monitoring, reporting, and verification, including the EPA's opportunities to independently verify EEPGL's compliance data.	No	Accepted	N/A	N/A

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			currently undertaking this monitoring? Where in the EIA do you provide reference to the records and findings of such monitoring? Where can the records be found? Are these records in the public domain? What is the evidence that you have transmitted those records, as EPA alleges that you have not when/where?					
167	11-Nov-2021	Virtual Meeting	Can an availability study of the gas injection system be requested as a prerequisite for approval of this ESIA given the track record of poor compressor reliability, sensitivity and currency of hydrocarbon emissions?	The comment should be referred to the EPA.	No	Accepted	N/A	N/A
168	11-Nov-2021	Virtual Meeting	Will the gas injection system PFD shown below be spared? Is there a common mode of failure between the trains?	The FPSO would incorporate two trains of export / re-injection gas compression in normal operation plus a spare with a total design basis of 3 x 50% capacity (three at 50% capacity each), where the export gas compressor and injection gas compressor would be driven by a common mechanical drive. The 3 x 50% design was selected so that when one train would be down, the other trains could continue to operate until the installed spared compressor train is online. This three-train configuration was selected to enhance the facility's safety, minimize flaring, and reduce production down time. Compressor design for the Yellowtail Project has taken significant steps to incorporate lessons learned from other projects, including Liza Phase 1. However, there are some common modes of potential failure for compressors in general. The most common mode of failure on compressors is dry gas seals where associated gas could get into the seals and cause their failure, which could lead to compressor malfunction. The systems have been designed to protect against such dry gas contamination but upsets can occur from time to time. As described above, installed spare compressors, along with spare parts, would enhance reliability.	No	Accepted	N/A	N/A
169	11-Nov-2021	Virtual Meeting	The fisheries study is an ecological one and does not look at the socio-economic impacts. It is not a baseline study of the fishing industry.	Fish and fisheries were described from both a socioeconomic perspective (Volume II, Appendix D, Participatory Fishing Study Final Report January 2019–March 2020) and a biological perspective (Volume II, Appendix M, Nearshore and Offshore Fisheries Study Summary). These studies are complete and although an additional year of the participatory study is currently being conducted, the data provided in the existing study reports provide ample baseline data to conduct the EIA.	No	Accepted	N/A	N/A
170	11-Nov-2021	Virtual Meeting	What radioactive substances come to shore and how are they treated? How is the radioactive waste that is coming to shore being treated?	There would be no treatment or disposal of radioactive sources from the Project in Guyana. All radioactive sources used during operations would be managed in accordance with conditions or approvals granted by the EPA and strict safety standards such as those set out by the International Atomic Energy Agency.	No	Accepted	N/A	N/A
171	11-Nov-2021	Virtual Meeting	The Haags-Bosch is not licensed or engineered for chemical waste. It is an extremely basic landfill meant to	The EPA and the Ministry of Local Government and Regional Development have authority over the permitting and operation of the HBL. No hazardous waste would be disposed at the HBL.	No	Accepted	N/A	N/A

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			sequester household waste - not industrial waste.					
172	11-Nov-2021	Virtual Meeting	Where are you putting the material cleaned up from a potential spill?	As described in Response #128, waste generated as a result of a spill response would be managed using licensed waste treatment and disposal facilities in accordance with the approved CWMP (see EPA website) and in consultation with the EPA. These facilities could include licensed Guyana-based treatment and disposal facilities and/or other regional facilities. OSRP Section 5.11 (included in Volume III of the EIA) describes the categories of waste that could be generated and the key steps of the process by which waste produced in a response scenario would be managed.	No	Accepted	N/A	N/A
173	11-Nov-2021	Virtual Meeting	Did or does the fisheries study include Caribbean fisheries?	The marine fish study and the participatory fishing study were limited to Guyanese waters.	No	Accepted	N/A	N/A
174	11-Nov-2021	Virtual Meeting	How much produced water is or will be stored on the FPSO?	The FPSO would not store produced water, with the exception of off-specification produced water which would be routed to an off-specification produced water tank (9,700 m^3 capacity), where it would be temporarily stored prior to reintroduction into the produced water treatment process. Produced water would be discharged overboard after being treated to the discharge specification of less than 42 mg/L daily or 29 mg/L monthly average oil-in-water content.	No	Include justification in EIA	Section 2.7.4.5 of the EIA has been updated to clarify that the off-specification tank is the only location on the FPSO where produced water will be stored.	p. 2-48
175	11-Nov-2021	Virtual Meeting	Also, if a spill does occur and you clean up, where will you dump the toxic waste? The EIA says nothing about this.	The waste generated as a result of a spill response would be managed using licensed waste treatment and disposal facilities in accordance with the approved CWMP and in consultation with the EPA. These facilities could include licensed Guyana-based treatment and disposal facilities and/or other regional facilities. OSRP Section 5.11 (included in Volume III of the EIA) describes the categories of waste that could be generated and the key steps of the process by which waste produced in a response scenario would be managed.	No	Accepted	N/A	N/A
176	11-Nov-2021	Virtual Meeting	The Yellowtail proposal indicates flow lines, umbilicals, abandoned equipment, mooring lines, anchor piles, subsea equipment - all will be abandoned on Guyana's seashore. This is contrary to best practices in the oil industry? Which best practice standards have you applied to this study? Is this the World Bank and IFC (International Finance Corporation) standard?	For well P&A, ExxonMobil P&A guidelines are broadly consistent with Oil and Gas UK's Well Decommissioning Guidelines, Issue 6 (June 2018). As described in the Preliminary End of Operations Decommissioning Plan included in Volume III of the EIA, globally ExxonMobil employs good international oilfield practice for decommissioning and abandonment. For offshore facilities, this includes utilizing IMO Resolution A.672(16) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the EEZ as a basic standard worldwide, as well as the UK Offshore Petroleum Regulator for Environment and Decommissioning's (OPRED's) "Offshore Oil and Gas Decommissioning Guidance Notes" December 2018, (ANNEX A—A Guide to Comparative Assessments). These embody the principle that where a decision is made to allow an offshore installation, structure, or parts thereof to remain on the seabed, it should be based on a case-by-case evaluation (by the jurisdiction over the installation or structure). Abandonment of selected equipment on the seafloor as part of decommissioning is currently proposed but further approvals would be required before this plan could be implemented. The industry supports the use of a Multi-Criteria Decision Analysis (MCDA) as the facilities are approaching end of production life in order to holistically evaluate the decommissioning approach for the subject facilities. The MCDA	No	Accepted	N/A	N/A

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				evaluates the potential safety and health, environmental, social, and economic risks; as well as technological challenges/developments that may be needed for the decommissioning options analysis (including reefing). Given the length of expected operational timelines and potential advancements in technology it is difficult to determine final disposition at this time. Therefore, industry general practice in these depths for SURF facilities is to remain in place at time of initial installation; however it will be re-evaluated as the field reaches end of life using an MCDA.				
177	11-Nov-2021	Virtual Meeting	What is the difference in risk between following international best practice and leaving all this toxic junk on the seafloor? How is this good decommissioning practice? Isn't the best practice to remove the structures when decommissioning. Leave the seafloor as you found it?	As described in the Preliminary End of Operations Decommissioning Plan included in Volume III of the EIA, globally ExxonMobil employs good international oilfield practice for decommissioning and abandonment. For offshore facilities, this includes utilizing IMO Resolution A.672(16) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the EEZ as a basic standard worldwide, as well as the UK Offshore Petroleum Regulator for Environment and Decommissioning's (OPRED's) "Offshore Oil and Gas Decommissioning Guidance Notes" December 2018, (ANNEX A—A Guide to Comparative Assessments). These embody that where a decision is made to allow an offshore installation, structure, or parts thereof to remain on the seabed, this should be based on a case-by-case evaluation (by the jurisdiction over the installation or structure). For well P&A, ExxonMobil P&A guidelines are broadly consistent with Oil and Gas UK's Well Decommissioning Guidelines, Issue 6 (June 2018).	No	Accepted	N/A	N/A
178	11-Nov-2021	Virtual Meeting	What guidelines are the EPA using to assess this EIA?	The comment should be referred to the EPA.	No	Accepted	N/A	N/A
179	11-Nov-2021	Virtual Meeting	Can you clarify if Yellowtail is not going to re-inject the produced water, then that appears to contradict clause 12 of the PSA 2016. And if XOM can unilaterally change the PSA 2016, you would agree that the government also change its mind on specific items in the PSA? Is the EPA willing to hold Exxon to reinjecting the produced water versus its preference for easier work in just releasing the water into our marine habitat? This is in addition to produced water released by the Liza One, Liza Two and Payara Projects. How does the EPA intend to monitor all of this? Does the EPA know what technologies will be used by ExxonMobil in this regard?	The Consultants acknowledge the statements and questions about the Production Sharing Agreement (PSA). The questions related to the content of the PSA are beyond the scope of the EIA. The Consultants acknowledge the questions about the EPA. These comments should be referred to the EPA.	No	Accepted	N/A	N/A
180	11-Nov-2021	Virtual Meeting	For seismic guns, at what distance can these noises be detected by whales? And how fast do whales swim?	The distance at which whales can detect a seismic impulse varies according to numerous factors, including but not limited to the type of seismic source, the species of whale, and the ambient sound levels in the environment at the time. Swimming speed also differs significantly by species, but the fastest	No	Kindly verify the speed of these marine mammals	The units included in the original response were incorrect. The statement should	N/A

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				whales can swim slightly faster than 20 kilometers per hour (746 miles per hour).			have read "…but the fastest whales can swim slightly faster than 32 km per hour (20 miles per hour).	
181	11-Nov-2021	Virtual Meeting	Can you say what will be the monthly average and daily maximum concentrations (mg/L) miligrams per litre of total oil destined for in produced water and other discharges for ocean disposal?	As noted in Chapter 2 of the EIA, the FPSO would be designed to accommodate an annual average produced water capacity of up to 225,000 BPD (36,000 m^3 per day). Peak rates would potentially be higher during the lifetime of the Project, depending on multiple factors (e.g., reservoir pressure, number of wells, equipment reliability, etc.). Produced water would be discharged overboard only after being treated to the discharge specification of less than 42 mg/L daily or 29 mg/L monthly average "oil-in-water" content. Details related to the treatment of produced water are provided in EIA Section 2.7.4.5.	No	Accepted	N/A	N/A
182	11-Nov-2021	Virtual Meeting	How are you going to treat the produced water from Yellowtail wells? To what standards? Name the standards that you will be using.	See the response to Comment #181.	No	Accepted	N/A	N/A
183	11-Nov-2021	Virtual Meeting	Can you say how and where you will be treating your produced 'waste-water'? Which components of the produced water will be treated?	See the response to Comment #181.	No	Accepted	N/A	N/A
184	11-Nov-2021	Virtual Meeting	What dynamic data do you have to allow you to make these assessments of negligible to minor impacts on fish? Please specify the international standards that you used.	There are no international standards for determining the significance of impacts on fish, so the Consultants used a combination of international standards (e.g., International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 [MARPOL 73/78]) to establish the magnitude of impacts on physical habitat characteristics (e.g., water quality) that could have implications for fish, and a weight-of-evidence approach and literature reviews to assess impacts that were not related to physical habitat characteristics. All impact ratings were determined using the impact rating system described in Chapter 4 of the EIA.	No	Accepted	N/A	N/A
185	11-Nov-2021	Virtual Meeting	The question to explore is why is fish production declining and we have just a few wells now versus 162 wells when Liza 1, Liza 2, Payara, and Yellowtail gets going.	As a baseline matter, EIA Section 8.1, Socioeconomic Conditions, discusses the issue of declining fish catches. See additional information in the response to Comment #207.	No	Accepted	N/A	N/A
186	11-Nov-2021	Virtual Meeting	The gas compressor malfunctioning was a big challenge for Exxon. Can EPA say how much fines were collected for flaring and what amounts of flared gas?	Questions related to enforcement actions on a separate project are beyond the scope of the EIA.	No	Accepted	N/A	N/A
187	11-Nov-2021	Virtual Meeting	Which Caribbean countries would be affected for instance and have they been consulted or apprised?	EIA Section 9.24 discusses potential transboundary impacts, including an identification of other countries that could be affected by a loss-of-well-control event. The Yellowtail EIA process did not include consultation with stakeholders outside Guyana, but the EIA was available for review on the EPA's website and any comments from persons outside of Guyana could have been submitted to the EPA during the 60-day review period. As described in Chapter 9, EEPGL would work with the Government of Guyana	No	Accepted	N/A	N/A

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				and other countries as appropriate to coordinate a response to an oil spill with the potential to affect other countries.				
188	11-Nov-2021	Virtual Meeting	Does Guyana have any specific legislation to command waste disposal? Or are we reduced to depending on extractor charity that they will be responsible for?	Relevant Guyana legislation includes the Environmental Protection Hazardous Waste Regulations (2000). Waste management procedures, described in the CWMP (see EPA website), would also be guided by applicable international standards. All waste treatment and disposal facilities that would be used by the Project would be permitted.	No	Accepted	N/A	N/A
189	11-Nov-2021	Virtual Meeting	Where are the drilling cuttings being discharged?	Water-based drill cuttings would be discharged at the seabed. Non-aqueous-based drill cuttings would be discharged overboard from the drill ship after treatment to relevant international standards.	No	Accepted	N/A	N/A
190	11-Nov-2021	Virtual Meeting	EEPGL ESMP speaks to a Flare Minimisation Plan being developed. Would this be a pre-requisite to approval of the ESIA?	Flaring minimization is discussed in the EIS and in EIA Section 6.1.3.2, Emissions of Air Quality Pollutants. As described, EEPGL would develop a flaring minimization plan to document the design measures, such as reinjection of associated gas, and operational practices that minimize flaring during Project FPSO operations.	No	Accepted	N/A	N/A
191	11-Nov-2021	Virtual Meeting	Does the flare minimisation plan include the re-injection of the up to 620 MMscfd as indicated in the Yellowtail Project Summary (see below)?	The Yellowtail Project Summary, submitted as a part of Application for Environmental Authorisation, refers to 620 MSCFD as a maximum gas production rate predicted at the time of the application submission on 1 April 2021. At the time of EIA development, EEPGL re-evaluated the gas production rate estimate to be 450 MSCFD (EIS Table EIS-1: FPSO Key Design Rates).	No	Accepted	N/A	N/A
192	11-Nov-2021	Virtual Meeting	A list of the Emergency Response Preparedness training equipment along with the cost and dates of arrival must be included in the EIA.	OSRP Table 6-1 lists or otherwise describes the international, regional, and local resources available to EEPGL for each potential response strategy. OSRP Tables 6-2 through 6-7 provide a further summary of the representative oil spill response equipment in Guyana.	No	Accepted	N/A	N/A
193	11-Nov-2021	Virtual Meeting	What legislation covers the cradle to grave waste generated by the company?	See the response to Comment #188.	No	Accepted	N/A	N/A
194	11-Nov-2021	Virtual Meeting	Will insurance cover biodiversity loss?	The Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts, including potential impacts on biodiversity. The co-venturers have the financial capacity to meet their responsibilities in case of an event. Pollution insurance policies today are not designed to address natural resources damages such as biodiversity loss.	No	Accepted	N/A	N/A
195	11-Nov-2021	Virtual Meeting	What policy covers the transboundary movement of waste?	EIA Section 8.6, Waste Management Infrastructure Capacity, describes the protocols and international agreements that pertain to the transboundary movement of waste.	No	Accepted	N/A	N/A
196	11-Nov-2021	Virtual Meeting	Have you addressed the cumulative impacts of EEPGL's operations on global temperature?	See the response to Comment #117 for discussion of assessment of GHG emissions on global climate change. The predicted impacts from Project air emissions, including those from GHG emissions, are described in EIA Section 6.1, Air Quality, Climate, and Climate Change. Cumulative impacts to air quality and climate / climate change are addressed in Chapter 10, Cumulative Impacts Analysis.	No	Accepted	N/A	N/A
197	11-Nov-2021	Virtual Meeting	How will produced water be treated, and to what standards? How and where will the produced waste water	Details related to the treatment of produced water are provided in EIA Section 2.7.4.5, Produced Water Treatment.	No	Accepted	N/A	N/A

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			be treated and which components will be treated?					
198	11-Nov-2021	Virtual Meeting	How much produced water will be stored on the FPSO?	See the response to Comment #174.	No	Accepted	N/A	p. 2-48
199	11-Nov-2021	Virtual Meeting	Will Yellowtail re-inject the produced water? If not, that would be a contradiction of clause 12 of the 2016 PSA.	The Yellowtail Development Project proposes to manage produced water via treatment and discharge overboard in accordance with good international oilfield practices.	No	Accepted	N/A	N/A
200	11-Nov-2021	Virtual Meeting	There is no comprehensive mapping of the fish nurseries in Guyana or the neighbouring feed on. There is no indication of migratory patterns of commercial and non-commercial species.	Fish and fisheries were described from both a socioeconomic perspective (Volume II, Appendix D, Participatory Fishing Study Final Report January 2019–March 2020) and a biological perspective (Volume II, Appendix M, Nearshore and Offshore Fisheries Study Summary). These studies are complete and although an additional year of the participatory study is currently being conducted, the data provided in the existing study reports provide ample baseline data to conduct the EIA.	No	Accepted	N/A	N/A
201	11-Nov-2021	Virtual Meeting	There is no description of the fisheries value chain in terms of economic or social value to Guyana.	See the response to Comment #200.	No	Accepted	N/A	N/A
202	11-Nov-2021	Virtual Meeting	There is no information on chemical studies/testing conducted on fishes.	See the response to Comment #200.	No	Accepted	N/A	N/A
203	11-Nov-2021	Virtual Meeting	There was no baseline data collected on fishes and fisheries prior to the commencement of conducting seismic surveys.	See the response to Comment #200.	No	Accepted	N/A	N/A
204	11-Nov-2021	Virtual Meeting	Is there liability on the part of the company for disposing hazardous waste in the landfill when it does not function as it should?	The Project would utilize permitted waste management facilities, which could include the HBL for management of the Project's non-hazardous waste—pending its permitted and operational status at the time Project waste generation occurs. No hazardous waste would be disposed of at the HBL. The EPA and the Ministry of Local Government and Regional Development have authority over the permitting and operation of the HBL.	No	Accepted	N/A	N/A
205	11-Nov-2021	Virtual Meeting	How do you evaluate the impact of your activities in a country that is still undergoing training for radiation spill management?	Radioactive materials in some of the equipment utilized by the Project would be stored at controlled locations as approved by Guyana authorities and would not be disposed in Guyana-based facilities. All radioactive sources used during operations would be managed in accordance with conditions or approvals granted by the EPA, under appropriate safety standards such as those set out by the International Atomic Energy Agency.	No	Accepted	N/A	N/A
206	11-Nov-2021	Virtual Meeting	What kind of toxic waste will be coming to shore, what is the composition, how much will be coming to shore, how is it being treated, where will it be disposed of, and what standards are being used?	In developing its approved CWMP (see EPA website), EEPGL has completed a study known as the Cradle to Grave Waste Study that describes the management of all of EEPGL's wastes from point of generation.	No	Accepted	N/A	N/A
207	11-Nov-2021	Virtual Meeting	News today says we are now importing fish from Jamaica. The Bank of Guyana half year report says shrimp and fish production	The last Bank of Guyana report related to fisheries that the Consultants reviewed was from 2020, which indicated that declines in finfish and shrimp production were due to decreases in demand due to COVID-19 restrictions (fish) and weather conditions combined with an extended closed season for	Yes	Accepted	N/A	7-193 to 7-194

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			declining. Did ERM look at that study?	shrimp fishing (shrimp). Several comments were received during the EIA disclosure process indicating that fish catches had declined significantly in recent years. EIA Section 8.1.2, Existing Conditions—Socioeconomic Conditions, identifies several possible causes for perceived declines in catches over the last several years, including interference with fishing activities by sargassum, inclement weather, unsustainable/illegal fishing practices, and more recently, COVID-19-related declines in fishing effort. Additional information was added to EIA Section 7.8.2.2, Targeted Surveys of Continental Shelf Fish Community, to further address this issue.				
208	11-Nov-2021	Virtual Meeting	Increased cost of living is a minor impact? For whom is this considered minor?	The significance of impacts is rated according to the methods described in Chapter 4 of the EIA. The rating for cost-of-living increases is meant to apply generally to Guyanese society.	No	Accepted	N/A	N/A
209	11-Nov-2021	Virtual Meeting	Have cost of living surveys been commissioned or is this all speculative?	No cost-of-living surveys have been commissioned as part of the Yellowtail EIA. However, EIA Section 8.1, Socioeconomic Conditions, evaluates potential impacts to cost of living as a result of the Project, with reference to available data including primary information gathered through interviews in 2021.	No	Accepted	N/A	N/A
210	11-Nov-2021	Virtual Meeting	Oil is gobbling up prime real estate, waterfront property. How will this affect the non-oil sector?	Offshore developments such as Yellowtail consume relatively little real estate because most activity is offshore and most onshore oil and gas-related activity occurs at shorebases that are designated for industrial activities and service other maritime industries.	No	Accepted	N/A	N/A
211	11-Nov-2021	Virtual Meeting	The purpose of an EIA is to gather information to allow a comprehensive risk assessment of the USD >9 billion Yellowtail development. I don't see this in the EEPGL/ERM Study. It does not take a proper risk management approach. A corporate risk assessment should cover: • Exploration • The production of oil and of water and of associated gas. • The FPSO and its activities. • The tankers that are coming in to load from the FPSO. • All the support vessels • The shore bases • And the contractors What are the different kinds of risks? How did you determine the probability of each risk? And for each risk, where is your assessment of the range of intensities of negative impacts, and the probabilities which of course	Most of the elements listed in the comment are assessed in the EIA (produced water and associated gas, activities on the FPSO, tanker and support vessel activities). Operation of most Project facilities would be contracted, so contractor activities are covered within the scope of the relevant EIA sections for each Project component. Activities at shorebases are not covered in the EIA because they are owned and operated by third parties under separate environmental authorizations. Exploration activities are also subject to separate authorizations, and are thus not covered in the EIA. The Cumulative Impact Assessment in the EIA (Chapter 10) assesses other reasonably foreseeable non Project-related impacts—including shorebases and EEPGL exploration activities—that could potentially contribute to impacts on the same resources that would be affected by the Project. As discussed in Chapter 9, Unplanned Events, the impact assessment methodology for planned events is based on a worst-case assumption that all impacts associated with planned activities would be certain to occur with a 100% probability. The EIA also evaluated risks in terms of the potential for unplanned events to occur during the Project life. These include various types of hydrocarbon spills, marine vessel collision, offshore discharge of untreated wastewater from the FPSO, and an onshore vehicular accident. Likelihood was estimated on the basis of experience and/or evidence that such an outcome has previously occurred. Chapter 9 describes the potential consequence of each event, its likelihood of occurring, and resultant risk rating. Assessing risk for each of these events was based on the potential consequence/severity of the unplanned event if it were to occur and the likelihood of the unplanned event occurring. The consequence/severity	No	Accepted	N/A	N/A

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			change over the range. Where in the EIA did you account for time?	element of the risk rating was assigned based on the sensitivity of the resource/receptor and the magnitude of the impact. Changes in impacts over time were addressed by Project stage for each resource with impact ratings provided for each stage.				
212	11-Nov-2021	Virtual Meeting	This is the 4th Project, but monitoring is still the 1st unknown after getting oil. Therefore evidence of monitoring of Guyana's assets and environment in the previous 3 projects MUST be a prerequisite to approval of any further project.	To the extent that the comment is not related to the Yellowtail Project, it is beyond the scope of the EIA. However, ESMP Table 3.6-1 (included in Volume III of the EIA) presents the monitoring measures recommended by the Consultants for the Yellowtail Project. EEPGL is also in the process of developing a framework for enhanced monitoring, reporting, and verification, including the EPA's opportunities to independently verify EEPGL's compliance data.	No	Accepted	N/A	N/A
213	11-Nov-2021	Virtual Meeting	What is sparing philosophy of these compressors given the sensitivity of this issue? What is the availability of the overall gas re-injection system from topsides down to reservoir given that only three(3) gas injection wells are show in the figure below of which two are daisy-chained?	There would be installed spares on compressors for the Flash Gas Compression, Main Gas Compression, and Re-Injection Gas Compression systems, such that when one compressor trips, the spare (backup) unit can could be started to allow partial or full production to continue, reducing non-routine flaring frequency and volume/duration. The Project would also maintain an inventory of spare parts in Guyana. The Yellowtail Project would have three gas injection lines and up to 25 water-alternating-gas injection wells. This would enable gas injection to continue even when one or more gas injection wells or one flowline is down.	No	Accepted	N/A	N/A
214	11-Nov-2021	Virtual Meeting	There is a neglect of transboundary issues.	Transboundary impacts are discussed in EIA Section 9.24.	No	Accepted	N/A	N/A
215	11-Nov-2021	Virtual Meeting	Where is the public disclosure on Insurance and assurance?	See the response to Comment #53.	No	Accepted	N/A	N/A
216	11-Nov-2021	Virtual Meeting	EIA must contain proof of insurance, coverage amount, and maximum third party coverage, transboundary coverage before it can be approved.	Insurance and financial security are addressed in EIA Table 4.7-4. Also, see the response to Comment #53 for additional information regarding insurance coverage maintained for the Project.	No	Accepted	N/A	N/A
217	11-Nov-2021	Virtual Meeting	Will all the questions asked here and answers be included in final documents?	The questions and responses have been included to the revised EIA in a dedicated appendix, and the affected sections of the EIA have been updated as needed.	No	Accepted	N/A	Appendix U
218	11-Nov-2021	Virtual Meeting	The EIA says that an oil spill has a high intensity of impact, very low probability. How do both intensities of impact and probability of occurrence change over time, from the time you open a deep well to the decommissioning?	The EIA evaluated risks in terms of the potential for unplanned events to occur during the Project life. The assessment of risk for each of these events was based on the potential consequence/severity of the unplanned event if it were to occur and the likelihood of the unplanned event occurring. The severity of impacts from an oil spill would depend on a variety of factors including but not limited to size, location, duration, and timing (seasonality) of the spill. The likelihood of an oil spill occurring would be somewhat dependent on project stage. While a loss-of-well-control scenario would be a highly unlikely event at all stages of a project, this type of event would be more likely to occur during the installation of the well than during the production operations phase.	No	Accepted	N/A	N/A
219	11-Nov-2021	Virtual Meeting	Is there insurance for Liza 1 and 2 wells? Which company issued the insurance, what is the third-party	The Liza Phase 1 and 2 Projects were evaluated in separate, approved EIAs. The question of insurance coverage for these projects is beyond the scope of the Yellowtail Development EIA.	No	Accepted	N/A	N/A

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			coverage, and where is the proof of the insurance?					
220	11-Nov-2021	Virtual Meeting	There is also no formal guarantee between ExxonMobil and the Guyana Government that it would cover in full the shortfall of costs associated with an unmitigated spill which are not covered by its subsidiary – the shell company, Esso Exploration and Production Guyana Limited (EEPGL). Does the EPA think that is acceptable?	The Consultants acknowledge the question. The question is beyond the scope of the EIA. For information regarding financial assurance for the Project, see the response to Comment #53.	No	Accepted	N/A	N/A
221	11-Nov-2021	Virtual Meeting	How about the Guyana Government's inability to audit oil expenses? Is that socioeconomic, and does that affect such monitoring?	The Consultants acknowledge the question. Assessment of oil expenses is not considered a socioeconomic impact in the context of the EIA, and is therefore beyond the scope of the EIA.	No	Accepted	N/A	N/A
222	11-Nov-2021	Virtual Meeting	Is Guyana fully covered with insurance in the event of a well blow out?	The question of whether the country of Guyana has an insurance policy is beyond the scope of the EIA. For information regarding insurance coverage maintained for the Project, see the response to Comment #53.	No	Accepted	N/A	N/A
223	11-Nov-2021	Virtual Meeting	If the project goes awry and damage the coastlines of others, who pays? Esso or Guyana?	The Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts. The co-venturers have the financial capacity to meet the responsibilities for an event including obligations under Guyanese law and the respective petroleum agreements. Regarding insurance, the Stabroek Block co-venturers have secured comprehensive insurance for petroleum activities as required by environmental permits. Under the existing legal framework and agreements with the government, there are extensive assurances of EEPGL's and co-venturers' commitments, including environmental protection measures to respond to operational incidents. The Government of Guyana has multiple mechanisms in place, including the Stabroek Block Petroleum Agreement and the environmental permits, to ensure that the companies would take responsibility for any adverse events. Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, should the Yellowtail Project receive necessary approvals, the co-venturers would have insurance coverage including Third Party Liability and the cost of regaining control of a well.	No	Accepted	N/A	N/A
224	11-Nov-2021	Virtual Meeting	Which laws and procedures are being followed?	EIA Chapter 3, Administrative Framework, provides an overview of the relevant laws that affect the Project and the conduct of the EIA. More information on resource-specific requirements is included in the resource-specific sections in Chapters 6 through 8. The analytical procedure of rating impacts is described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment.	No	Accepted	N/A	N/A
225	11-Nov-2021	Virtual Meeting	VP Jagdeo is reported to be asking Exxon to deposit $US2 billion for insurance. In light that the Macondo 2010 spill cleanup cost was $US 60	See the response to Comment #53.	No	Accepted	N/A	N/A

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			billion+, does the EPA consider $US2B to be adequate?					
226	11-Nov-2021	Virtual Meeting	The EIA should say which standards are obligatory in the industry and which best practices are being followed. Where are these obligatory standards documented? Where can we find these best practices? Where is the logbook of each best practice? What are the monitoring and reporting procedures in respect of each standard?	The EIA identifies applicable legal or regulatory requirements, as well as relevant national or international guidelines, that were applied in the design of the Project, in the impact assessment, and in recommendations for management measures—included in Chapter 2, Chapters 6 through 8, and in the ESMP. Chapter 3 and the applicable administrative framework tables at the beginning of each resource-specific section in Chapters 6 through 8, as applicable, along with recommended management measures and the ESMP, identify applicable requirements. If the Project is approved by the EPA, such requirements would also be considered a condition of the Environmental Permit issued for the Project. The ESMP, included in Volume III of the EIA, makes several recommendations regarding monitoring that should be conducted if the Project is approved.	No	Should be addressed following meeting with the Redford group	Per the response to Redford Group's comments, the legislation, policies, and treaties referenced in Chapters 6, 7, and 8 of the EIA have been added to Chapter 3, so that all administrative requirements to which the project would be subject can be reviewed in one place in the EIA.	pp. 3-10 to 3-22
227	11-Nov-2021	Virtual Meeting	Where are the reports from monitoring from Liza-1 wells?	Monitoring related to the Liza Phase 1 project is not within the scope of this EIA.	No	Accepted	N/A	N/A
228	11-Nov-2021	Virtual Meeting	Name the independent auditors that are verifying which aspects of your operation(s). Where are the audit reports published?	No auditing is currently being done for the Yellowtail Project because the Project has not been approved yet. The ESMP, included in Volume III of the EIA, makes several recommendations regarding monitoring that should be conducted if the Project is approved.	No	Accepted	N/A	N/A
229	11-Nov-2021	Virtual Meeting	Please share the pre-treatment and monitoring of pollutants and hazardous elements prior to discharge in accordance with permit requirements, international conventions, standards and best oil & gas industry practice.	EIA Section 2.7.4, FPSO Process Systems, discusses the treatment systems that would be used for effluent discharges from the FPSO. The ESMP describes the details of the commitments for monitoring and reporting to which the Project would adhere.	No	Accepted	N/A	N/A
230	11-Nov-2021	Virtual Meeting	Please take into account the closely interrelated impacts of the Exxon-Mobil related shore-based service hazardous waste facilities (such as Schlumberger radioactive waste facility at Houston EBD) and include these impacts on the general health and well-being of humans.	There is currently no proposal, design, or permit application for additional shore-based waste management facilities that would serve the Yellowtail Development Project, so there is no such project to include in the cumulative impact assessment in the EIA. Under the Environmental Protection Act, additional onshore support facilities, including waste management facilities, would require separate environmental permitting processes and associated environmental analyses to support those permitting processes. These environmental analyses would assess impacts on human health and wellbeing, as appropriate.	No	Accepted	N/A	N/A
231	11-Nov-2021	Virtual Meeting	What are the risks that you assessed? And how are the risk probabilities assigned?	The EIA evaluates risks in terms of the likelihood for unplanned events to occur during the Project life and the potential consequence/severity of the unplanned event if it were to occur. The consequence/severity element of the risk rating was assigned based on the sensitivity of the resource/receptor and the magnitude of the impact. Likelihood was estimated on the basis of experience and/or evidence that such an outcome has previously occurred. Chapter 4 outlines the methodology in greater detail and Chapter 9 describes the potential consequence of each event on the various resources and	No	Accepted	N/A	N/A

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				receptors, their assessed likelihood of occurring, and the resultant risk ratings (e.g., “Minor,” “Moderate,” etc.).				
232	11-Nov-2021	Virtual Meeting	Please explain how you have complied with FPIC recommendations in relation to the Indigenous communities in Regions 1, 2, and 3?	EEPGL respects the rights and cultures of Indigenous Peoples and commits to conducting meaningful consultations with them, incorporating traditional knowledge and use into its plans, and seeking mutually beneficial long-term relationships. EEPGL further recognizes that Free, Prior and Informed Consent is a process by which accurate, accessible, and timely information is shared in regard to proposed developments, with opportunities for constructive and two-way dialogue. EEPGL’s stakeholder engagement program has included (and continues to include) indigenous communities and Toshaos in Regions 1 and 2. EEPGL has been responsive to the questions, concerns, and interests of indigenous stakeholders and continues to work with these communities to identify opportunities to support local benefits.	No	Include justification in EIA	This information has been added to Section 4.7.1 of the EIA.	pp. 4-8 to 4-9
233	11-Nov-2021	Virtual Meeting	How would you calculate “insurance” for the Caribbean Islands?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
234	11-Nov-2021	Virtual Meeting	At what stage of the EIA process does the EPA grant permission for the project to go ahead with or without insurance?	The Consultants acknowledge the question. The comment should be referred to the EPA.	No	Accepted	N/A	N/A
235	11-Nov-2021	Virtual Meeting	Why wasn’t the consultation extended to other Caribbean nations which will potentially be impacted by an oil spill?	The question is beyond the scope of the EIA. The Yellowtail EIA process did not include consultation with stakeholders outside Guyana, but the EIA was available for review on the EPA’s website and any comments from persons outside of Guyana could have been submitted to the EPA during the 60-day review period.	No	Accepted	N/A	N/A
236	11-Nov-2021	Virtual Meeting	How can the EIA and the consultant be trusted if the document was cosigned as being prepared by a member of the governing party? There is no indication of a conflict of interest in the document.	The Consultants did not engage with or involve the referenced individual to provide support to the Yellowtail Development Project EIA. The referenced individual's signature was inadvertently included on the cover of the version of the EIA Non-Technical Summary (NTS) for the Yellowtail Development Project that was posted on the EPA’s website. A corrected version of the NTS has been posted on the EPA website in place of the incorrect version.	No	Accepted	N/A	N/A
237	11-Nov-2021	Virtual Meeting	How do you present an EIA will still collecting baseline data, as in the case of fisheries?	Fish and fisheries are described from both a socioeconomic perspective (Appendix D, Participatory Fishing Study Final Report January 2019–March 2020) and a biological perspective (Appendix M, Nearshore and Offshore Fisheries Study Summary). These studies are complete and although an additional year of the participatory study is currently being conducted, the data provided in the existing study reports provide ample baseline data to conduct the EIA.	No	Accepted	N/A	
238	15-Dec-2021	Fair Deal for Guyana	**What are the Greenhouse Gas (GHG) Emissions from the proposed Yellowtail project?** Section 11 (4)(a) of the EP Act requires the developer to identify, describe and evaluate the direct and indirect effects of the proposed project on the environment. The environment includes the atmosphere and climate.	The estimated GHG emissions from the Yellowtail Project are presented in EIA Section 2.13.2, Emissions, and Section 6.1.3.4, Characterization of Potential Impacts—Climate / Climate Change. These represent the estimated Scope 1 and Scope 2 GHG emissions for the full Yellowtail Project life cycle, noting that estimated Scope 2 GHG emissions from the Project would be *de minimis*—as the components and activities comprising the Project would utilize a negligible amount of electricity, if any, from third-party sources. An estimate of end-use GHG emissions from the Project is not within the scope of the EIA, which complies with the Environmental Protection Act and applicable regulations. This is consistent with guidance for the oil and gas	No	Accepted	N/A	N/A

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			(i) What are the total scope 1, scope 2 and scope 3 greenhouse gas emissions from the Yellowtail project? (ii) What would be the effect of those greenhouse emissions on the climate system? (iii) What would be the effect of those greenhouse emissions on the ocean?	industry which recognizes that reporting end-use (sometimes referred to as "Scope 3") GHG emissions may not be possible under circumstances such as the current Project. The guidance, published by the IPIECA states, "[I]n certain cases, the eventual end use of sold intermediate products may be unknown, and companies may be unable to reasonably estimate the downstream emissions associated with processing, end uses or waste of the intermediate product. In such cases, companies can disclose and justify the exclusion of downstream emissions in any account." See IPIECA, Estimating petroleum industry value chain (Scope 3) greenhouse gas emissions - Overview of methodologies, https://www.ipieca.org/resources/good-practice/estimating-petroleum-industry-value-chain-scope-3-greenhouse-gas-emissions-overview-of-methodologies (accessed 23 November 2021). As discussed in EIA Section 6.1.3.4, potential climate / climate change impacts are a global concern and stem from cumulative worldwide GHG concentrations. The Global Circulation Models used to predict climate impacts from global concentrations are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project such as the Yellowtail Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate using observed data, and can be used to estimate future local climate changes based on the results of Global Circulation Models. However, the reverse approach of predicting the impact of local GHG emissions on global (or local) climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions. For these reasons, while it is possible to quantify the total GHG emissions from the Project, it is difficult to assign an impact magnitude rating that reflects the potential effects the climate / climate change will experience specifically as a result of the Project (as is done for other resources assessed in the EIA). Recognizing this limitation, this EIA provides a qualitative rating for impact significance. The assessment of potential impact significance for the Project's impacts on global climate / climate change is conducted differently from the assessment for other resources. The approach taken in the EIA is to assign a significance rating for potential Project GHG emissions, as a proxy for impacts on global climate change, based on the following factors: • Comparison of Project GHG emissions to those of Guyana (i.e., without the Project) and to regional and global GHG emissions; and • Comparison of Project GHG emissions to those of the global oil and gas industry. Additionally, while the EIA cannot assess potential impacts of the Project emissions on climate / climate change, EIA Section 6.1.2.3, Current Scientific Understanding of Consequences of Climate Change, provides a discussion of the current scientific understanding of consequences of climate change. Section 6.1.2.3 provides a discussion of the current scientific understanding of consequences of climate change, including a discussion of potential sea level rise, ocean temperature, and ocean acidification.				
239	15-Dec-2021	Fair Deal for Guyana	**What would be the full extent of the climate damage caused by the proposed Yellowtail project?**	As noted in the response to Comment #238, an estimate of end-use (Scope 3) GHG emissions from the Project is not within the scope of the EIA. This complies with the Environmental Protection Act, and is consistent with	No	Accepted	N/A	N/A

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			Page 2 of the Project Summary states: "The production facilities to be installed include subsea equipment attached to the seafloor as well as processing equipment on the ocean's surface known as a Floating, Production, Storage, and Offloading (FPSO) vessel (see Figure 11). …. "The FPSO is an industrial floating complex that continuously separates produced water and associated gas from the oil. The anticipated production rate for the FPSO ranges between approximately 34 977 m3 (220,000 barrels) and 39 747 m3 (250,000 barrels) of oil per day." ExxonMobil Corporation's business model is to extract oil and convert it to energy, such as the transportation fuels the company sells. is the intention that nearly all such oil the project generates be combusted, resulting in emissions of CO2 that further raise atmospheric levels of CO2. It is well established that emissions of CO2 increases the global burden of adverse climate consequences caused by rising atmospheric levels of greenhouse gases. The EIA for the proposed Yellowtail Project must provide a full accounting of the cost of the climate damages associated with the project, including costs associated with emissions of CO2 from the intended ultimate use of the project's expected production of oil and gas. The most recent estimate of the cost of greenhouse emissions is $417 for every ton of CO2 emitted into the atmosphere under the most widely expected climate scenarios. See: Ricke, K., Drouet, L., Caldeira, K., & Tavoni, M. (2018). Country-level social cost of carbon. Nature Climate Change, 8(10), 895.	guidance for the oil and gas industry. The United Kingdom has similar statutes and regulations to the Environmental Protection Act, and does not require reporting of end-use GHG emissions from crude oil production projects. Like in Guyana, regulations in the United Kingdom require EIAs for petroleum production projects to include descriptions of the direct and indirect significant effects of the relevant project on human health, biodiversity and land, soil, water, air and climate (see United Kingdom Offshore Petroleum Production and Pipelines [Environmental Impact Assessment and Other Miscellaneous Provisions] [Amendment] Regulations 2017). Those regulations are not interpreted to require reporting of estimated end-use GHG emissions. Furthermore, the UK's Offshore Petroleum Regulator for Environment and Decommissioning uses similar language in its guidance for producing EIAs, but does not require reporting of end-use GHG emissions.				

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240	15-Dec-2021	Fair Deal for Guyana	**Well blowout** The proposed Yellowtail project is in the Stabroek Block which is located in the Amazon-Orinoco influence zone an area of high biodiversity. The Yellowtail Development Project proposed by EEPGL involves wells that would be drilled at great depths. This ultra-deep water drilling is extremely dangerous and carries the risk of a well blow out like the Macondo/Deepwater Horizon catastrophe in 2010 which killed 11 people, devastated wildlife populations and destroyed livelihoods. It also cost BP more than US$68Bn.1 A well blow out would be a catastrophic event that could damage/destroy marine ecosystems in Guyana and the Caribbean. In testimony to the Hearing before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce House of Representatives 111th Congress on 17 June 2010, Rex Tillerson the then CEO of ExxonMobil stated that the response capability to respond to a spill did not exist and probably never will. 1. Does the response capability to a spill exist now and if so what is it? 2. Can EEPGL guarantee that there will be no well blowout? 3. If a well blows out, how long will it take for EEPGL to bring a capping stack to the well? 4. How long will it take for EEPGL to fit the capping stack to the well? 5. Who will EEPGL employ to transport and fit the capping stack? 6. How will EEPGL remove from the ocean the oil that surges into the ocean from a well blow out?	1. EIA Volume III OSRP Table 6-1 lists or otherwise describes the international, regional, and local resources available to EEPGL for each potential response strategy. 2. EEPGL cannot guarantee that there would be no well blowouts. However, with all mitigation measures in place, a well blowout would be an exceptionally unlikely event. 3. As described in EIA Volume III OSRP Section 6.3.4, EEPGL has a subscription with Boots & Coots (in Houston, Texas) for access to the Boots & Coots GRIP system, which includes a 15k capping stack, debris removal equipment, and other associated equipment. The GRIP system is an air-freightable system that is located adjacent to George Bush Intercontinental Airport. A response time analysis indicates that the capping stack deployment would be possible within 5 days, assuming no debris removal activities are required. 4. Capping stack deployment and installation are influenced by a number of factors including, but not limited to, weather, sea state, capping stack type, deployment method, well discharge properties, and subsea hardware condition. Assuming no debris removal is required along with favorable installation conditions (e.g., good sea state, good ROV visibility at seafloor, vertical attachment point), capping stack deployment and installation are estimated to take 12 to 24 hours. However, adverse conditions (e.g., poor sea state, poor ROV visibility at seafloor, non-vertical attachment point) could complicate operations and result in prolonged capping stack deployment and installation time. 5. In the event that a capping stack is required, the GRIP system would be air-freight to Guyana from the United States by Boots & Coots and sea delivered to the location using existing EEPGL logistics' resources in Guyana. 6. For potential spills larger in nature, the use of all available response resources including mechanical recovery, burning product on water and dispersants is anticipated. Leveraging results of the NEBA for selection of response technologies is vital to the responses decision making process. A NEBA or the Spill Impact Mitigation Assessment is a process used by the response community for making the best choices to minimize impacts of oil spills on people and the environment. During spill modeling reviews, EEPGL completed NEBA studies for a Tier III (loss of well control) and Tier II (crude spill from FPSO loading operations) by applying different available response options. The NEBA process helps identify and select the option or combination of options that minimizes overall harm to environmental and socioeconomic resources (including cultural sensitivities). The combination of response options and strategies is factored into OSRP Table 3-1: Possible Hydrocarbon Release Scenarios by Tier content. 7. Response equipment is described in EIA Volume III OSRP Table 6-1. According to the table, 22 boats are available to support oil spill response. 8. See the response to Comment #53 for additional information regarding insurance coverage maintained for the Project. 9. In the very unlikely oil spill event that would have transboundary impacts on the neighboring Caribbean countries, EEPGL would work through the	No	Accepted	N/A	N/A

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			7. How many boats and personnel will EEPGL have available for clean up? 8. How much money will set aside to pay for the costs of clean up? 9. Will EEPGL pay compensation to the Caribbean islands for damage to their fishing and tourism industries? 10. Is it possible for oil to reach Guyana's coast and rivers? 11. What would be the impact of oil on Guyana's coast and rivers, including the impact on marine and freshwater wildlife and ecoystems?	Ministry of Foreign Affairs, at the direction of the Government of Guyana, to establish appropriate claims and/or livelihood remediation processes. 10. Based on modeling, an unmitigated Most Credible and Worst Case oil spill could reach Guyana's coast and enter to the rivers with high tides. 11. EIA Table 9.6-3: Risk Ratings for Unplanned Event Impacts on Coastal Habitats illustrates potential impacts on coastal habitats as Minor to Moderate, depending on the nature of the event.				
241	15-Dec-2021	Fair Deal for Guyana	• How does EEPGL plan to comply with international best practices in regard to deep water wells? The inability to activate, or trigger, the blowout preventer and regain well control during the Macondo disaster in the Gulf of Mexico spill exposed a serious design defect of oil exploration wells in deep water. As a result of the Deepwater Horizon oil spill, the U.S. Bureau of Safety and Environmental Enforcement (BSEE) finalized a rule intended to prevent another similar disaster by imposing design requirements for blowout preventers and related equipment for controlling a well in the event of a serious accident. Please refer to 30 CFR Part 250, Subpart G - Well Operations and Equipment2 and 30 CFR 250.734 - What are the requirements for a subsea BOP system? • What systems will EEPGL put in place to prevent a well blowout? • The EIA for the proposed Yellowtail Project must provide an item-by-item account of how the project would comply with each applicable provision of 30 CFR Part 250, Subpart G - Well Operations and Equipment and in	Together with its drilling contractors and service partners, EEPGL places strong emphasis on prevention of source control events through implementation of appropriate safeguards. EEPGL leverages a structured and disciplined approach to planning and executing wells, and well design practices employ global standards and industry best practices. Wells are drilled dynamically overbalanced and are designed for expected formation pressures, accounting for a range of geologic outcomes. In addition, EEPGL utilizes a structured risk assessment process to identify, evaluate, and appropriately control potential hazards that may be encountered during operations. With respect to equipment, the drill ships supporting EEPGL operations in offshore Guyana utilize blowout preventer (BOP) equipment and safety systems. EEPGL well control practices apply global standards that were developed leveraging industry best practices, including API STD 53. A subsea BOP stack is deployed on riser from each drillship for any operations occurring below the surface casing. Key BOP components are tested at regular intervals over the course of operations to verify functionality and maintain subsea BOP system equipment readiness. Inspection, maintenance, and servicing of BOP equipment is performed leveraging industry best practices and manufacturer guidance. ROV intervention capability and emergency safety systems (i.e., autoshear, deadman, emergency disconnect sequence) are in place during riser connected operations to secure the well in the event of unforeseen operational circumstances. Additional drillship safety systems (i.e., power management, station keeping), which are developed with built-in redundancy, are utilized to further prevent source control events from occurring. The cited U.S. Code of Federal Regulations (i.e., 30 CFR Part 350, Subpart G) are not applicable in offshore Guyana. However, as previously discussed, EEPGL's well design, well control, and operational practices leverage global industry practices. Operationally, EEPGL utilizes industry best practices for pressure surveillance and well control. Drilling and logging data are closely monitored in real-time by trained rigsite personnel to ensure timely detection of potential abnormal pressure trends and influx indicators. Drilling crew leadership positions (e.g., toolpusher, driller, assistant driller) undertake accredited classroom-based well control training, which includes coverage of deepwater	No	Accepted	N/A	N/A

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			particular 30 CFR section 250.734.	well control theory, concepts, and practices. Well control drills (e.g., pit drill, trip drill, power choke drill, emergency disconnect / hang-off drill), which are performed at regular intervals over the course of operations, are held on each drillship to reinforce training and build drilling crew operational proficiency, specifically as it relates to detecting and efficiently responding to a potential influx. In summary, prevention of source control events are managed effectively by EEPGL through well design and execution planning, readiness of BOP equipment and safety systems, and well control preparedness of rigsite personnel.				
242	15-Dec-2021	Fair Deal for Guyana	• How does EEPGL plan to comply with international best practices in regard to the prevention of flaring? • Since beginning operations in December 2019 EEPGL has flared billions of cubic feet of gas and continues to flare. Flaring of gas associated with oil & gas activities is a cause of substantial harm to the environment. • Page 1 of the Project Summary states: "In 2020, the FPSO Liza Destiny experienced unanticipated technical challenges and unplanned gas flaring during its startup and commissioning process. EEPGL has conducted comprehensive root cause analyses of these issues, and evaluated potential improvements to gas handling systems, sparing philosophy, and execution procedures. EEPGL plans to take significant steps to incorporate the lessons learned from the commissioning of the Liza Destiny into future projects, including Yellowtail." • Under rules enacted by the U.S. Bureau of Safety and Environmental Enforcement, flaring of associated gas is strictly regulated. If ExxonMobil were proposing the Yellowtail Development Project in waters of the United States, then the project would need to comply with restrictions on flaring under 30 CFR Subpart K - Oil and Gas	While the Yellowtail Project is not subject to US Federal regulations such as 30 CFR Subpart K, as described in EIA Chapter 2, the Project would be designed to re-inject associated gas under routine conditions—except that which would be used as fuel gas, flare pilot gas, and background flare gas (e.g., purge, compressor seals) for FPSO operations and *de minimis* sources not captured by the VRU—back into the reservoir except during times of injection/compression system unavailability, which would require temporary, non-routine flaring during maintenance/repair. With respect to incorporating lessons learned from the commissioning of the Liza Destiny, a key strategy integrated in the FPSO design to reduce the frequency and duration of non-routine flaring for upsets and maintenance on the compression system would be the inclusion of installed spare gas compression equipment capacity. During instances where one compression unit is offline for upset or maintenance, installed spare compression equipment could be used to allow partial or full production to continue while reducing the volume and duration of flared gas. The gas compression sparing capacity provided in the Yellowtail Project design exceeds that included in the designs of prior EEPGL development project FPSOs. Additionally, a VRU would collect vapors from the cargo tanks and other low-pressure sources. The low-pressure sources captured by the VRU would include vapors coming from the triethylene glycol regeneration and produced water treatment systems (vapors that would otherwise be directed to the flare). As described in EIA Section 2.7.5.3, Flaring System, there are three main ways in which flaring would be reduced during steady-state operations: maintenance programs, operational procedures, and monitoring. Implementation of proactive and preventative maintenance and testing programs would reduce flaring by minimizing downtime from equipment failure and would facilitate continuous maximum flare efficiency. Additionally, the operations team would follow specific developed procedures for starting up and shutting down equipment. The facility would be monitored on a 24-hour per day basis to manage operational events that may cause flaring. This monitoring would provide the capability to intercept and deflect events that may result in flaring to the extent possible. Finally, lessons learned from commissioning, start-up, and operation of other FPSOs in Guyana would be reviewed and appropriate mitigations put in place to avoid recurrence of issues found in the past. For example, as described above, the FPSO compression systems would be equipped with spare compression capacity to reduce non-routine flaring duration.	No	Accepted	N/A	N/A

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			Production Requirements, § 250.1160 When may I flare or vent gas. • The EIA for the proposed Yellowtail Project must provide an item-by-item account of how the project will comply with each applicable provision of 30 CFR Subpart K - Oil and Gas Production Requirements, § 250.1160 When may I flare or vent gas.					
243	15-Dec-2021	Fair Deal for Guyana	**Noise** • How many decibels of noise will the project generate, over what period of time? Please set out this information on a graph. • What is the impact of noise on marine wildlife in particular whales, dolphins, turtles and fish? Please differentiate by species.	At the nearest onshore residential receptor (the shoreline portion of Vreed-en-Hoop) atmospheric noise (i.e., noise in the air) levels are predicted to be 34 dB and would last for the duration of the Project's operational life. This number is provided in EIA Table 5.2-3. Offshore, underwater impulsive noise would not be expected to exceed 220 dB re 1 µPa², and would be limited to the drilling and installation phase of the Project. Underwater non-impulsive noise exposure would not be expected to exceed 180 dB re 1 µPa², and would last for the duration of the Project's operational life. These offshore maxima have been added to the text in EIA Section 7.5.3, Impact Assessment—Marine Mammals. Regarding the potential impacts of marine noise on marine wildlife, see the response to Comment #144. Generally, these impacts were rated from Negligible to Minor depending on the type of sound, sensitivity of a particular taxonomic group to auditory impacts, and availability of appropriate management measures. The potential impacts of noise on whales and dolphins are discussed in Section 7.5.3; these depend on the functional hearing group to which the species belongs, as discussed in EIA Section 7.5.3.3, Characterization of Impacts—Injury or Disturbance from Underwater Sound. The potential impacts of noise on turtles are discussed in EIA Section 7.7.3, Impact Assessment—Marine Turtles. The potential impacts of noise on fish are discussed in EIA Section 7.8.3, Impact Assessment—Marine Fish.	Yes	Accepted	N/A	p. 7-120
244	15-Dec-2021	Fair Deal for Guyana	**Discharges** • What are the proposed discharges into the ocean? • What are the impacts of those discharges on the environment?	The planned discharges to the ocean from the Project are described in EIA Section 2.13.3, Discharges. Potential impacts of planned discharges to the ocean from the Project are discussed in EIA Section 6.3.3 (Marine Geology and Sediments), Section 6.4.3 (Marine Water Quality), Section 7.4.3 (Seabirds), Section 7.5.3 (Marine Mammals), Section 7.7.3 (Marine Turtles), Section 7.8.3 (Marine Fish), Section 7.9.3 (Marine Benthos), Section 7.10.3 (Ecological Balance and Ecosystems), Chapter 10 (Cumulative Impact Assessment), and Appendix C (Water Quality Modeling Report).	No	Accepted	N/A	N/A
245	15-Dec-2021	Fair Deal for Guyana	**Cumulative impact** EEGPL proposed to carry out Yellowtail after Liza 2 and Payara come on stream. What are the cumulative impacts of Yellowtail when the impacts of Liza	Cumulative impacts from the Project combined with those from previously approved EEPGL projects, as well as reasonably foreseeable future projects, are described in Chapter 10, Cumulative Impact Assessment. See the response to Comment #108.	No	Accepted	N/A	N/A

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			1, Liza2 and Payara are taken into account?					
246	15-Dec-2021	Fair Deal for Guyana	**Decommissioning** The International Energy Agency has stated that there should be no new oil and gas developments if the world is to stay within safe limits of global heating. ExxonMobil shareholders have stated that, “Exxon’s current direction is premised on outdated assumptions about high oil prices, demand, and margins that are incompatible with the reality of climate change and the inevitable transition to renewable energy sources.” On May 26th, ExxonMobil shareholders voted on to ExxonMobil’s board 3 new directors who are committed to aligning the company’s business operations to achieve net zero emissions on an accelerated timeframe. Also on May 26th, a Dutch court ruled that in order to comply with the goals of the Paris Agreement, Royal Dutch Shell must reduce its CO2 emissions by 45% by 2030 from 2019 levels. There is a risk of similar cases and similar decisions being made against ExxonMobil. Consequently, there is a risk that decommissioning will occur earlier than expected. • What would be the cost of decommissioning of the Yellowtail project based on today’s costs? • Does EEPGL have the money to cover the costs of decommissioning? • How much equipment will be abandoned on the ocean floor? • What is the impact on the environment of abandoning equipment on the ocean floor?	• A Preliminary End of Operations Decommissioning Plan for Guyana Development Projects is included in Volume III of the EIA. As stated in the plan, near the time of decommissioning, EEPGL would develop a more detailed decommissioning plan, in consultation with the appropriate Guyanese regulators. EEPGL would perform comparative assessments for the various facility components. The comparative assessment is designed to evaluate five criteria, including safety, environmental, technical, impact to other users of the sea, and economics—and to select the best option for the final decommissioning plan. Consultation with stakeholders would also be conducted by EEPGL during decommissioning planning. A revised plan would be submitted to the appropriate Guyanese regulators in advance of commencing field work. The cost of the decommissioning is not within the scope of the EIA. • An assessment of the financial capacity of the Project proponent is not within the scope of the EIA. • As described in the Preliminary End of Operations Decommissioning Plan included in Volume III of the EIA, globally ExxonMobil employs good international oilfield practice for decommissioning and abandonment. For offshore facilities, this includes utilizing IMO Resolution A.672(16) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the EEZ as a basic standard worldwide, as well as the UK Offshore Petroleum Regulator for Environment and Decommissioning’s (OPRED’s) “Offshore Oil and Gas Decommissioning Guidance Notes” December 2018, (ANNEX A—A Guide to Comparative Assessments). These embody the principle that where a decision is made to allow an offshore installation, structure, or parts thereof to remain on the seabed, it should be based on a case-by-case evaluation (by the jurisdiction over the installation or structure). Abandonment of selected equipment on the seafloor as part of decommissioning is currently proposed, but further approvals would be required before this plan could be implemented. The industry supports the use of a Multi-Criteria Decision Analysis (MCDA) as the facilities are approaching end of production life to holistically evaluate the decommissioning approach for the subject facilities. The MCDA evaluates the potential safety and health, environmental, social, and economic risks, as well as technological challenges/developments that may be needed for the decommissioning options analysis (including reefing). Given the length of expected operational timelines and potential future advancements in technology, it is difficult to determine final decommissioning options at this time. Industry general practice in these depths for subsea components is, at the time of initial installation, to plan for such components to remain in place at decommissioning; however, this would be re-evaluated as the field reaches end of life. The comparative analysis described above, such as an MCDA process, would be employed to assess the best overall options based on the various factors, and leaving subsea components in situ would not be proposed at that time if it were determined that this would have a significant negative impact on the environment or users of the sea. • The Preliminary End of Operations Decommissioning Plan states that, as part of the decommissioning process, all risers, pipelines, umbilicals, and	No	Accepted	N/A	N/A

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				other subsea equipment would be safely and properly isolated, de-energized, and flushed to remove hydrocarbons and any hazardous materials to a suitable level prior to being taken out of service. Accordingly, if the final approved decommissioning plan calls for subsea equipment to be left in situ on the seafloor, the potential for impacts related to exposure of environmental receptors to hazardous materials would be negligible. As discussed in EIA Section 7.9.3.5, Characterization of Impacts—Injury Due to Drill Cuttings Deposition, the addition of the small amounts of hard substrate would likely increase the diversity of the local benthic community as species that require hard substrate colonize the area where none existed before. However, this would be balanced with the loss of soft substrate that would continue to be unavailable within the footprint of the subsea infrastructure. This would only occur within the immediate footprint of the abandoned infrastructure and would be expected to affect a relatively small number of organisms.				
247	15-Dec-2021	Fair Deal for Guyana	**Financial ability to carry out the Yellowtail project.** What profit did EEPGL make in 2020?	The Consultants acknowledge the question. EEPGL's 2020 financial information is not within the scope of the EIA.	No	Accepted	N/A	N/A
248	15-Dec-2021	The Environmental Law Alliance Worldwide Science Team Submitted by Mark Chernaik, Ph.D	**1. The EIA fails to assess the substantial indirect impacts of the proposed project on the earth's climate.** Section 11(4)(a) of the Environmental Protection Act requires the following: "(4) Every environmental impact assessment shall be carried out by an independent and suitably qualified person approved by the Agency and shall— "(a) identify, describe and evaluate the direct and indirect effects of the proposed project on the environment including— human beings; flora and fauna and species habitats; soil; water; air and climatic factors; …' The proposed Yellowtail Development Project involves the extraction of oil and gas from deep offshore seabed deposits and marketing the recovered crude oil to refineries, and ultimately to consumers of petroleum products.	As noted in the response to Comment #238, an estimate of end-use (Scope 3) GHG emissions from the Project is not within the scope of the EIA.	No	Accepted	N/A	N/A

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			The Executive Summary of the EIA describes the nature of the project as follows: “The Project will consist of the drilling of approximately 41 to 67 development wells (including production, water injection, and gas re-injection wells); installation and operation of Subsea, Umbilicals, Risers, and Flowlines equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block; and— ultimately—Project decommissioning. … “The initial production is expected to begin by end of 2025–early 2026, with operations continuing for at least 20 years. …. The FPSO will offload produced crude oil to conventional oil tankers on a regular basis. ….. Crude oil will be pumped from the FPSO storage tanks to the offloading tanker using a floating hose at a rate of approximately 1 million barrels (160,000m3) of oil in approximately 24 hours.” It is well understood that the combustion of petroleum products derived from crude oil is an indirect effect on the environment of proposed fossil fuel development projects. After EEPGL pumps oil into conventional oil tankers, it would be transported to petroleum refineries for the production of transportation fuels. Owner of cars and other vehicles would combust the transportation fuels, resulting in substantial indirect emissions of CO2. However, the EIA provides information only about the much smaller direct emissions of the proposed project. Page 6-36 states: “The primary sources of GHG emissions are the combustion turbines and flares on the FPSO, with smaller amounts from other fuel combustion sources. GHG					

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			emissions were calculated in three parts: the quantity of carbon dioxide (CO2) in the fuel that is emitted directly as CO2; products of combustion of various fuel components based on the potential for each component to contribute to GHG emissions; and the CO2-equivalent (CO2e) emissions of other emitted compounds such as methane and nitrous oxides. Emission factors from the AP-42 document noted above were used to calculate the combustion-related GHG emissions (USEPA Undated). "As shown in Table 6.1-19, GHG emissions will occur during all three of the time periods considered for atmospheric emissions. In the first time period (characterized by drilling and installation activities), GHG emissions will be relatively low. In the second time period, drilling will still be ongoing, commissioning and start-up will occur, and production operations will begin. "In the last time period, production operations will be ongoing, potentially with continued development drilling for up to 5 years. This period has an estimated average annual pre-mitigation GHG emission level of 1,328 kilotonnes of CO2e emissions per year for the Design Case and 1,613 kilotonnes of CO2e emissions per year for the Modeled Case; these average annual GHG emission rates during the third time period are the focus for the remainder of this assessment. GHG emissions during the decommissioning stage will be relatively low, comprising emissions principally from decommissioning vessels." Indirect emissions of the proposed Yellowtail development project can be estimated on the basis of its oil production rate, which, according to Table 2.7-1 is estimated to be 250,000 barrels per day.					

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			Production rate of 250,000 barrels per day is equivalent to a production rate of 91.2 million barrels per year. The average CO2 emissions from production and eventual combustion of crude oil (including its refined products) is estimated at 0.43 metric tons CO2/barrel.1 Therefore, CO2 eamissions of the project, including indirect emissions, would be roughly 39 million metric tons of CO2 per year2 – nearly 25 times higher than the 1,613 kilotonnes of CO2e emissions EEPGL has presented to decision-makers in the EIA. Indirect emissions of 39 million metric tons of CO2 per year would have substantial impacts on human beings that EEPGL has not disclosed. In July of 2021, the number of expected deaths caused by the emission of one additional metric ton of CO2 was published in a study based on research conducted at the Columbia University School of International and Public Affairs: The study states the following: “In this study, we create an extension to DICE-2016 called DICE-EMR (Dynamic Integrated Climate-Economy Model with an Endogenous Mortality Response). We construct an additional reduced-form mortality damage function that projects the effect of climate change on the mortality rate using estimates from studies chosen from an interdisciplinary systematic research synthesis of the scholarly literature …. We use DICE-EMR to produce a new metric that avoids some of the limitations of the SCC: the mortality cost of carbon (MCC). The 2020 MCC is the number of expected temperature related excess deaths globally from 2020 to 2100 caused by the emission of one additional metric ton of carbon-dioxide equivalent emissions in 2020. “We find that optimal climate policy in DICE-EMR, however, involves					

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			large immediate emissions reductions and full decarbonization by 2050. This results in 2.4 °C warming by 2100. “If the world undertakes the optimal emissions path in DICEEMR and restrains global average temperatures to 2.4 °C, we largely avoid the temperatures where marginal increases in temperature resulting from a marginal emission today are most damaging. Therefore, the SCC and the MCC are highly sensitive to future climate policy. On the optimal emissions path the 2020 MCC drops by 53% from 2.26 × 10−4 lives per metric ton in the baseline emissions scenario to 1.07 × 10−4 lives per metric ton (**see Table 1, Appendix A**). This implies that under DICE-EMR’s optimal climate policy, adding (reducing) 9,318 tons of carbon dioxide …. causes (reduces) one excess death globally between 2020 and 2100. ….” This allows us to calculate the number of lives that would be lost if the Yellowtail Development Project is implemented. If the world undertakes an optimal emissions path and restrains global average temperatures to 2.4 °C by 2100, then emissions of 39 million metric tons of CO2 per year would be associated with more than 4000 lives lost over a subsequent eighty-year period. If the Yellowtail Development Project maintains a 250,000 barrels per day production rate for 20 years, then such emissions would be associated with a loss of more than 80,000 lives as a result of climate change. Direct emissions of the project, although much smaller - 1,613 kilotonnes of CO2e emissions per year for the Modeled Case – would still be associated with a significant loss of life: more than 3400 lives lost					

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			if the Yellowtail Development Project persisted for 20 years.					
249	15-Dec-2021	The Environmental Law Alliance Worldwide Science Team Submitted by Mark Chernaik, Ph.D	**The EIA fails to disclose how the proposed project is inconsistent with Guyana's international obligations under the Glasgow Climate Pact.** In November of 2021 at the 26th Conference of the Parties (COP26) to the United Nations Convention on Climate Change (UNFCC), countries around the world re-affirmed their commitment to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels.6 Specifically, at COP26, the Conference of the Parties agreed to the Glasgow Climate Pact, which includes the following provisions: "15. Reaffirms the long-term global goal to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; "16. Recognizes that the impacts of climate change will be much lower at the temperature increase of 1.5 °C compared with 2 °C, and resolves to pursue efforts to limit the temperature increase to 1.5 °C; "17. Also recognizes that limiting global warming to 1.5 °C requires rapid, deep and sustained reductions in global greenhouse gas emissions, including reducing global carbon dioxide emissions by 45 per cent by 2030 relative to the 2010 level and to net zero around mid-century, as well as deep reductions in other greenhouse gases; 18. Further recognizes that this requires accelerated action in this critical decade, on the basis of the	Any tax-related agreements between the Stabroek Block co-venture partners and the Government of Guyana are beyond the scope of the EIA and should be referred to the Government of Guyana.	No	Accepted	N/A	N/A

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			best available scientific knowledge and equity, reflecting common but differentiated responsibilities and respective capabilities and in the context of sustainable development and efforts to eradicate poverty; 19. Invites Parties to consider further actions to reduce by 2030 non-carbon dioxide greenhouse gas emissions, including methane; 20. Calls upon Parties to accelerate the development, deployment and dissemination of technologies, and the adoption of policies, to transition towards low-emission energy systems, including by rapidly scaling up the deployment of clean power generation and energy efficiency measures, including accelerating efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies, while providing targeted support to the poorest and most vulnerable in line with national circumstances and recognizing the need for support towards a just transition ….” Oil Change International defines a fossil fuel subsidy as follows: “A fossil fuel subsidy is any government action that lowers the cost of fossil fuel energy production, raises the price received by energy producers, or lowers the price paid by energy consumers. Essentially, it’s anything that rigs the game in favor of fossil fuels compared to other energy sources. “The most obvious subsidies are direct funding and tax giveaways, but there are many activities that count as subsidies – loans and guarantees at favorable rates, price controls, governments providing resources like land and water to fossil fuel companies at below-market rates, research and development funding, and more.”8 There is ample evidence that EEPGL receives subsidies that the Glasgow Climate Pact now requires					

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			countries to phase-out, and that the President of Guyana states must be removed. For example, the Institute for Energy Economics and Financial Analysis (IEEFA) has reported: "The Guyanese government has granted a tax concession to three companies (ExxonMobil, Hess and the China National Offshore Oil Company) that are drilling under the Stabroek oil profit-sharing agreement. The tax concession absolves the companies from paying annual income taxes to the Guyana government—taxes that other Guyanese companies and citizens would be required to pay. "The agreement with the companies establishes that the income made by the companies in Guyana is taxable under Guyana law. The normal corporate tax rate is 25%. The contract, however, requires the government of Guyana to pay the annual tax for the companies." In order to determine whether the proposed Yellowtail Development Project is consistent with the Glasgow Climate Pact and the Statement of the President of Guyana at the COP26 meeting, the EIA for the project must disclose the fossil-fuel subsidies it would receive.					
250	15-Dec-2021	The Environmental Law Alliance Worldwide Science Team Submitted by Mark Chernaik, Ph.D	**The EIA fails to contain required information about the effects of the elimination of waste associated with the proposed project and measures to mitigate adverse effects of the proposed onshore disposal of such waste.** Section 11(5)(c) of the Environmental Protection Act requires the following: "(5) Every environmental impact assessment shall contain the following information— "(c) a description of the likely significant effects of the proposed project on the environment resulting from—	To clarify, EIA Table 2.13-8 provides a summary of the estimated quantity of waste that would be generated by the Project during the referenced years—not all of which would be disposed in onshore facilities. No hazardous waste would be disposed in the HBL prior to treating such waste to render it non-hazardous. With respect to the potential impacts of Project waste generation on Guyana resources, EIA Section 8.6, Waste Management Infrastructure Capacity, is entirely devoted to the assessment of these impacts on Guyana's waste management infrastructure capacity. While the referenced excerpt from Section 8.6.2.3, Industrial/Hazardous Waste Management Facilities, describes the existing waste management infrastructure, the remainder of the section discusses the analysis of the capacity of this infrastructure in the context of its ability to accommodate Project waste generation as well as the other anticipated waste management demands of non-Project users.	No	Accepted	N/A	N/A

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			the existence of the project; the use of natural resources; the emission of contaminants, the creation of nuisances and the elimination of waste." EEPGL proposes to use Guyana as a permanent depository of toxic wastes it would generate from offshore oil & gas activities associated with the Yellowtail Development Project. For example, with respect to oil bilge tank sludge, page 2-48 of the EIA states: "2.7.4.8. Bilge Water System "The bilge system is provided to dispose of oily water residue that may accumulate in machinery spaces and in various bilges throughout the vessel due to condensation, washing, maintenance, etc. It is also capable of controlling limited flooding in the aft machinery space, e.g., as a result of damage to piping systems. Bilge water collected in the machinery space bilge wells, doublebottoms, voids, cofferdams, etc., is transferred to the bilge holding tank using the oily bilge pump. Bilge water is sent from the bilge holding tank to the bilge water separator unit for oil/water separation, with separated water (with low oil-in-water content) passing through an OCM package for automatic monitoring of oil-in-water content prior to overboard discharge. In the event that the OCM package detects an oil-in-water content above 15 ppm, the overboard discharge line will close and the recirculation line will open automatically; the off-specification bilge water will then be recirculated to the Bilge Holding Tank. Separated oil is sent to the oily bilge tank. Sludge from the oily bilge tank is pumped periodically to a supply vessel, or tote tank, for ultimate onshore disposal."				

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			Table 2.13-8 on page 2-90 of the EIA (Summary of Estimated Annual Generation for Project Wastes that will be Managed Onshore) discloses that 5630 tons of hazardous waste would be shipped to Guyana for onshore disposal in 2024 and 2025. The impact on Guyana of the onshore disposal of more than 5000 tons of hazardous waste in 2024 and 2025 is not assessed in the EIA. However, page 8-161 of the EIA contains the following admission: "There is a limited number of facilities for the treatment of hazardous and industrial waste in Guyana, although the construction and proposal of additional such facilities are growing commensurate with the planned expansion of oil and gas activities. Tiger Rentals Guyana Inc. (TRG), located at the Guyana Shorebase Inc. (GYSBI) facility, is currently the primary provider of hazardous and non-hazardous waste treatment services in Guyana. TRG employs a variety of waste treatment technologies (sorting/segregation of recyclables, physical/chemical/thermal treatment of hazardous and non-hazardous wastes), discharges its treated fluids as permitted to the Demerara River, and sends its treated non-hazardous solid waste as well as other wastes received (including general waste, paper/cardboard, and scrap wood) to the HBL."					
251	15-Dec-2021	The Environmental Law Alliance Worldwide Science Team Submitted by Mark Chernaik, Ph.D	**The EIA contains no information about how bringing more hazardous waste from the Yellowtail Development Project to TRG located at the GYSBI would impact the environment of Guyana, including water quality of the Demerara River, which flows past Georgetown.** It is important to note that the Guyana EPA waived a requirement that TRG submit an EIA for its activities.10	Under the Environmental Protection Act, permitting of third-party onshore support facilities, including hazardous waste management facilities, is a separate process from the Yellowtail EIA and authorization process. With respect to the provision of the referenced CWMP, this document has been approved by the EPA and is publicly available on the EPA's website.	No	Accepted	N/A	N/A

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			Section 11(5)(g) of the Environmental Protection Act requires the following: "(5) Every environmental impact assessment shall contain the following information— (g) a description of the measures which the proposed developer intends to use to mitigate any adverse effects and a statement of reasonable alternatives (if any), and reasons for their rejection; The EIA fails to contain a description of the measures which EEPGL intends to use to mitigate adverse effects of its generation and onshore disposal of hazardous waste. Instead, EEPGL proposes to defer such description until later and place it outside the scope of the EIA for the proposed Yellowtail Development Project. Page 2-75 of the EIA states: "All waste streams for the Project will be managed in accordance with a Comprehensive Waste Management Plan (CWMP) that will be used for the management of all EEPGL waste. The CWMP will be subject to final approval by the EPA. The CWMP is under development as of the time of this EIA, with an anticipated submittal to the EPA in 4Q2021." Failure to include in the EIA for the proposed project a Comprehensive Waste Management Plan (CWMP) that will be used for the management of all EEPGL waste is contrary to the requirement of Section 11(5)(g) of the Environmental Protection Act.					
252	15-Dec-2021	The Environmental Law Alliance Worldwide Science Team	**The impacts of an extended, large-scale, active oil and gas extraction project will not be negligible or positive for marine mammals.** The Environmental Impact Assessment (EIA) for the Yellowtail project explains the impact summary	The types of impacts of noise on marine mammals discussed by Duarte et al. (2021), e.g., injury, disturbance, and masking, are evaluated in EIA Section 7.5.3, Impact Assessment—Marine Mammals. The types of potential impacts of noise on marine mammals and their geographic extents, frequencies of occurrence, durations, and intensities are discussed in EIA Section 7.5.3.3, Characterization of Impacts—Injury or Disturbance from Underwater Sound. Section 7.5.3.3 and Appendix H, Underwater Sound Modeling Report, describe the quantitative sound modeling that forms the basis for the objective assessment of sound impacts on marine mammals. The intensity of	No	Accepted	N/A	N/A

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			table for marine mammals as follows: "Table 7.5-15 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine mammals. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, as well as the marine mammals-specific methodology described in Sections 7.5.3.2 and 7.5.3.3." In essence, the Table tells the reader that there are no serious impacts to marine mammals from this oil and gas development project. And the very real concern of light pollution is—without offered evidence—flipped to be a positive impact. This characterization is not accurate. The impact of sound in the ocean on marine species was reviewed recently by Duarte et al. (2021) in the premier scientific journal Science (Figure 1, Appendix A). In their review, the authors concluded that "…construction and operation of oil and gas infrastructure (e.g., platforms, pipelines) increase anthrophony (56). [Anthrophony is defined as, "sounds generated by human activities." The dynamic positioning systems (i.e., propellers and thrusters) used to maintain the position of offshore structures, such as drilling platforms, produce low-frequency noise (57)." They reviewed 538 studies on the effects of noise on marine mammals. The authors stated, "There was high confidence that anthropogenic noise negatively affected marine animals. The evidence was strongest for marine mammals, for which 85 to 94% of quantitative studies found significant effects…" Many of the activities studied were directly or	potential impacts on marine mammals from underwater sound is defined according to the definitions provided in Table 7.5-5. Based on the definitions of receptor sensitivity levels provided in Table 7.5-6, the representative marine mammal assumed to be the receptor for potential impacts of noise is considered to have a Medium sensitivity. Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the assumed sensitivity rating and the various magnitude ratings of potential impacts on marine mammals from sound led to the significance ratings summarized in Table 7.5-15. The Duarte et al. 2021 paper is a literature review that cites multiple other studies to conclude that antrophony generally has the potential to negatively affect a variety of marine life. This is consistent with the findings of the EIA, which acknowledges and quantifies the range at which these impacts could occur. Unlike Duarte et al. (2021), the findings of the EIA are supported by quantitative analysis that accounts for the unique location and equipment specific to the Yellowtail Project. The conclusion that the Project would have minor residual acoustic impacts on marine mammals is consistent with independent assessments conducted by the U.S. Minerals Management Service (MMS), National Oceanographic and Atmospheric Administration (NOAA), and Bureau of Ocean Energy Management, which determined that oil and gas activities since the 1970s had no had lasting effects on marine mammal populations. These studies are referenced in EIA Section 7.5.3.3, Characterization of Impacts—Injury or Disturbance from Underwater Sound. It is also noteworthy that the MMS and NOAA study reached this conclusion while including activities that predated the Joint Nature Conservation Committee (JNCC) guidelines, which have been accepted as industry best practice for managing acoustic impacts on marine mammals, and which the Consultants have recommended be applied to the Yellowtail Development Project. Artificial lighting on the FPSO and the concentration of food resources it would be expected to cause would represent changes to the natural environment in the immediate vicinity of the FPSO. EIA Section 7.5.3.5, Characterization of Impacts—Artificial Lighting, explicitly states that this effect would be limited to the immediate vicinity of Project vessels. While these changes would represent departures from baseline conditions in a small part of the AOI, it is the Consultants' opinion that concentrating food resources for a predator would represent an overall benefit to the predator species. This is the basis for rating the impacts of artificial lighting on marine mammals as positive. The potential for cumulative impacts on marine mammals is evaluated in Chapter 10, Cumulative Impacts, and recommendations to minimize cumulative impacts to marine mammals are included in Section 10.7.2.				

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			indirectly connected to oil and gas production. This kind of scientific analysis makes it difficult to find the EIA's conclusions of negligible impact credible. In addition to the substantial evidence gathered by Duarte et al. (2021), one of the central reasons why we can be fairly certain that the impact is not negligible is the sheer scale at which it is occurring. Figure 2 (See Appendix A) from their paper shows the spatial and temporal extent of the impact for oil and gas production. The EIA does not take this long-term, cumulative impact into account. The project is meant to include, "…drilling of approximately 41 to 67 development wells; installation and operation of Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel; and ultimately, Project decommissioning." These actions will produce varying sounds over many years, an impact that cannot be simply written off as minor. The project proponents are aware that this impact is significant. The EIA states: "Underwater sound can potentially cause a variety of impacts on marine mammals, such as behavioral changes in life functions (e.g., feeding, breeding, migration route deviations) or direct physical impacts affecting auditory systems." Why, then, they have not adequately evaluated this known, dangerous impact to marine mammals begs asking.				

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253	14-Dec-2021	Dr. Erik E Cordes	1. In general, I found the sections of the EIA I reviewed, like most projects at these depths (> 1000 m), to be missing critical information that is required to make an informed decision on the potential impacts of the proposed project. Very little data about the distribution of potentially sensitive species is provided, particularly for the benthic organisms that likely occur in the area. In addition, I found large parts of the EIA difficult to assess because of the poor quality of the maps provided. There was no position information (latitude and longitude) provided on the axes and the bathymetric data were extremely low resolution, which resulted in very wide-spaced depth contours in the images. Certainly, EEPGL and its partners have higher-resolution multibeam ecosounder (MBES) data in the project area, as well as high-resolution seismic reflectivity data that could reveal the presence of hard substrate in the vicinity of the proposed site. 2. In section 3.1.3., there is one particularly glaring statement that cannot be justified with the information presented: “While the mortality rate of immobile taxa individuals from physical disturbance resulting from installation of the subsea infrastructure will be high, the population is not anticipated to be sensitive to the reduction in individuals within the limited area affected.” I cannot imagine how they can reach this conclusion without any data on the population size of potentially sensitive species (see below) inside the area of impact and in the region. 3. Section 6.3.2.2. Here we see some effort to provide higher resolution bathymetry, which	1. The multi-beam echo sounder (MBES) data referenced in the comment was collected during the Yellowtail geophysical study referenced in EIA Section 6.2.2.2, Marine Stratigraphy, and is depicted in Figure 6.3-2. Figure 6.3-2 is low resolution because it is meant to show the results of the hard seafloor feature (HSF) survey across the entire Yellowtail survey area, which encompassed a much larger area than the Yellowtail PDA (although the Yellowtail PDA was located entirely within the survey area). The survey also produced much higher resolution imagery than is depicted in the main image in Figure 6.3-2, and analysis of this higher resolution imagery informed the conclusion in EIA Section 6.2.2.2 that no HSFs were detected in the Yellowtail PDA. This high-resolution analysis did detect HSFs as the comment suggests, but not within the Yellowtail PDA. For clarity, Figure 6.3-2 has been edited to include an inset of high resolution black and white imagery showing an area of high-density HSFs to the north of the Yellowtail PDA that were detected during this survey. EIA Section 7.9, Marine Benthos, discusses the presence of relatively sensitive species that are often associated with HSFs, but these are not discussed in detail because as stated earlier in Section 6.2.2.2 of the EIA, there are no reasonably foreseeable pathways for potential impacts on these features (or their biological communities) from planned Project activities. 2. Since geophysical data from the Yellowtail PDA and surrounding areas suggest that HSFs do not occur within the Yellowtail PDA, any populations of relatively sensitive immobile benthic organisms in the vicinity of the Project are therefore very likely also located outside the Yellowtail PDA. Accordingly, even if a small number of sensitive organisms occur within the PDA and most of these individuals were to be killed or injured by installation of the SURF, impacts at the population level would be very low because the core habitats for these species are outside the area of seafloor that would be affected by Project activities. 3. The MBES data depicted in Figure 6.3-2 were acquired from a series of 146 AUV dives. The primary line spacing was 150 meters (492 feet) and the AUVs were flown at a 40-meter (131-foot) altitude. AUV data were acquired within and outside of the Yellowtail PDA. The purple areas in Figure 6.3-2 do indicate HSFs, which the Consultants have clarified by including a higher-resolution inset in Figure 6.3-2. The closest area of HSF habitat to the Yellowtail PDA is approximately 2 kilometers (1.2 miles) to the northeast of the PDA. However, as described in EIA Section 7.9.3, Impact Assessment—Marine Benthos, and depicted in Figure 7.9-17, hydrodynamic modeling predicts that impacts of subsea activities (primarily smothering from drill cuttings deposited on the seafloor) would be expected to be minimal beyond 500 meters (1,640.4 feet) from a wellhead. 4. The text from EIA Section 7.8.2.1, Targeted Surveys of Deepwater and Offshore Pelagic Fish Community, quoted in the comment applies to a single type of fish sampling, specifically baited demersal trapping. Although this type of sampling did not collect fishes beyond 1,000 meters (3,281 feet), other survey techniques, including pelagic longlining, drop camera surveys, and incidental observations by PSOs have documented a variety of fish species in the deepwater portions of the Stabroek Block, including (as described in EIA Section 7.8.2, Existing Conditions—Marine Fish) grenadiers, rajiform fishes, tripodfish, eelpout, Robinson’s hagfish, sharptailed eel, and lanternfish. This species list is not as extensive as	Yes	Accepted	N/A	1. p. 6-54

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			indicates that EEPGL have access to these data. From this low-resolution version of the image, it is still apparent that there are submarine canyons in the area and possibly some hard-substrate areas near the project location. There is also one small area covered by side-scan sonar outside of the proposed project site. Were there no autonomous underwater vehicle (AUV) side-scan data acquired within the project area? These data would reveal areas of high relief that likely represent hard substrate habitats in the vicinity. There are also some areas delineated in purple on the map. I suspect that they represent areas of high surface acoustic reflectivity interpreted from the back-scatter of MBES data or from the 3D seismic data that surely exist for this project. These kinds of signals almost invariably indicate the presence of hard-substrate areas. If that is what they are, they are very close to the proposed site, possibly within 2 km, if I am interpreting the grid on the map correctly. 4. Section 7.8.2.1. Here is an instance where the general paucity of data for the area around the proposed site is apparent: "No fish were captured deeper than 1,000 meters." (p. 7-183). While there are exceedingly few studies of the deep-sea fauna of Guyana in the published literature (I had difficulty finding any public records, which in itself is telling), in a study of the deep-sea fishes off of the northern coast of Brazil (de M. Klautau et al. 2020, Neotropical Ichthyology) a total of 30 fish species are listed with a bathymetric distribution that exceeds 1000 m depth, and	the list from Brazil cited in de M. Klautau et al. (2020), but considering the substantial effort that has been expended to date sampling the deepwater environment in and around the Yellowtail PDA, the Consultants consider the comparative lack of deepwater fishes in the Stabroek Block as indicative of a sparse and widely dispersed fish community rather than an incomplete sampling effort. 5. The Consultants agree with some of the points made by the commenter regarding deepwater corals (e.g., the likely presence of additional coral colonies in unsurveyed portions of the Stabroek Block, and the uncertainty regarding whether the corals on the continental shelf are recovering). However; the seafloor imagery presented in EIA Section 6.2.2.2, Marine Stratigraphy, and the hydrodynamic modeling analysis presented in Section 7.9.3, Impact Assessment—Marine Benthos, strongly indicate that the hard seafloor areas required by these corals to attach and grow do not occur in sufficiently close proximity to the Yellowtail PDA to be negatively affected by the Project. 6. As the commenter suggests, the HSFs described in EIA Sections 6.2.2.2 and 7.9.3 are very likely associated with seeps, and were described as such in detail in the Fugro 2019 hard seafloor report, which was cited as a source document in the EIA. This report was also submitted to the EPA in its entirety as an appendix to the Payara Development Project EIA. The origin and nature of the HSFs are not discussed in detail in the Yellowtail EIA because, as described above, HSFs do not occur in close proximity to the Yellowtail PDA, and the Project would not significantly impact hard seafloor habitat that has been mapped outside the Yellowtail PDA. 7. It is true that the communities that colonize anthropogenic structures are not necessarily the same as those that occur on natural habitats. This is particularly true of the Yellowtail Development Project because, as demonstrated by the MBES data and the hydrodynamic analyses described in the responses above, the benthic communities that would be impacted by the Yellowtail Project are soft substrate communities, consisting primarily of burrowing and sifting organisms. The hard-bottom species that are likely to colonize the SURF occur only on hard substrates and are therefore more habitat-limited than soft-bottom species that can occur across a much wider expanse of the Stabroek Block seabed. In this sense, the Project would provide a benefit for the most sensitive benthic organisms.				

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			it is highly likely that the majority of these also occur off of Guyana, as deep-sea fishes in general have a very wide distribution. This demonstrates that their sampling of this community was obviously incomplete. 5. Section 7.9.2.2. Some of the statements in this section confirm some of my suspicions about the true abundance of sensitive species in the project area. In numerous places in this section (starting on p. 7-223), the presence of deep-sea coral species is mentioned, including the reef-forming species Madrepora oculata and Solenosmilia variabilis, as well as long-lived black corals (some colonies have been determined to be over 1000 yrs old,). Their presence is later dismissed by saying "it is unknown whether the corals represent the remnant of a long-established population or a nascent recovery of a previously degraded community." (p. 7-244). I cannot think of a way to reach the conclusion that these are just "remnant" populations or indications of "nascent recovery" of a past population, both of which suggest a small population and one that has suffered a drastic decline at some point in the recent past. There is also a relatively long list of coral species on p. 7-245, and clear pictures of hard substrates and corals in Fig. 7.9-13 and 7.9-14. Based on my 10+ years of experience with photographic surveys from AUVs, this certainly indicates that there are more deep-sea coral populations that remain to be discovered. Interestingly, the corals in Fig. 7.9-10 do NOT look like black corals, but rather gorgonian octocorals. These						

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			samples, and likely many more obtained during the impact assessment surveys, should be examined by a true expert. 6. The image of the octopus in Fig. 7.9-11 looks a lot like a species of octopus that we see around cold seeps in the region. In this image, there are (what look to me to be) authigenic carbonate rocks and stained sediments that are indicative of a seep environment. I could not find any mention of natural gas or oil seeps or their associated communities in the assessment. However, there are historical records of seep species in the region, including the type-specimen of Lamellibrachia luymesi (from lat 8.0167, long -57.4). This is a seep tubeworm (a close relative of the giant tubeworms at hydrothermal vents) that can live for over 200 years (Cordes et al. 2003, Ecology Letters) and is identified as one of the key indicators of sensitive seep habitats in the Gulf of Mexico. This species, along with many other seep and coral species, is therefore protected by the exclusion of any oil and gas activity within or near areas of "seismic anomalies" which are acoustically-reflective areas of the seafloor that indicate hard substrates (see U.S. Minerals Management Service Notice to Lessees No. 2009-G40). I am confident that the proponents have the 3D seismic data to locate these areas, but it is not presented here. 7. Finally, in section 7.9.3.5, the proponents describe the creation of hard substrate in the form of seafloor infrastructure as a reasonable replacement for any loss of hard substrate by burial from drill cuttings or other activities. This is simply not an					

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			acceptable one-for-one trade since the communities that colonize anthropogenic structures will not necessarily be the same as those on natural habitats. In conclusion, my recommendation is that additional data are required to properly evaluate the potential impacts of the proposed project. Without higher resolution multibeam bathymetry along with MBES backscatter or seismic reflectivity data, and review of imagery by experts, the EIA is deficient and the EPA does not have the scientific and technical information required to make an informed decision about the potential impacts of the proposed project in the Stabroek block. The distribution and abundance of hard substrata, and a complete assessment of the distribution and abundance of hard substrate fauna, including deep-sea corals and cold-seep endemic fauna (chemosynthetic tubeworms and mussels), are required before any conclusions about the impacts on regional populations of sensitive benthic species can be reached. Without this information, this project is highly likely to have greater impacts than those indicated here.					
254	15-Dec-2021	Malinda Janki	Ms Janki has attached the following studies which are incorporated into the matrix. For reference, please see below list of studies along with points extracted and presented in her submittal:	N/A	No			N/A
255	15-Dec-2021	Malinda Janki	**Dr Erik Cordes is an Associate Professor and Vice Chair of Biology at Temple University in Philadelphia.** He is an expert i.e. a person who is qualified, has over 20 years' experience of deep sea ecology hydrocarbon seeps, and is recognised by his peers as an expert. He has been chief scientist on 10 research cruises. His details	Detailed responses to each of Dr. Cordes' comments are included in Comment #253.	No	Accepted	N/A	N/A

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			are here https://schmidtocean.org/person/erik-cordes-pi/ Dr Cordes' report states that the sections of the EIA that he reviewed are, "missing critical information that is required to make an informed decision." For example, he points out the paucity of the data relating to fish. You will be aware of the recent collapse in fishing stocks as evidenced by the testimony of Guyana's fishing community and therefore of the need to have accurate and up to date information in order to protect marine wildlife. Dr Cordes' recommendation is that, "additional data are required to properly evaluate the potential impacts of the proposed project." His conclusion is that, "… the EIA is deficient and the EPA does not have the scientific and technical information required to make an informed decision about the potential impacts of the proposed project in the Stabroek Block." Dr Cordes also warns that without this information the Yellowtail project is highly likely to have greater impacts than those indicated.					
256	15-Dec-2021	Malinda Janki	**ELAW Comments on Marine Mammals as treated in EIA vol 1 rev 0 Yellowtail Development Project** I attach a review from the Environmental Law Alliance Worldwide Scientific Team. The team includes Dr Heidi Weiskel a marine expert. Her information is here: https://elaw.org/users/heidi-weiskel The ELAW science team point out that ERM's conclusions are incorrect and unsupported by evidence. ERM claims that the impact of the proposed Yellowtail Project will be negligible. ELAW points to a review of 538 studies of the effects of noise on marine mammals. They conclude	EIA Section 7.5, Marine Mammals, concludes that the potential adverse impacts of the proposed Project would range from Negligible to Minor and include a positive impact. Regarding the methodology used to reach these conclusions, see the response to Comment #252.	No	Accepted	N/A	N/A

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			that, "This kind of scientific analysis makes it difficult to find the EIA's conclusions of negligible impact credible." According to the ELAW review, ERM reviewed these studies. In that case the EPA must seriously question the competence of ERM in reaching a conclusion of 'negligible' impact that is contradicted by the science that ERM reviewed. This is particularly blatant as ERM admits that there is 'high confidence that anthropogenic noise negatively affected marine animals." The devastating impact of sound on marine mammals is no longer a matter of specialist scientific knowledge but has made its way into general and public knowledge. This is a matter of grave public concern given the rich marine life in the area, including rare and endangered cetaceans. The ELAW review also points out that the EIA treats light pollution as a positive impact not a negative impact.					
257	15-Dec-2021	Malinda Janki	**Evaluation of the EIA for the Proposed Yellowtail Development Project: Dr Mark Chernaik** I attach an independent review by Dr Mark Chernaik a science expert as well as a respected lawyer. Dr Chernaik's opinions have been cited in courts in various jurisdictions. Dr Chernaik points out that the EIA: 1. fails to address the indirect impacts of greenhouse gas emissions. 2. fails to disclose how the inconsistency with the Glasgow Climate Pact; and 3. fails to contain the required information about waste. • Study: Soundscape of the Anthropocene: Duarte et al.	Responses to the ELAW comments enumerated in items (i) through (iii) are provided above (Comments #248 to #250). The reference to the Duarte et al. study is unclear in the context of this comment, but please see response to Comment #252 relating to this study.	No	Accepted	N/A	N/A

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			I attach the above study which is referred to in the ELAW Comments.					
258	14-Dec-2021	WWF	• Guyana has committed to transitioning to renewable energy. • Guyana established several targets in its Nationally Determined Contributions to the UNFCCC to limit carbon emissions. • Guyana faces the reputational risk over the perception that it is forsaking a low-carbon and sustainable future through the way it is embracing the oil and gas industry. • The country's carbon emissions have increased because of gas flaring, and it has now become a carbon emissions exporter as a result of the offshore oil and gas development. **Supplemental Discussion:** Guyana has committed to transitioning to renewable energy to meet the demands of its households and the private sector; and established several targets in its Nationally Determined Contributions to the UNFCCC to limit carbon emissions. This goal in the wake of the recently launched new Low Carbon Development Strategy is timely and relevant particularly in the context of the recent IPCC report in which leading climate scientists have warned that there is only 12 years remaining for global warming to be kept to a maximum of 1.5 degrees Celsius. Beyond this, the risk will be worsened especially for most of the population that currently reside on the low coastal plain below sea level, for severe droughts, floods, extreme heat and poverty. However, Guyana faces the reputational risk over the perception that it is forsaking a low-carbon and sustainable future through the way it is embracing the oil and gas industry. And there is the reality that the country's carbon emissions have	The Consultants acknowledge the comment. Evaluation of the Government of Guyana's strategy for addressing its commitments under its international agreements is not within the scope of the EIA.	No	Accepted	N/A	N/A

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			increased because of gas flaring, and it has now become a carbon emissions exporter because of the offshore oil and gas development. Further, the displacement of mangroves (approx. 40 acres) along the mouth of the Demerara River for downstream oil and gas shore-based development, causing the displacement of some 11,000 tonnes of carbon dioxide to be released into the atmosphere, shows how some developers in the oil and gas industry are demonstrating low interest in keeping to their promises and acting in good faith at the very least, and at times, even flouting the nation's laws.					
259	14-Dec-2021	WWF	**Ratings are "romanticized" in the ESIA; for instance, GHG emissions are set to rise 24-30% (!), and the impact varies between "negligible" and "moderate".**	EIA Sections 6.1.3, Impact Assessment—Air Quality, Climate, and Climate Change, and 6.1.4, Management Measures—Air Quality, Climate, and Climate Change, describe the methodology used to assign impact significance ratings for potential impacts on climate / climate change. As described in these sections, the Negligible impact significance rating was assigned for the drilling and installation stages of the Project, during which GHG emissions would be relatively low. During the production operations stage, the estimated average annual GHG emission levels would be comparatively higher and the duration of this stage would be much longer; accordingly, the production operations stage average annual GHG emission rates are the focus of the assessment. For this stage, an impact significance rating of Moderate was assigned. This is based on a balancing of the following factors: (1) the referenced increase in national Guyana GHG emissions represented by the Project, taking into account that the mitigated emissions represent a relatively small percentage decrease of Guyana's net removals; (2) the fact that the Project would have applied technologies aligned with good international oil field practice to reduce GHG emissions; and (3) the fact that climate change nonetheless remains an issue of global importance.	No	Justification to be provided in the revised EIA	The justification for the residual significance ratings assigned for potential impacts on climate change during the production operations stage – including all of the points referenced in the comment response - is provided in Section 6.1.4.	N/A
260	14-Dec-2021	WWF	• Independent Technical Monitoring Needed • A lot of measures come down to adhering to standards, proper maintenance, and communication. This information is not provided. What kind of standards? What kind of maintenance (precision, predictive, preventive?) How is communication done from shift to shift? • Institutions charged to monitor oil exploration and exploitation lack	EEPGL employs an Operations Integrity Management System (OIMS) and Controls Integrity Management System to reduce environmental risks and increase production performance. OIMS has been certified by Lloyd's Register Quality Assurance to comply with the requirements of the international standards for Environmental Management Systems, ISO 14001:2015 and Occupational Health & Safety Management Systems, ISO 45001:2018. Training of and communications between personnel is covered by OIMS. Maintenance strategy and programs would be developed during Project planning and design and would continue to evolve during production.	No	Accepted	N/A	N/A

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			the capability to match the companies involved in the industry, independent monitoring will ensure adherence to mitigation actions and 'embedded controls' proposed in the ESIA. This was manifested in the flaring of gas which occurred at an alarming rate during the latter part of 2020 and the earlier part of this year on Exxon Mobil's first Oil and Gas Platform in the Stabroek Block. • 3rd parties being allowed to audit the degree of compliance with standards (international, independent annual monitoring, during the project and more-so during the production phase onward, to ensure that activities are being implemented in the best possible ways, utilizing most updated technologies and the best available standards). This implies: • Strengthening Capacity of National Regulatory Institutions • Monitoring Safety risks • Monitoring environmental risks • Create a transparent and accountable sector. **Supplemental Discussion:** The rapid expansion in exploration, seismic surveys and production will have an impact on marine species and ecosystems, particularly in the event of an oil spill. This continuous and expanding development in the Exclusive Economic Zone of Guyana is occurring against the backdrop of an area that is poorly studied and understood, including from the perspective of biodiversity - ecosystem functioning. In addition, Guyana's inexperience, and limited preparedness to manage the industry, in particular to respond timely and adequately in the event of an oil spill, further present serious threats to livelihood and the marine/coastal ecosystems.	The Consultants acknowledge the comment. The Government of Guyana's institutional capacity to oversee the oil and gas industry is not within the scope of the EIA. See the response to Comment #346.				

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			Cognizant of the fact that the institutions charged to monitor oil exploration and exploitation lack the capability to match the companies involved in the industry, WWF recommends that independent technical monitoring be conducted throughout the project to ensure adherence to mitigation actions and 'embedded controls' proposed in the ESIA. This is particularly important to us, given that the level of monitoring exercised in the previously approved projects in the Stabroek Block leaves a lot to be desired. This was manifested in the flaring of gas which occurred at an alarming rate during the latter part of 2020 and the earlier part of this year on ExxonMobil"s first Oil and Gas Platform in the Stabroek Block. We note in this current ESIA, that EEPGL proposes to re-inject recovered natural gas that is not used as fuel on the FPSO back into the targeted Project reservoirs for reservoir pressure management, which contributes to a significant reduction in potential GHG emissions versus that which would result from continuous gas flaring. Adherence to this proposal is paramount in our opinion. The same applies to the discharges where it is mentioned that they will be disposed of in keeping with applicable standards such as the World Bank Environmental Health and Safety Guidelines on oil and grease content. ---------- At the same time, we recommend that regulatory agencies be supported with independent technical monitoring (as their capacity is being built) to ensure adherence to mitigation actions and embedded controls proposed in the EIA, and utilisation of updated technologies. The goal of independent monitoring would be to drive continuous improvement in policies and practices since the					

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			reliance on a prescriptive regulation with inspection model would not be effective. The developers should then be required to adapt based on monitoring recommendations and accommodate upgraded technology and practices during the lifetime of the project.					
261	14-Dec-2021	WWF	**Strengthen the capacity of national regulatory institutions** • It is obvious that the expansion of the oil and gas industry in Guyana has outmatched the pace at which regulatory institutions are benefiting from strengthening their resource base in terms of personnel, technical knowledge, and financial resources. • It is critical for agencies to be able to access and secure necessary resources to help them exercise their authority and enable them to respond to the demands of industry expansion. Waste streams and their effects have been addressed individually in the ESIA, but what are the synergetic? **Supplemental Discussion: Capacity building for monitoring and regulating the sector and associated industries.** WWF reiterates what we have advocated for in comments made in relation to previous ESIAs, that strengthening the capacity of national regulatory institutions be made a priority. It is obvious that the expansion of the oil and gas industry in Guyana has outmatched the pace at which regulatory institutions are benefiting from strengthening their resource base - in terms of personnel, technical knowledge, and financial resources. It is critical for agencies to be able to access and secure necessary resources to help them exercise their authority and enable them to respond to the demands of industry expansion.	The Consultants acknowledge the comment. The Government of Guyana's institutional capacity to regulate the oil and gas industry is not within the scope of the EIA. However, EEPGL has indicated its willingness to work with the Government of Guyana to support technical and regulatory capacity building.	No	Accepted	N/A	N/A

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			-------- The developers suggest a vast number of best practices and standards for reducing impacts to the environment and people. However, the EPA and other regulatory agencies do not currently have the required capacity to ensure that standards and practices are implemented by operators in the sector. Capacity development in some areas is ongoing and this is a positive indication, but much more investment in this is needed to improve human resources and technical capacity. It still holds true that the pace at which the oil and gas industry is expanding in Guyana has outmatched the pace at which regulatory institutions are strengthening their capacities - in terms of personnel, having specialist staff in all relevant levels of expertise, technical knowledge and financial resources. It is critical for agencies to be able to access and secure necessary resources to help them exercise their authority and enable them to respond to the demands of industry expansion. Sufficient budget and technical expertise must be a priority if effective national oversight is to be achieved for the sector. Further, political leaders must work to ensure that the regulatory agencies are empowered, including maintaining autonomy, to be able to ensure stringent safety regulations are maintained. --------- We also recommend continued and strengthening of a coordinated approach among regulatory agencies, which is essential for proper management of the sector. Communication, strong leadership, resource sharing and strong political commitment and the platforms necessary to support this, are needed.				

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262	14-Dec-2021	WWF	**Onshore land-use planning** • As discovered quantities of offshore hydrocarbon resources continue to grow, there will be a corresponding increase in the demand/competition for land and other onshore resources in the city and surrounding areas. • EPA, Georgetown Mayor and City Council, Local Government bodies including RDC and NDCs, GLSC, Central Housing and Planning Authority, Civil Defense Commission, Ministry of Natural Resources, Ministry of Public Works, GGMC, civil society, and other relevant stakeholders should come together and plan for the effective, fair, and transparent use of onshore spaces and resources. **Supplemental Discussion:** Yellowtail represents the 4th major offshore oil development in 5 years and as discovered quantities of offshore hydrocarbon resources continue to grow, there will be a corresponding increase in the demand/competition for land and other onshore resources in the city and surrounding areas that directly or indirectly result from the project. This has been acknowledged by the developer as well as the Guyana Lands and Surveys Commission (GLSC), within the EIA. This necessitates an urgent need to strengthen land/urban planning and implementing and enforcing high standards of practice - including addressing challenges experienced over the years relating to financing, equipment and human resources short falls, hindrances to cooperation among decision-making and responsible agencies, and low levels of transparency and accountability.	Increased demand for goods, services, and housing are considered in EIA Section 8.1, Socioeconomic Conditions, and Section 8.5, Social Infrastructure and Services, respectively. These sections recognize that increased demand could lead to increased prices and/or competition for resources. However, the nature of onshore land use planning processes (and multi-stakeholder involvement in planning processes) is beyond the scope of the EIA.	No	Accepted	N/A	N/A
263	14-Dec-2021	WWF	**Biodiversity offsets and biodiversity monitoring and evaluation programmes**	The assumption that critical habitat likely exists in the Project area is premature without a formal Critical Habitat Assessment (CHA). CHA is a unique element of EIAs conducted under the IFC Performance Standards,	No	Accepted	N/A	N/A

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			International best practices necessitate that the developer implements additional safeguards – such as biodiversity offsets and appropriately designed, long-term biodiversity monitoring and evaluation programmes, since it is likely that critical habitats exist in the area (given the areas offshore Guyana have been described as ecologically and biologically significant). **Supplement Discussion: Biological considerations** The EIA assesses the impacts on marine benthos, sea birds, marine fish, marine mammals, marine turtles, and the general marine ecosystem as largely negligible to minor. We believe that this assessment gives the impression that the marine ecosystem and the fauna which inhabits it will remain largely unchanged despite the Oil and Gas activities being conducted in the region over the next 20 years. This conclusion seems to have been arrived at by focussing on the more immediate areas where the actual FPSO is located, rather than considering the wider seascape. Regardless of what the impacts are assessed to be, there is a need to compensate for it by supporting marine protected areas and having a robust response in the event a major oil spill occurs, since the impacts to biodiversity would be significant affecting other parts of South America and large portions of the Caribbean region. Ballast water exchange during the production operations stage is predicted to have potential impacts on biodiversity due to the potential for the introduction of exotic or invasive species. WWF is concerned that this possibility is being downplayed based on embedded controls which have not been clearly spelt out in the document.	and is not generally included in EIAs that are not subject to the IFC Performance Standards (such as the Yellowtail Project). Nevertheless, the impact assessments for several biological resources (including marine birds, marine mammals, and marine fish) include components that would typically be included in a CHA (such as listing status, congregatory behavior, and migratory life histories) as factors when determining sensitivity to potential Project impacts. EIA Section 7.10, Ecobalance and Ecosystems, is specifically intended to describe biological impacts at the ecosystem/seascape scale as required by Guyana's Environmental Protection Act. As demonstrated by the residual impact ratings included throughout EIA Chapters 6 through 8 of the EIA, the combination of embedded controls and mitigations included in the EIA would be sufficient to manage the impacts of planned Project activities. The establishment of marine protected areas would constitute an offset under the mitigation hierarchy, and is only appropriate in cases where project impacts cannot be adequately managed through embedded controls and mitigation alone. As stated in several locations in Chapter 7 and in the ESMP, the Consultants recommend that the Yellowtail Project be required to comply with the IMO / MARPOL 73/78 requirements. As described in Section 7.10, these standards would require that all Project vessels would exchange ballast water just outside the Guyana EEZ, immediately before entering Guyanese waters. This practice is consistent with good shipping industry practice worldwide and is intended to minimize the potential of introducing invasive or exotic species. The EIA includes, either directly or by reference, several baseline biological studies covering numerous biological resources. In most cases, the impact assessments for specific biological resources were supported by data from multiple years of study. The Consultants' position is that, when considered in aggregate, the current body of biological knowledge as reflected in the EIA is sufficient to support an assessment of the Project's potential impacts on biological resources and development of appropriate embedded controls and mitigation measures.				

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			When compared to previous EIAs, this EIA has shown improvement and slightly a better understanding of specific data on biological resources within our coastal and marine space, however, WWF is still of the opinion that the area remains largely understudied and would still like to advocate for more long-term monitoring on our biological resources inclusive of all life stages and various breeding, migratory, foraging grounds etc, to gain better understanding their importance and values. There remain gaps on species data and sub-population to determine their direct impact as it relates to the activities proposed especially given that this EIA seems to be more focused on the impacts of the biodiversity that occurs within direct or specific range of the project area. It is also recommended that the Management Measures proposed for each biodiversity group follow international best practices and are closely monitored through the lifespan of the project.					
264	14-Dec-2021	WWF	**(Major) oil spill** • Precise role and processes of local partners and how they fit into the system of response remains unclear. • Local agencies have small budgets to fund their operation. • Decentralization of capacity to respond to oil spill is critical given the geography of Guyana's coastline. • Training and capacity building will need to be funded and undertaken **Supplemental Discussion: Unplanned events** The main unplanned events of concern to all are oil spills, especially since the Project will be producing, processing, storing, and offloading oil as its core activity. Models presented in the OSRP demonstrate that oil spills with the	OSRP Chapter 6 describes oil spill response resources available to support Tier I, II and III spills; Chapter 7 describes exercises and trainings scope. Sections of the OSRP describe systems for working with local stakeholders within Guyana and appropriate representatives of other jurisdictions (in coordination with the Government of Guyana) to respond to oil spills within Guyana and transboundary events in Sections 2 and 1.2.3, respectively. As further described in Section 1.2.3, the OSRP explicitly anticipates working with local communities within the impacted areas to raise awareness of oil spill planning and preparations. To facilitate localized responses, each operating location maintains an Emergency Response Team governed by their Facility Response Plan that addresses the immediate actions required upon the discovery of an abnormal condition or emergency. EEPGL recognizes the need to build local oil spill response capacity. As described in OSRP Section 2.3, EEPGL works cooperatively with Guyanese regulators, agencies, and interested stakeholders. To supplement in-country response resources, EEPGL is collaborating and pursuing other cooperatives with regional Oil Spill Response Organization(s) (OSROs) to support Tier II+ spill response efforts, should additional OSROs with appropriate capabilities be identified, and should there be interest among other regional organizations in industry to participate.	No	Accepted	N/A	N/A

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			right menu of circumstances can affect many neighbouring countries in South America and in the Caribbean as far as the Greater Antilles. As pointed out in the ESIA, even though the probability of a spill may be low, such an oil spill would likely have adverse impacts on marine resources such as marine water quality, seabirds, marine mammals, and marine turtles. Given that the modelling does not account for oil spill response, it therefore means that the difference between an oil spill and the scenarios presented in the modelling occurring is the oil spill response. WWF is therefore concerned with the capacity of local institutions identified to respond in the event of an oil spill. Decentralisation of capacity to respond to oil spill is critical given the geography of Guyana's coastline and against this background, training and capacity building will need to be funded and undertaken.					
265	14-Dec-2021	WWF	**Synergetic effects of waste streams** • Waste streams and their effects have been addressed individually in the ESIA, but what are the synergetic? • Cumulative impacts, not only from EEPGL project activities, but from other oil and gas projects both on and offshore should be evaluated bearing in mind earlier comments on impact ratings, lack of data, socio-economic impacts etc. The assessment should be done at the seascape-coastal level rather than being site specific. **Supplemental Discussion: Management of Wastes** As in previous EIAs, this EIA has also noted the lack of long-term capacity of waste disposal facilities to deal with non-hazardous wastes; and that the existing capacity will be exhausted and new areas will need	EIA Section 10.6.3, Waste Management, describes the combined impacts associated with hazardous and non-hazardous waste streams generated by the Project and by other offshore EEPGL activities included in the scope of the cumulative impact assessment (i.e., exploration through 2028, Liza Phase 1, Liza Phase 2, Payara, Yellowtail, FPSO #5, and FPSO #6 development projects, Fiber Optic Cable Project, Guyana Office Complex Project, and Gas to Energy Project operational by 2027), including a summary of estimated annual waste volumes. (The Consultants were unable to identify publicly available waste generation estimates for the non-EEPGL projects included in the cumulative impact assessment.) Conservatively assuming all of the non-hazardous waste and all of the treated hazardous waste (assuming no reduction in mass during treatment) ultimately is disposed in a non-hazardous landfill, this represents approximately 6.2 % of the total current demand on Georgetown-based landfill facilities (on the order of approximately 15,000 tonnes per month). Taking into consideration the opening of Cell 2, the reasonably anticipated development of additional cells at the HBL, and the limited percent contribution of the Project, this represents a relatively low level of impact on non-hazardous waste management infrastructure capacity for the longer-term (up to 10 years). New landfill development in the region may be appropriate for consideration going forward. Also, see the responses to Comments #37, 38 and 171.	No	Noted. Clarity to be provided in the EIA based on capacity of waste sites also taking into account discussions with Redford Group.	Section 10.6.3 of the EIA has been updated to reflect all of the points in the comment response.	p. 10-37

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			to become operational. Given that the Yellowtail project will be operating in Guyana for more than 20 years, this situation must be monitored and improved quickly, especially as the volumes of waste that will be generated will also grow from other sectors. Since new sites or expansion of current sites will be undertaken, we recommend a planning approach which gives first priority to human health and the environment. Challenges experienced by residents of communities located within the zone of impact of the Haggs Bosch Landfill site, for example, should not be allowed to recur. **Supplemental Discussion: Physical considerations** The EIA has noted the lack of long-term capacity of waste disposal facilities to deal with non-hazardous wastes; and that the existing capacity will be exhausted by 2019-2020. Given that this project will be operating in Guyana for more than 20 years, this situation must be improved quickly. Haggs Bosch Landfill site has been identified as one location in the menu of facilities for waste management but given the problems that have been ongoing on the site and general issues with waste management in the country, these local facilities are woefully inadequate. The plan should identify the quantities of hazardous substances and other waste materials which will be generated throughout the different phases of the project and require disposal onshore.					
266	14-Dec-2021	WWF	Thousands of tonnes of hazardous wastes will be generated during the lifetime of this project. Any treatment of hazardous wastes should be done in keeping with best available standards, technology and the need to safeguard human and environmental health. Although a comprehensive waste management	The CWMP, dated October 2021, is available on the EPA website. The regulations, standards, and guidelines described in the CWMP would be applicable to the Yellowtail Project, including those for hazardous waste management and treatment, as described in Section 3.1.4, Onshore Waste Management Operations, of CWMP Appendix C. See also the response to Comment #188.	No	Accepted	N/A	N/A

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			(CWMP) plan is referred to in the main document, the CWMP could not be located in the appendices or in any of the volumes of the EIA.					
267	14-Dec-2021	WWF	The management of some types of wastes generated will lie with sub-contractors. In the absence of adequate national standards to guide their operations, sub-contractors should operate in accordance with generally established standards for the industry or standards of EEPGL. We also recommend that EEPGL hold responsibility for negative impacts resulting from its subcontractors. The EIA was not clear on this aspect, although EEPGL committed to auditing contractors.	As described in EIA Chapter 2, Description of the Project, and Section 8.6, Waste Management Infrastructure Capacity, the Project will manage its wastes in accordance with a CWMP, which has been approved by the EPA. EEPGL will use waste management contractors that are licensed by the authorities, and will undertake its own assessments to assess whether contractors are operating to international environmental and health and safety standards. The responsibility for contractors' and subcontractors' activities would be determined in accordance with Guyana's laws and regulations.	No	Accepted	N/A	N/A
268	14-Dec-2021	WWF	In the Payara EIA, incineration onshore is mentioned as a waste disposal method in the EIA and EEPGL indicated that they are utilising a regional supplier who is operating an existing onshore waste treatment/incineration. Is this facility being utilized as part of the Yellowtail project?	As discussed in EIA Section 8.6, Waste Management Infrastructure Capacity, two facilities with thermal treatment capabilities are currently operational and identified as potential options to manage Project wastes requiring thermal treatment. The Tiger Rentals Guyana Inc. (TRG) facility has expanded its capabilities to include an additional thermal treatment unit and construction is continuing at the TRG facility to add additional thermal treatment capacity. Additionally, another third-party, Sustainable Environmental Solutions Guyana, Inc. (SES), has developed a new integrated waste management facility at Guyana Shore Base Inc. (GYSBI) designed to manage wastes that are generated from offshore oil and gas operations. The EIA has been updated to reflect that the SES facility is now fully operational and employs various hazardous and non-hazardous waste management technologies, including hot oil thermal desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing operations. Both of these waste management facilities have a design/processing capacity sufficient to treat and store hazardous wastes. Several additional qualified third-party waste management operators are currently seeking authorization for facility developments or expansions, as discussed above. These are expected to further expand the capacity of onshore waste management infrastructure to manage the Project's hazardous, non-hazardous, and exempt hazardous waste storage, processing, treatment, and/or recycling needs.	Yes	Accepted	N/A	pp. 2-78, 8-163
269	14-Dec-2021	WWF	**Assist with depletion policy formulation** Development of a depletion policy as it could impact national investments, planning for the management of the industry, energy policies and transition to renewable energy, development	The Consultants acknowledge the comment. The comment is beyond the scope of the EIA and should be referred to the Government of Guyana.	No	Accepted	N/A	N/A

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			of other economic sectors and economic diversification etc.					
270	14-Dec-2021	WWF	**Socio Economic Impacts, Livelihoods and Community Wellbeing.** As part of its embedded controls for mitigating socio-economic impacts the developer states that it will implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) earlier on, prior to the onset of Project activities and ensure CGM is well publicized and understood by the public. Having the CGM in the EIA however does not ensure transparency and accessibility. The EPA should ensure that the CGM is accessible to stakeholders and there is transparency in dealing with issues arising from stakeholders' submissions. **Supplemental Discussion: Socio Economic Impacts, Livelihoods and Community Wellbeing.** As part of its embedded controls for mitigating socio-economic impacts the developer states that it will implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) earlier on, prior to the onset of Project activities and ensure CGM is well publicized and understood by the public. Having the CGM in the EIA however does not ensure transparency and accessibility.	As recommended in the EIA and stated in the SEP (Volume III of the EIA), EEPGL has in place a transparent, accessible, and consistent CGM that applies to Yellowtail, both prior to the onset of Project activities and throughout its life cycle. The SEP describes the objectives of the CGM, examples of how feedback is shared with the public, and contact information for the public to submit feedback by multiple means. CGM effectiveness would be periodically evaluated and the CGM would be updated as necessary.	No	Accepted	N/A	N/A
271	14-Dec-2021	WWF	The EIA assesses the impacts on artisanal fishing livelihoods as Minor while determining the potential impacts on employment and livelihoods as Positive as a result of Project employment, procurement, and worker spending. This is a narrow way to determine positive economic impacts especially in an environment where the local private sector continues to cry foul when it comes to local content. Project	The focus of the EIA is on the identification and management of potential adverse impacts of the proposed Project. As such, potential positive impacts (benefits) are acknowledged but are not assessed in terms of magnitude nor significance. In this manner, potential Project benefits such as employment and procurement are identified and described in EIA Section 8.1, Socioeconomic Conditions, and Section 8.2, Employment and Livelihoods. Although the Yellowtail Project will result in an incremental addition to local employment, the benefit to the Guyanese workforce is quantified for EEPGL's activities in Guyana to date, as stated in EIA Section 8.1.3.1, Relevant Project Activities and Potential Impacts: *As of the first half of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more*	No	Accepted	N/A	N/A

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			employment and procurement is also limited to those with very direct relations with the Oil and Gas sector while worker spending cannot be seen as a broad-based game changer in the local economy. On the contrary, it may lead to inflation (already noticeable in the cost of housing, food and services) and the widening of the gap between the rich and poor.	*than 5,400, more than half of whom (more than 2,800 workers, or 53 percent of total) are Guyanese. The number of Guyanese workers has increased by [more than] 35 percent since June 2020... Roles held by Guyanese employees cover a range of skill levels and professions, including but not limited to entry level positions, apprentices, equipment operators, administrators, skilled trades, supervisors, professional personnel…and managerial staff.* The benefit of employment supported by the Project does not negate the potential adverse impacts on other livelihoods, including fisherfolk. For this reason, a potential adverse impact on fisherfolk is separately identified and assessed in EIA Section 8.2. Additionally, potential adverse economic impacts including inflation and increased cost of living are also identified and assessed in EIA Section 8.1. In reality, socioeconomic benefits and adverse impacts would co-exist. The relationship between impacts and benefits can be complex, and may be experienced differently by different stakeholders. The approach of the EIA is to identify both socioeconomic benefits and adverse impacts, and to assess the adverse impacts in greater detail, including consideration of mitigation and management measures to reduce the significance of the expected impact. This approach is aligned with the requirements of the Environmental Protection Act and with international good practice for environmental and social impact assessment.				
272	14-Dec-2021	WWF	The recent revelation by the Minister of Agriculture that there is uncertainty about why there is a decline in catch in the fisheries sector and that a study needs to be conducted to determine this shows the difficulty we are in with little or no credible baseline data in Guyana. On that basis, the only way that we can verify minor impacts on artisanal fisheries would be to provide support for credible research into what the baseline is for the fisheries sector. This is especially important for ExxonMobil since it is being accused by fisherfolk as being responsible for the current decline in fisheries catch.	The Consultants have added additional information to the EIA on potential causes for observed fisheries declines based on review of the latest fisheries-related report from Bank of Guyana and information collected from consultations with fisherfolk. Please see response to Comment #207 for further details on this issue.	Yes	Accepted	N/A	7-193 to 7-194
273	15-Dec-2021	Janet Bulkan	It is clear in appendices D and M in volume II of the EIA that ERM has tried to obtain access to longitudinal fish population and catch data which should be readily available from the government Fisheries Department. It is significant that ERM, through its sub-contractor EMC, has drawn on the 1962 publication by Rosemary Lowe-McConnell on the two seasons of research trawls in 1958 and 1959 (35 cruises, 2246 fishing	The Consultants contacted the Fisheries Department in 2021 with a request to meet and obtain updated data on fisheries. The Fisheries Department provided some information on seasons and general changes in the market for fisheries products, and these are reflected in EIA Chapter 8; however, no information on fish populations was available. The Consultants therefore relied on primary data from 2 years of direct biological surveys and participatory fishing studies, published sources, and more recent information on fishing activities collected from local fishing cooperatives and the other government sources to inform the baseline information on marine fish and fisheries in Chapters 7 and 8, respectively.	No	Accepted	N/A	N/A

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			hours, 1070 sampling stations) which yielded a total of 213 marine species. ERM apparently did not find government data on accessible file, and so commenced snapshot surveys in 2014 through sub-contractors, including the local consultancy EMC in 2018. The two appendices D and M in volume II of the Yellowtail EIA provide confirmatory evidence about marine biodiversity, following Lowe-McConnell. That is, there is no evidence in the EIA that marine biodiversity has declined between 1959 and 2015. The EIA volume I notes that EEPGL/XOM commissioned environmental baselines studies (EBS) which include campaigns in 2014 (by Maxon Consulting and TDI-Brooks), 2016 (Fugro GB Marine), 2017 (ESL), 2018 (Canje tract, Maxon and Fugro), 2019 and 2020 (Hammerhead oil field in the Stabroek tract, Maxon et al.). Some of the baseline studies have been included in Appendix I of volume II of the Yellowhead EIA. They include results of benthic sampling of the sea floor but do not cover fish populations. However, right at the end of this Appendix I are a few charts of salinity and dissolved oxygen against depth in the ocean. Marine water quality studies (snapshot data) are reported in section 6.4.2 (physical pages >428) of volume I of the Yellowtail EIA and may be helpful in interpreting fish population data at some future date. Only a few of the EBS are included in Appendix 1; some others were provided with the Payara EIA. It is not clear why all the EBS have not been provided in Yellowtail Appendices. Small-scale fish surveys were carried out by EMC and by ERM, in September-October 2017 (dry season), April 2018 (wet),	Including all of the EBS reports that informed the baseline discussions in EIA Chapters 6 and 7 would have increased the Volume II page count by thousands of pages. All of the EBS reports detailing the findings of the studies that informed the Yellowtail EIA (including the appendices with data tables) have been made available to the EPA. Following precedent, new reports that have not been provided previously are included in Volume II of the Yellowtail EIA. Historical reports were previously made available in Volume II of either the Liza Phase 2 or Payara EIAs. These documents are available to the public on the EPA's website. Sampling was conducted inside mangroves. Attachment G of Appendix M, Nearshore and Offshore Fisheries Study Summary (Volume II of the EIA), includes photographs of samples being taken in mangroves. These areas were sampled specifically because they tend to function as nursery areas for fish and shellfish. This effort was supplemented by including a participatory/Traditional Ecological Knowledge element to the coastal sensitivity mapping that was provided to the EPA and the public in Volume II of the Payara Development Project EIA (specifically Appendices P and V) in 2020. The important fish habitat areas included in the maps in Appendix P include nursery areas.				

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			November 2018-January 2019 (dry), and April-June 2019 (wet) in four depth zones: Stabroek tract deepwater, on the continental shelf, near-shore, and estuarine. It seems that some sampling was done on the fringes of some mangroves, but no systematic study inside mangroves. If correct, this was a major omission because of the importance of Guyana mangroves as spawning grounds and nurseries for shrimp and young fish of some demersal species. Ms Simone Mangal-Joly has already pointed out that that ERM did not try to locate the breeding or nursery grounds for even the main commercial species, nor was there any attempt to study the annual patterns of migration of major fish species (Stabroek News, 2021). Anecdotal evidence from fishermen and fish market stallholders confirms that there are seasonal patterns of variation in fish catches and icthyoplankton presence. Some variation may be linked to the tremendous outflows of freshwater during the wet seasons from the major north-flowing rivers of Guyana, especially Essequibo, which affect both salinity and water temperature. As surface sea temperatures in the near-shore and continental shelf zones are close to the natural upper limit of comfort for ocean fish (32°C) even a small rise because of hotter river water may drive fish further offshore. Likewise, anecdotally, fishermen are aware of the continuous discharge of heated cooling water from the FPSO Liza Destiny, but probably not aware that ERM claims that the extra heat does not exceed 3°C at a distance of 100 metres from the FPSO. The Yellowtail EIA volumes spend many pages on the claimed insignificant negative impacts of pile-driving for SURF components and the vertical seismic profiles	Historical 3D and 4D seismic surveys are not assessed in the Yellowtail Development Project EIA because they have already been completed and as such, any effects of these surveys would be reflected in the existing biological and socioeconomic baselines presented in the EIA. Future seismic exploration projects are not specifically discussed in EIA Chapter 10 because there are no reasonably foreseeable seismic exploration programs that would overlap temporally with the drilling and installation phase of the Yellowtail Development Project, which is the only phase of the project that could potentially include seismic activities.				

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			(VSPs) planned within each oil field to help determine the locations and flows of the petroleum resources. It is not the VSPs which concern the fishermen but the widespread knowledge and rumour of the very long distances at which the air guns of the exploratory seismic mapping can be heard underwater and the reports of damage from these air guns to cetacean biology and social communications. I have been unable to see if these 3-D and 4-D seismic surveys are covered by the EPA's environmental authorisations for the three fields Liza-1, Liza-2 and Payara. Anecdotal information from fishermen includes a frequent comment that 'vibrations' from the vessels of XOM contractors are driving populations of commercial fish species away from the customary fishing grounds. seems to be some confusion among fishermen, possibly because of the absence of culturally appropriate information from ERM/EEPGL. The fishermen are not able to distinguish the functional differences between the anchored FPSO, the 25 platform supply and service boats, the vessels used to lay the fibre-optic control cables between the Liza-1 field and the Georgetown office, and the geo-technical and sea bottom survey vessels. It seems unlikely that the coastal fishermen have access to the MARAD Notices to Mariners which announce the arrival, movement and departure of drillships and the Marine Safety Information notes which announce survey ships for geotechnical study of sea bottom and sub-surface conditions. In 2021 there have been at least the following campaigns, some of which may have been visible from the coastline or from near offshore, and some have been covered by retrospective MARAD Notices.	The Consultants recognize the challenges to effective communication with small-scale fishing operations and communities. The ESMP includes a recommendation to augment EEPGL's ongoing stakeholder engagement process (along with relevant authorities) to identify both commercial and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones. Additionally, as described in several responses above, an additional year of the participatory fishing study is currently being conducted by EEPGL. EEPGL frequently uses the periodic engagements that are integral to the participatory fishing study methodology to disseminate information on offshore activities at the local level within fishing communities in Regions 1through 6.				

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			Fibre-optic cable work – MARAD Notice 66, 18 June for 1 June – 30 August (6 vessels); MARAD Notice 95, 30 July for 26 August to 10 October (1 vessel); MARAD Notice 103, 24 August for 28 August – 31 October (1 vessel); Geo-technical and bottom surveys – MARAD Notice 43, 23 April for 18 March – 30 June (2 vessels); MARAD Notice 76, 02 July for up to 31 October (2 vessels for bottom surveys off Plantation Best); MARAD Notice 85, 08 July for 08 July – 31 October (3 vessels for the Demerara River and coastline westwards); MARAD Notice 92, 30 July for 04 August – 04 November (1 vessel); MARAD Notice 128, 18 October for 19-31 October (2 vessels for survey NW of the Demerara Main Ship Channel). It is not surprising that fishermen believe that such near-shore work may include activities which could be causing declining fish catches, in the apparent absence of efforts by ERM/EEPGL to explain what the various oil-related vessels are doing and why. I do not find in the EIA volumes for the Yellowtail EIA any consideration of these matters. There are widespread beliefs among fishermen and fish traders that the activities of XOM and its contractors are affecting negatively the declining populations of commercial fish species. Although XOM has carried out some awareness-raising activities in some coastal locations, it seems that the style of communication was neither culturally meaningful nor encouraged retention of the information. There seems to be no provision in the EIA for regular systematic monitoring of the commercial fish populations which may be affected negatively by XOM activities, or for public reporting of such monitoring. Given that artisanal					

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<tr><th>Comment</th><th>Date</th><th>Stakeholder</th><th>Comment</th><th>Response</th><th>EIA Edit?</th><th>EPA Response</th><th>Consultant Response</th><th>Page Numbers with EIA Edit</th></tr>
<tr><td></td><td></td><td></td><td>fishing, selling and processing are a major source of coastal employment and family income, and given that the EP Act requires the developer to develop the EIA for the whole of a project (section 11 (5) (a) (i)).</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>274</td><td>10-Dec-2021</td><td>Concerned Citizens & Participants at the November 11, 2021 Public Consultation on the EEPGL’s
Yellowtail Development Environmental Impact Assessment Study

Simone Mangal-Joly
Alfred Buhlai
Vanda Radzik
Janette Bulkan
Denuta Radzik
Jerry Jailall
Alissa Trotz
Maya Trotz</td><td>Impacts of total volume of waste brought to shore for the lifetime of the Yellowtail project:
What is the exact quantity of waste that will be brought on shore for the life of the project?</td><td>Although it is not possible to project an exact quantity of waste that would be generated and brought ashore for treatment/disposal during the Yellowtail Project life cycle, EIA Table 8.6-2 provides a summary of the estimated annual generation of Project wastes that will be brought onshore for treatment and/or disposal during the Project life cycle.
<table><tr><th>Waste Generated by Category</th><th colspan="9">Volume by Year/Metric Tonnes [a]</th></tr><tr><th></th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031-2032</th></tr><tr><td>Non-Hazardous wastes (total) [b, c]</td><td>750</td><td>1,900</td><td>2,030</td><td>1,670</td><td>1,670</td><td>1,670</td><td>1,670</td><td>110</td><td>1,670</td></tr><tr><td>Hazardous wastes (total) [b, d]</td><td>300</td><td>2,360</td><td>3,270</td><td>700</td><td>700</td><td>700</td><td>700</td><td>100</td><td>700</td></tr></table>[a] The annual totals reflect the current preliminary Project schedule and production profile, which could conservatively assume three drill ships are supporting the Project continuously throughout the drilling indicated on the preliminary Project schedule.
[b] Totals may not sum exactly due to rounding.
[c] Includes wastes that will be directly shipped to an approved landfill and wastes that can be recycled, reused. Volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes wastes that are treated to produce residual non-hazardous wastewater than can be dischar permitted outfalls; and wastes that are treated to produce residual non-hazardous solid wastes that ca recycled, reclaimed, or reused, or transported for disposal in an approved landfill.</td><td>No</td><td>Accepted</td><td>N/A</td><td>N/A</td></tr>
<tr><td>275</td><td>10-Dec-2021</td><td>Concerned Citizens</td><td>What is the constituent component of that waste?</td><td>EEPGL has developed a waste profile for each waste stream that is expected to be generated by the Project. The purpose of the waste profile is to compile all the relevant information needed to properly manage these waste streams. This information is compiled an EPA-approved Waste Profile Sheet (WPS) for each waste stream.

The EPA’s WPS requires the completion of numerous data fields. Most of the WPSs are complemented with a Safety Data Sheet (SDS), where applicable. The WPS includes information about the generator, waste classification, projected annual volume, and various waste physical characteristics and chemical properties, as illustrated in the CWMP under which the Project’s waste management activities will be conducted. To date, EEPGL has developed 35 separate waste profiles for wastes generated from both offshore and onshore operations.</td><td>No</td><td>Accepted</td><td>N/A</td><td>N/A</td></tr>
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				The EPA-approved CWMP, dated October 2021, is publicly available on the EPA's website.				
276	10-Dec-2021	Concerned Citizens	How will the waste be transported and offloaded at treatment site(s)?	As described in the CWMP, which is publicly available on the EPA's website, the wastes generated from the Project's offshore operations would be off-loaded to other marine support vessels for transport to shore-based waste management facilities. Support vessels used to transport wastes would have the necessary licenses and approvals from the Guyana authorities. Vessels transporting wastes would carry both a completed Marine Transport Manifest and a completed Waste Manifest. These documents must contain the name, description, and quantity of all wastes being transported. Offshore wastes received at the GYSBI shorebase would be first off-loaded from the vessels using onshore cranes. After off-loading is complete, the waste containers would be transferred to the appropriate waste management facilities (e.g., TRG, SES) located at GYSBI, or to a temporary transit area adjacent to TRG/SES pending transfer to these waste management facilities.	No	Accepted	N/A	N/A
277	10-Dec-2021	Concerned Citizens	What specific risks does its transport pose at the specific sites of treatment giving surrounding receptors?	As illustrated in the CWMP, dated October 2021, waste characterization and classification is conducted to support the following management measures to address risks associated with waste transportation, including worker exposure, waste mishandling, improper waste treatment/disposal, and spillage: • Proper selection of appropriate personnel protective clothing and equipment to mitigate worker exposure during waste handling, storage and transportation; • Training of workers to manage and mitigate hazards related to waste handling, storage, and transport; • Development of appropriate emergency response measures in case of spills or other incidents; • Proper container selection for safe containment, handling, and transportation of waste; and • Proper segregated storage of wastes based on incompatibility, reactivity, or other physical/chemical characteristics. Additionally, the existing waste TRG and SES management facilities are located at the GYSBI Shorebase. All offshore wastes received at this shorebase are transferred directly to these adjacent waste management facilities. The transportation of wastes to co-located facilities instead of off-site third-party facilities for treatment reduces the risks associated with waste transportation services. Finally, various mitigation measures would provide protection for surrounding air/water/land receptors, such as secondary containment, spill control, and air pollution control on all treatment systems.	No	Accepted	N/A	N/A
278	10-Dec-2021	Concerned Citizens	What are the specific toxicities and risks to human health and ecology of each component, and specifically how will the waste be treated to remove toxic components?	EEPGL has identified and characterized each waste stream generated from the Projects to date. This waste characterization has included an evaluation of processes and process knowledge, and review of manufacturers' SDS and product specifications. Where SDS and generator knowledge is not sufficient for proper characterization of wastes, sampling and laboratory analysis is conducted so that information is available to assess the hazards for each waste, including whether they are flammable, corrosive (acid or base), reactive (oxidizer, pyrophoric, reducer), and/or toxic. This characterization informs the treatment process that is applied to the specific waste. As	No	Accepted	N/A	

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				described in the response to Comment #268, the TRG and SES facilities currently in operation employ a variety of different treatment technologies. This information is discussed in further detail in the CWMP, dated October 2021, which is available on the EPA's website.				
279	10-Dec-2021	Concerned Citizens	What discharges will there be to air, water, and ground during treatment and what are the chemical compositions of these discharges and what risk do they pose to human health and ecology?	The TRG and SES facilities at the GYSBI are operating under independent permits issued by the EPA. The current permits require environmental testing of treated wastewater before discharge and testing of treated solid wastes for various parameters prior to landfill disposal.	No	Accepted	N/A	N/A
280	10-Dec-2021	Concerned Citizens	Will any discharge be directly into rivers and estuaries with protected forest species, and if so, what threats do they pose to such bodies over the full life of the Yellowtail project?	Treated wastewater from the TRG and SES facilities is discharged to the Demerara River though a permitted outfall at the GYSBI facility. These discharges are conducted in accordance with the provisions of permits issued by the EPA. There are no other discharges of wastewater from these waste facilities into other rivers or estuaries.	No	Accepted	N/A	N/A
281	10-Dec-2021	Concerned Citizens	Will this discharge affect fisheries and other activities into any estuary?	Treatment of wastewater discharges from the TRG and SES facilities is conducted in accordance with the provisions of permits issued by the EPA. Treated wastewater is discharged through the permitted GYSBI outfall and into the Demerara River. There are no other discharges of wastewater from these waste facilities into other rivers or estuaries.	No	Accepted	N/A	N/A
282	10-Dec-2021	Concerned Citizens	What is the chemical composition and risks of the residues that will be taken to a landfill?	All treated solid wastes are tested before landfill disposal. Treated wastes are tested for total petroleum hydrocarbons, total oil and grease, and Toxicity Characteristic Leaching Procedure (TCLP) extractable metals content (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and zinc) to confirm they have been rendered non-hazardous in the treatment process. Wastes are re-treated if they do not meet non-hazardous classification criteria. See also response to Comment #275.	No	Accepted	N/A	N/A
283	10-Dec-2021	Concerned Citizens	What is the total volume of waste bound for landfills during the life of the project?	EIA Table 8.6-2 provides a summary of the estimated annual generation of Project wastes that will be managed onshore. See the response to Comment #274. A conservative assumption is that all of the estimated nonhazardous waste and the treated hazardous waste (assuming no reduction in mass during treatment) ultimately would be disposed in a non-hazardous landfill.	No	Accepted	N/A	N/A
284	10-Dec-2021	Concerned Citizens	What is the total land demand for such landfill given the volume of waste produced over the life of the project?	At current disposal rates, Cell 2 at HBL is expected to last for approximately 4 to 6 years. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next 5 years. There remain two additional cells at the site (Cell 3 and Cell 4) for future development. Each cell is 6.5 hectares (16 acres) in size and could be anticipated to last for 5 to 6 years each. New landfill development in the region may be appropriate for consideration going forward.	No	Accepted	N/A	N/A
285	10-Dec-2021	Concerned Citizens	What are the standards for operation of such landfill, and what are the risks of these standards are violated?	All non-hazardous solid wastes generated to date from the EEPGL projects have been disposed at the HBL. The HBL is the only engineered landfill in Guyana and started operations in early 2011. Key engineered features of the HBL include: • Liner System (geotextile over 20-meter (65.6-foot) thick native clay) • Landfill Leachate Collection System (drainage layer for leachate collection)	No	Accepted	N/A	

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				• Leachate Treatment System (two facultative ponds, two stabilization ponds) operational since March 2018 • Waste Compaction and Cover • Litter Fences • Environmental Monitoring (leachate, groundwater, surface water) ExxonMobil has a corporate-level Approved Waste Site List (AWSL) Program that governs usage of third-party waste management facilities globally. Specifically, the purpose of the system is to mitigate potential Safety, Security, Health & Environment concerns associated with the recycle, treatment, storage, transfer, and disposal of wastes generated by ExxonMobil Corporation and its affiliates globally. The third-party waste management facilities currently being used in Guyana by EEPGL are subject to the requirements of the AWSL Program.				
286	10-Dec-2021	Concerned Citizens	**The cumulative impacts of total volume of waste brought to shore for treatment and disposal for the lifetime of Liza1, Liza 2, Payara, and Yellowtail:** What is the total volume of waste produced by all four production platforms, and what would be the cumulative impact of transport, treatment, and disposal of the total volume of waste?	Although it is not possible to project an exact quantity of waste that would be generated and brought ashore for treatment/disposal during the life cycle of EEPGL projects, EIA Table 10.6-1 provides a summary of the estimated annual generation of wastes that will be brought onshore for treatment and/or disposal for i.e., exploration through 2028, Liza Phase 1, Liza Phase 2, Payara, Yellowtail, FPSO #5, and FPSO #6 development projects, Guyana Office Complex Project, and Gas to Energy Project operational by 2027). **Table 10.6-1: Summary of Estimated Annual Project Waste Generation and Management Methods—Cumulative EEPGL Activities** Waste Generated by Category / Volume by Year/Metric Tonnes[a] 2023 / 2024 / 2025 / 2026 / 2027 / 2028 / 2029 / 2030 / 2031–2032 / 2033–2044 Non-Hazardous wastes (total)[b, c]: 5,370 / 4,830 / 5,290 / 5,240 / 4,940 / 4,810 / 3,310 / 1,750 / 3,310 / 1,750 Hazardous wastes (total)[b, d]: 4,310 / 3,270 / 5,970 / 5,070 / 3,090 / 1,790 / 1,180 / 580 / 1,180 / 580 [a] The annual totals reflect the current preliminary Project schedules and the production profiles for development projects and exploration drilling, which could change. The Yellowtail portion of the annual totals conservatively assumes drilling up to 2032. [b] Totals may not sum exactly due to rounding. [c] Includes wastes that will be directly shipped to an approved landfill and wastes that can be recycled, reclaimed, or reused. Volumes include estimated quantities of residue from treatment of hazardous waste. [d] Includes wastes that are treated to produce residual non-hazardous effluent than can be discharged through permitted outfalls and wastes that are treated to produce residual non-hazardous solid wastes that can then be recycled, reclaimed, reused, or transported for disposal in an approved landfill.	No	Accepted	N/A	N/A
287	10-Dec-2021	Concerned Citizens	What is the total amount of land that will be required for waste disposal and how will this land use requirement be met in terms of volume of waste and land fill requirements?	See the response to Comment #284.	No	Accepted	N/A	N/A
288	10-Dec-2021	Concerned Citizens	**Baseline information on Guyana's fisheries sector:** Where is the baseline data on the fisheries industry that specifies total number of informal and informal operators, size, catch per unit effort in the dry versus the wet season, economic value of formal and informal production, livelihood dependency, economic linkages,	A complete inventory of number of participants in each fishery and seasonal catch per unit effort is beyond the scope of the EIA, and is the type of data that are typically included in a fisheries management plan. However, information on total economic productivity of the sector over the last several years, estimated size of the artisanal fishing fleet, and various economic concerns affecting the industry are described in EIA Section 8.1, Socioeconomic Conditions, and Appendix D, Participatory Fishing Study Final Report January 2019–March 2020 (Volume II of the EIA).	No	Accepted	N/A	N/A

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			and total economic value of the sector considering linkages with other sectors?					
289	10-Dec-2021	Concerned Citizens	Where are the nearshore and offshore fish nurseries located and mapped by geospatial coordinates?	Important nearshore fish habitats (many of which serve as nurseries) are delineated in the coastal sensitivity maps included in Appendix O (Volume II of the EIA). Offshore pelagic species have many different preferred spawning and nursery habitats, some of which are poorly documented. Marine species known from Guyana waters spawn and complete their early lifestages at various locations throughout the entire Atlantic basin, depending on species. Although the ichthyoplankton data cited in EIA Section 7.8.2.1 indicates that many of these marine species spawn and mature in Guyana waters, no important offshore nursery habitats have been mapped within the Guyana EEZ to date.	No	Accepted	N/A	N/A
290	10-Dec-2021	Concerned Citizens	What are the life cycle migration patterns relative to the offshore oil blocks and locations of offshore and nearshore nurseries?	As described in the previous response, the specific areas that are important to Guyana's marine fishes are extremely varied. Some species, particularly the demersal fishes such as snappers, grunts, and seatrouts, are known to use estuaries and mangroves as nursery habitats and gradually move offshore as they mature. Many of these inshore areas have been mapped as important fish habitat areas in the coastal sensitivity maps included in Appendix O (Volume II of the EIA).	No	Accepted	N/A	N/A
291	10-Dec-2021	Concerned Citizens	Where is the document proving that this information was collected and analysed and publicly ventilated for feedback from fisherfolk prior to extensive 2015 seismic surveys and disturbances conducted by EEPGL?	The coastal sensitivity maps in Appendix O were created with the input from knowledgeable residents from coastal communities in the coastal regions as described in Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Reports. Both Appendices are available in Volume II of the EIA.	No	Accepted	N/A	N/A
292	10-Dec-2021	Concerned Citizens	Where is the ongoing monitoring and evaluation data since 2015 covering the start-up and production at Liza 1 and all exploratory drilling activities conducted to date, their effects on said nurseries in population samples collected and the change in catch per unit effort of fisheries?	The first and second year fish studies described in Appendix M, Nearshore and Offshore Fisheries Study Summary, were completed in 2018 and 2019, respectively; the participatory fish study included in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, was completed in 2020. Liza Destiny (Liza Phase 1) began production activities in 2019, so the data presented in these appendices spans the pre-production (i.e.; exploration) and production phases of EEPGL's activities offshore Guyana. Catch per unit effort is not formally monitored for Guyana's fisheries at a national scale, but EIA Section 8.1, Socioeconomic Conditions, contains data on total production of the fishery sector for several recent years.	No	Accepted	N/A	N/A
293	10-Dec-2021	Concerned Citizens	Where has this data been made available for public scrutiny?	Please see the response to Comment #292 for the location of marine fish and fisheries data in the Yellowtail EIA.	No	Accepted	N/A	N/A
294	10-Dec-2021	Concerned Citizens	Where are the offshore and near shore fish nurseries for the species of commercial fish and their prey located on a map with geospatial coordinates relative to the Yellowtail production area, effluent discharge, and current patterns?	Please see the response to Comment #289.	No	Accepted	N/A	N/A
295	10-Dec-2021	Concerned Citizens	What is the cumulative geospatial area of production areas for Liza 1, Liza2, Payara, Yellowtail and other	The total area of long term exclusion zones surrounding the Liza 1, Liza 2, Payara, and Yellowtail FPSOs is 17,200 hectares (42,400 acres). This area represents a total of 0.6% of the Stabroek Block and does not overlap with	No	Accepted	N/A	N/A

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			exploratory well operations in relation to offshore and nearshore nurseries and current patterns and what is the cumulative effect of effluent discharge on these areas?	any mapped fish nursery zones. The cumulative impacts of the Project and other reasonably foreseeable projects (including oil and gas projects and non-oil and gas projects) on marine water quality (including the effects of effluent discharges) received a priority ranking of Low. As described in Chapter 10, Cumulative Effects Assessment, this ranking was assigned primarily because impacts on marine water quality from non-Project activities are not expected to overlap (temporally and/or spatially) with those of the Project.				
296	10-Dec-2021	Concerned Citizens	Where is the geospatial assessment of no-go areas for fisheries to avoid offshore activities and service vessels in the offshore, nearshore and Demerara Estuary and the cumulative geospatial exclusion area of Liza 1, Liza 2, Payara, Yellowtail and all exploration drilling activities?	Please see the response in Comment #295 for information on the total area included in the safety exclusion zones for the Liza 1, Liza 2, Payara, and Yellowtail FPSOs. There are no safety exclusion zones planned for any of these projects in nearshore or estuarine areas.	No	Accepted	N/A	N/A
297	10-Dec-2021	Concerned Citizens	Where is the log of the fishers who use those areas and the cumulative amount of time and geospatial area they have been excluded from since the 2015 seismic surveys commenced?	All exclusion zones are established following the regulatory process including approval by MARAD and alignment with the Department of Fisheries. The Department of Fisheries issues fishing licenses and advises EEPGL in is the event of a conflict with an issued and active license within an exclusion zone. MARAD publishes all restrictions on navigation areas (exclusion zones) in the Notice to Mariners on the MARAD website at Notice to Mariners—Maritime Administration Department (marad.gov.gy) Exclusion zones, except zones around permanent Projects' facilities (e.g., FPSO, drill centers), are temporary in nature. To date, the Consultants are unaware of any incidents where fishing vessels have been intercepted or turned away from the exclusion zones.	No	Accepted	N/A	N/A
298	10-Dec-2021	Concerned Citizens	Where is the monitoring information on how periods of exclusion have affected fisheries vessels, catch, and the income of informal and formal fishers?	As mentioned in the response to Comment #297, all exclusion zones are established based on the regulatory process and in alignment with the Department of Fisheries and MARAD. The exclusion zone for the Yellowtail Development Project has not been established to date so there are no data available on how it may affect fishing vessels. However, the Department of Fisheries has not indicated that they anticipate Project activities would impact any licensed fishing activities.	No	Accepted	N/A	N/A
299	10-Dec-2021	Concerned Citizens	Where is the monitoring log of affected fisheries vessels for all exclusion areas to date?	Please see the response to Comment #298.	No	Accepted	N/A	N/A
300	10-Dec-2021	Concerned Citizens	**Baseline for fisheries loss claims:** Where is the baseline data on formal and informal production that will used for claims of losses from fishermen in the event of an oil spill?	Please see the response to Comment #44 for information on how the claims and livelihoods remediation processes would be implemented in the event of an oil spill, if appropriate. The participatory fish study included in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, includes information on prices at the dock for various types of fish, and EIA Section 8.1, socioeconomic conditions, contains data on total production of the fishery sector for several recent years, both of which could be used to inform these processes.	No	Accepted	N/A	N/A

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301	10-Dec-2021	Concerned Citizens	How has this data been produced?	The participatory fish study report included in Appendix D includes a methodology section describing how the study was conducted, and Chapter 8 of the EIA cites the sources of data used to prepare the analyses in that chapter.	No	Accepted	N/A	N/A
302	10-Dec-2021	Concerned Citizens	Where is the proof that the methodology has been subject to public scrutiny?	The EIA methodology is described in detail in Chapter 4, and the participatory fish study report included in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, includes a methodology section describing how the study was conducted. These materials were provided for public review for 60 days per the requirements of the Environmental Protection Act, as described in EIA Chapter 4.	No	Accepted	N/A	N/A
303	10-Dec-2021	Concerned Citizens	Where is there proof that the claims process has been consulted upon and agreed to by fisherfolk and other impacted parties?	As mentioned in the response to Comment #270, EEPGL has in place a transparent, accessible, and consistent CGM that would apply to the Yellowtail Project prior to onset of Project activities and throughout its lifecycle. Any claims from fisherfolk may be submitted through the CGM process. Claims may also be submitted to the Department of Fisheries, such that they would be able to bring them to EEPGL's attention. Each claim will be reviewed on a case-by-case basis following the established process. The CGM is described in EEPGL's SEP (EIA Volume III). The CGM is therefore available to the public, including fisherfolk, and was available for review and comment during the EIA disclosure and public comment period. Additionally EEPGL meets with fisherfolk on a regular basis and has provided contact information for grievances and claims submission. EEPGL periodically evaluates the CGM effectiveness and the CGM would be updated going forward as necessary.	No	Accepted	N/A	N/A
304	10-Dec-2021	Concerned Citizens	Where is the baseline data on fisheries value in neighbouring Caribbean countries that could be impacted and claim losses in the event of an oil spill?	As the Yellowtail Development Project is located within the Guyana EEZ, there is no requirement to collect fisheries baseline data outside of Guyana. However, in instances where fishing is a significant driver of the local economy and/or important fishing areas or ports have been mapped in neighboring countries' territorial waters, this information is included in Section 9.24.2, and in the coastal sensitivity maps provided to the EPA and public as Appendix P of the Payara EIA. These maps informed the Geographical Strategic Response Maps developed by EEPGL, examples of which are provided in OSRP Appendix E in Volume III of the Yellowtail Development Project EIA. In the very unlikely event of an oil spill that could have a transboundary impact on neighboring Caribbean countries, EEPGL would work through the Ministry of Foreign Affairs, at the direction of the Government of Guyana, to determine financial liability and establish claims and/or livelihood remediation processes.	No	Accepted	N/A	N/A
305	15-Dec-2021	Conservation International	**General Remarks** **Abide by high standards.** Given EEPGL developments are the first of their kind in Guyana, they will set the benchmark for future oil and gas exploration and development projects in the country. It is therefore paramount that the project abides by high industry standards of	See response to Comment #226.	No	Accepted	N/A	N/A

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			accountability and good governance.					
306	15-Dec-2021	Conservation International	**Adopt the precautionary principle.** The high level of complexity in the technical aspects of this kind of project's operations, inherent high variability and complexity of oceanic systems (and more broadly, water as a medium) and the relative paucity of knowledge of Guyana's marine ecosystems, create conditions in which there could be far-reaching unknown impacts. This warrants application of the Precautionary Principle encompassed in Section 4(a) of the Environmental Protection Act, (2006). Considering this principle, we recommend the use of independent, third-party monitoring on a periodic basis to verify management plans and data, as well as structuring independent research programs to enhance the information available for improved decision-making.	The Consultants agree that monitoring is vital to performance assurance. The ESMP for the Project does not envision stand-alone, open-ended research programs because such programs are not required to assess the accuracy and effectiveness of the EIA or ESMP, respectively. However, as indicated in ESMP Section 3.7, the results of the proposed monitoring program would be externally reported. Volume III of the EIA contains the ESMP, and ESMP Section 3 describes the proposed monitoring program for the Project. Table 3.6-1 contains over 40 resource-specific monitoring measures, and additional monitoring measures are included in the CWMP, SEP, Preliminary Decommissioning Plan, and OSRP, which are included in Volume III of the EIA and/or on the EPA website. These measures are intended to monitor the effectiveness of the proposed management measures and inform the EPA and EEPGL of any potential impacts not identified in the EIA, should they arise.	No	Accepted	N/A	N/A
307	15-Dec-2021	Conservation International	**Undertake a cumulative EIA encompassing all current development projects.** We echo recommendations that EEPGL produce a cumulative EIA covering all projects, in addition to the stand-alone EIAs for each project. This should also be done for the other development projects currently planned by EEPGL in the Stabroek and Kaieteur Blocks. This is essential since the cumulative effects of the EEPGL and non-EEPGL projects in these and adjacent blocks could exacerbate potential negative impacts to the environmental and social conditions of Guyana. Similarly, increased development along the banks of the Demerara River for increased shore-based activities will result in significant impacts to mangrove and mud flat ecosystems.	The Consultants acknowledge the question of a programmatic EIA, which is beyond the scope of the Yellowtail EIA and should be referred to the EPA. However, the cumulative impact assessment in the EIA (Chapter 10) meets the requirements for cumulative impact analysis established in Part IV Section 17 of the Environmental Protection Act. It considers future offshore oil and gas development projects in the Stabroek Block, future exploration projects in the Stabroek and adjacent blocks, and other development activities including development of the Gas to Energy Project and a fiber optic cable installation (the Fiber Optic Cable Project), among others.	No	Accepted	N/A	N/A
308	15-Dec-2021	Conservation International	**Aim at achieving net gain for biodiversity and communities.** Given the important precedent the	The Consultants acknowledge the comment, noting that net gain for biodiversity receptors is neither a requirement of the Environmental Protection Act nor within the scope of the Yellowtail Development Project	No	Accepted	N/A	N/A

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			EEPGL projects are setting, we recommend that the company adopts a net gain goal for biodiversity and communities. This is especially given the current uncertainties around Guyana's marine biodiversity and ecosystems, and the potential future additional oil and gas development which might increase the effects of indirect and cumulative impacts. We believe that this should be done regardless of whether the project would cause significant residual impacts from any planned activities. The project could achieve net gains by identifying additional opportunities to enhance habitat, conserve biodiversity, support communities' livelihoods and well-being, and contribute to research and knowledge about the country's marine and coastal resources.	EIA; accordingly, it is not an appropriate standard to apply to the EIA. That said, the Consultants note that EEPGL has conducted extensive research regarding Guyana's biological resources, in programs that have spanned multiple years and contributed significantly to scientific knowledge for the country. These data have been shared publicly as appendices to the Liza Phase 2, Payara, and Yellowtail EIAs, all of which were available to the public on the EPA's website as of December 2021.				
309	15-Dec-2021	Conservation International	**Adopt continuous and meaningful engagement with communities and Indigenous Peoples.** As per IFC Performance Standards, there should be continuous robust stakeholder engagement during the life of the project. For each of those engagements the Project should ensure deliberative spaces and appropriate communication tools that are inclusive and tailored to the different audiences and enable effective participation of vulnerable and underrepresented stakeholders. We note efforts made in previous EIA submissions to create user friendly formats, however, we are of the view that this was not adequately distributed publicly and may result in many stakeholders being unable to sufficiently comprehend the information contained in the EIA documents to constructively comment on it. This lack of follow through can no doubt negatively affected the credibility of the management processes undertaken by the company and impressions of the proposed development.	EEPGL has been responsive to the questions, concerns, and interests of indigenous stakeholders and continues to work with these communities to identify opportunities to support local benefits. The SEP (EIA Volume III) describes the Consultant team and EEPGL's engagement with communities, including indigenous communities. Engagement of indigenous communities has always included an indigenous leader representative from the National Toshaos Council (NTC) to ensure all the engagements are fair and impartial and the concerns of the indigenous communities are raised and addressed. The participation of the NTC is beneficial since communities are generally more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, have more confidence in the process and participate freely in the discussions. While the Yellowtail Project EIA is not subject to the IFC Performance Standards, EEPGL agrees that engagement is an ongoing activity that continues throughout the life of a project and that it should be appropriate and inclusive to the audience. The SEP documents the multiple years of engagement that have taken place by EEPGL and its consultants. In reference to the comment regarding user-friendly material, in response to comments received in other EEPGL Project consultations about the complexity of the materials, the Consultants developed for the Yellowtail EIA a highly visual NTS as well as other materials to help in messaging the Project risks and benefits. This NTS was distributed at EIA disclosure meetings early in the EIA disclosure period to support an informed understanding of the Project within the public comment period. The Consultants also facilitated two in-person discussions with indigenous communities in Region 1, including non-technical presentations of the Project and EIA process and results, and extensive question-and-answer sessions.	No	Accepted	N/A	N/A

Comment	Date	Stakeholder	Comment	Response	EIA Edit?	EPA Response	Consultant Response	Page Numbers with EIA Edit
310	15-Dec-2021	Conservation International	**Execute on-going monitoring programs for vulnerable species to inform a Critical Habitat Assessment (CHA).** We recommend the project, following a Precautionary Principle (referenced in point 3b above), execute an on-going monitoring program for vulnerable species identified through the field studies, even if residual impacts affecting them are considered negligible. Special emphasis should also be placed on a comprehensive baseline assessment of herpetofauna along the coast, as these are usually the first indicators of ecosystem health. The results of all these additional studies should help eventually inform a Critical Habitat Assessment (CHA) to determine if critical habitats are likely be impacted and to what degree.	The Consultants note that the ESMP includes a recommendation for ongoing monitoring of marine and riverine mammals as well as marine turtles. The Consultants have not recommended monitoring of terrestrial coastal herpetofauna because there is no credible pathway for significant impacts on those species from planned Project activities. With respect to critical habitat, a CHA is a unique element of EIAs conducted under the IFC Performance Standards, and is not generally included in EIAs that are not subject to the IFC Performance Standards (such as the Yellowtail Project). Compliance with the IFC Performance Standards is not required by the Environmental Protection Act and was not within the scope of the Yellowtail EIA, so it would be inappropriate to require a CHA for the Project. The inappropriateness of a CHA in the context of the Yellowtail Development Project notwithstanding, the impact assessments for several biological resources (including marine birds, marine mammals, and marine fish) include several attributes that would typically be considered in a CHA (such as listing status, congregatory behavior, and migratory life histories) as factors when determining sensitivity to potential Project impacts.	No	Accepted	N/A	N/A
311	15-Dec-2021	Conservation International	**Support mechanisms for strengthening data collection to improve knowledge and management of Guyana's marine natural resources and ecosystems.** The development of the sector offshore in ecosystems that are poorly understood also present unique challenges especially when combined with the pace of this development. The environmental data collection that is being undertaken in the marine environment by EIA consultants for the various oil and gas developments is exceedingly valuable because of the paucity of research in Guyana's EEZ. It is therefore of great importance that measures be put in place to manage this data and result in progressively improved knowledge of the space within which these projects are being developed, especially given that the research is almost entirely new. One possible means of doing this is the establishment of a data management system to which the EIA consultants conform and use to collate and submit their data. This	The Consultants agree that much of the information that has been generated through ongoing studies, including those that informed the Yellowtail EIA, is new and of significant value to the Government of Guyana, academic institutions, non-governmental organizations (NGOs), and other stakeholders with an interest in conserving Guyana's natural heritage. All of the reports detailing the findings of the studies that informed the Yellowtail EIA (including the appendices with data tables) have been made available to the EPA. Following prior precedent, new reports that have not been provided previously are included in Volume II of the Yellowtail EIA. Historical reports were previously made available in Volume II of either the Liza Phase 2 or Payara EIAs. These documents are available to the public on the EPA's website.	No	Accepted	N/A	N/A

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			would allow for future research to build on prior set of work and support further research activities and identification of gaps. The Project should consider sharing the information collected from baseline and monitoring assessments more broadly in ways and formats that are useful for wider use by the EPA, the conservation community, academia and the general public. Additionally, EEPGL has a great opportunity to support research efforts and initiatives that can contribute to increasing knowledge and understanding of the marine ecosystems and natural resources of Guyana.					
312	15-Dec-2021	Conservation International	**Development of a Biodiversity Action/Management Plan (BAP/BMP) to protect threatened species.** Considering the high biodiversity value of the coasts of Guyana, as well as the potential uncertainties about project impacts, a stand-alone BAP/BMP Is important to communicate clearly to stakeholders the company's selected mitigation strategy, and its working philosophy and ability to operate responsibly in areas of known conservation value. EEPGL could also opt to incorporate biodiversity-related mitigation and management measures into more general Environmental Management Plans or Action Plans, but the risk in this case, is that commitments might appear less evident or buried among many others, and possibly be less focused.	The ESMP included in Volume III contains several biodiversity-related management measures as suggested in the comment. The biodiversity-focused measures are grouped together in ESMP Table 3.6-1, although many of the air quality- and marine water quality-focused measures included in prior sections of the ESMP would also contribute to management of impacts on biodiversity by minimizing potential impacts on habitat.	No	Accepted	N/A	N/A
313	15-Dec-2021	Conservation International	**Expand the scope of IUCN assessment to include all observable species.** We commend the EIA's identification of IUCN Red List species in Guyana and overlap with respect to coastal bird species, however, clarity is needed for observed marine bird, marine mammal, fishes, flora, fauna, and turtle species and whether they are	Not every species that has been observed in Guyana has been assessed by the International Union for Conservation of Nature (IUCN). EIA Section 7.1.2.2, Special Status Species, provides the number of species that have been documented in Guyana and which appear on the IUCN Red List (296 species at the time the EIA was prepared).	No	Accepted	N/A	N/A

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			on the IUCN Red List of Threatened Species.					
314	15-Dec-2021	Conservation International	**The marine mammal observation data presented should be strengthened.** We believe this data lacks structured attempts to catalogue these species and relies largely on opportunistic sightings from marine vessels over a period of 10 years. This method is limited as it is neither systematic nor structured and assumes that vessel captains can correctly identify species.	The Consultants agree that there has been an element of opportunism to the marine mammal observer data collected to date; however, as indicated above, the ESMP includes a recommendation to report detections of marine mammals and marine turtles made from the FPSO, drill ships, installation/decommissioning vessels, and support vessels over the operational lifetime of the Project (see ESMP Table 3.2-1). The FPSO would remain stationary for the entire monitoring period, which will effectively create a permanent, full-time monitoring point within the Project AOI. Responsibility for observing marine mammals does not rest solely with vessel captains; crews for the FPSO, support vessels, and installation vessels receive basic training on the need to watch for and record sightings of marine mammals and turtles.	No	Accepted	N/A	N/A
315	15-Dec-2021	Conservation International	**The turtle telemetry data presented should be strengthened.** This data was collected from few turtles and over only one nesting season. This data is therefore not sufficiently indicative of the migratory routes all nesting species utilize. More robust data is needed to formulate a clearer picture.	The Consultant team considers the turtle telemetry data presented in the EIA (which includes data from two nesting seasons for the most common species that use Guyana's beaches) as adequate to support the analysis of potential Project effects on migrating turtles. The 12 turtles that have been satellite tagged to date generally showed consistent movement patterns during both the internesting and postnesting periods, so the Consultants consider the existing turtle telemetry data to be sufficient for the purposes of rating the anticipated impacts on the Yellowtail Development Project on marine turtles.	No	Accepted	N/A	N/A
316	15-Dec-2021	Conservation International	**Adopt recommendations that the sampling area be widened to appropriately assess baseline conditions of areas potentially impacted by indirect or cumulative impacts.**	The Consultants note that biological resource data have been collected from across the Stabroek Block (and between the Stabroek Block and the shoreline), specifically for marine fish, marine birds, and marine mammals. Further, coastal bird data have been collected across the Guyana coast. With respect to future monitoring, the monitoring program described in the ESMP focuses on the Direct AOI because the Direct AOI (specifically the immediate vicinity of the FPSO and drill centers) is where the most significant Project-related environmental impacts would be expected to occur. To the extent that low-level impacts could occur farther away from the Direct AOI, the EIA predicts that their significance would be too low to warrant a seascape-level monitoring program. However, some marine receptors that are vulnerable to potential impacts outside of the immediate vicinity of the FPSO and wells (such as vessel collisions with marine mammals and sea turtles, for example) would be monitored wherever Project vessels are operating.	No	Accepted	N/A	N/A
317	15-Dec-2021	Conservation International	**Present information on sampling dates and locations in a clearer manner to better convey their seasonal and temporal variations.** It was previously recommended that "additional sampling periods be carried out to better capture temporal variations in baseline conditions." While additional sampling has been proposed for various studies it is still not clear whether capturing seasonal or temporal variation has been factored in the studies associated with this	The biological field studies referenced in EIA Chapter 7 were conducted with seasonal variations in mind. Not all taxonomic groups (deep marine benthos for example) are likely to be affected by seasonal changes, but efforts were made to collect data in the wet and dry seasons for the major taxonomic groups that are likely to be affected by seasonal changes. In addition, sampling events have been conducted over multiple years for most taxonomic groups. Information on when and where the field studies for each of the major taxonomic groups is included in the relevant reports in Volume II of the EIA, or in the appropriate study report for historical studies.	No	Accepted	N/A	N/A

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			EIA. We suggest presenting this information in a clearer way, by including an additional column to better denote the studies done to date, and when they were done, including aspects such as the season during which they were performed. This will allow for better and easier assessment of the robustness of sampling conducted and gaps can be clearly assessed.					
318	15-Dec-2021	Conservation International	**Project Generated Impacts** We recognize that the EIA references the World Bank's Environmental, Health and Safety Guidelines (EHS Guidelines) for the evaluation and selection of resource efficiency and pollution prevention and control techniques for the Project. However, we recommend the following:	N/A	No	Accepted	N/A	N/A
319	15-Dec-2021	Conservation International	It is important to also consider the risks and potential impacts on priority ecosystem services that may be exacerbated by climate change, as per IFC PS4. For instance, socio-economic impacts on fisheries and fishing communities due to climate change which might also be exacerbated by the Project's exclusion zones.	While the Yellowtail Project EIA is not subject to the IFC Performance Standards, as discussed in EIA Section 8.3.2, Guyana's marine fisheries and food security have exhibited a high degree of vulnerability to climate-related effects. Both changes in rainfall patterns and predicted sea-level rise associated with climate change pose significant threats to the Guyanese population and its livelihoods, including fishing and shore-based livelihoods. However, specific to potential Project impacts, which is the focus of the EIA, Section 8.9, Ecosystem Services, does not identify potential impacts to ecosystem services as a result of planned Project activities, and potential exacerbation by climate change is not expected to change the conclusion that planned Project activities and Project use of the Guyana shorebases and onshore support facilities would not result in significant impacts on coastal habitats. In regard to the example of how impacts of climate change on fisheries and fishing communities could be exacerbated by the Project's exclusion zones, EIA Section 8.2, Employment and Livelihoods, and Section 8.4, Marine Use and Transportation, highlight that subsistence fishing and most commercial fishing occurs between the coast and the PDA and would not be affected by the exclusion zones. Very few commercial vessels are engaged in deepwater fishing that may approach the boundary of the PDA. As such, impacts of the Project would not be expected to exacerbate any potential challenges related to climate change.	No	Accepted	N/A	N/A
320	15-Dec-2021	Conservation International	Vessel offshore anchoring and specific drilling activities might disturb seabed habitats; this is an additional project interaction with environmental resources/receptors that should also be considered.	It is noted that only the FPSO would be moored; no other Project vessels would be anchored, moored, or otherwise attached to the seafloor at any time. The potential physical impacts associated with the FPSO's mooring spread are assessed in Section 6.3 and the biological impacts of the mooring spread are assessed in several locations in Chapter 7, including EIA Section 7.5 (Marine Mammals), Section 7.8 (Marine Fish), and Section 7.9 (Marine Benthos).	No	Accepted	N/A	N/A

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321	15-Dec-2021	Conservation International	The proposed disposal of solid waste detailed in the EIA must take into consideration the already insufficient capacity of current landfills in Georgetown; these may not have enough capacity for the additional waste the project will generate. Special emphasis should be placed on the efficient and effective disposal of the project's hazardous waste, taking into consideration that Guyana does not currently have a functioning commercial incinerator.	The Yellowtail EIA did take into consideration the types and quantities of solid and hazardous waste to be generated by the Project. See the responses to Comment #265 regarding solid waste disposal capacity. With respect to hazardous waste treatment capacity, there has been significant expansion of third-party commercial hazardous waste handling, storage, and treatment facilities in Georgetown in recent years. TRG, located at the GYSBI facility, is currently the primary provider of hazardous and non-hazardous waste treatment services in Guyana. As described in Section 4.3.3, Current and Future Waste Treatment, of Appendix C of the CWMP, certain hazardous wastes, including oily rags, spent solvents, paint cans, brushes, biomedical wastes, etc., are treated in an incinerator unit at TRG. In addition to TRG, several additional private waste management facilities have come online or are expected to come online in the near-term for hazardous (and non-hazardous) waste treatment. These are expected to further expand the capacity of onshore waste management infrastructure to manage the Project's hazardous, non-hazardous, and exempt hazardous waste storage, processing, treatment, and/or recycling needs. EIA Chapter 8 discusses the mitigation measures that were already in the process of being implemented at the time the EIA was written to address potential infrastructure capacity constraints. Based on the progress with these measures, the Consultants have concluded that sufficient waste management infrastructure would be in place to manage the wastes from the Project.	No	Accepted	N/A	N/A
322	15-Dec-2021	Conservation International	Impacts from unplanned events (i.e. oil spill): We consider that the rating of impacts on marine species, coastal habitats as well as communities and indigenous peoples from a potential oil spill or natural geological event should be conservative and follow a precautionary principle. We recommend evaluating these potential impacts from the perspective of the possible magnitude, alongside the likelihood of their occurrence. The likelihood of these event might be low but the magnitude and irreversibility of the impacts which would result should they occur could be very significant, as it could take decades or more for all these receptors/resources to fully recover.	Consistent with the typical approach taken for assessment of unplanned events, a risk assessment approach was taken in order to incorporate the aspect of likelihood (i.e., to distinguish from assessment of an event which is planned or practically certain to occur). The Consultants agree that there are a number of resources for which the consequence/severity of an oil spill would be high, and many of the resources have therefore been assigned the highest consequence/severity rating in the methodology. That said, the likelihood of an oil spill of sufficient magnitude to produce this type of consequence is very low and it is therefore appropriate to assign a likelihood rating of Unlikely. It is acknowledged that this produces a combined risk rating that is Moderate (rather than Major), and this is consistent with typical risk assessment methodology—which does not automatically assume a very rare event will happen. It is further noted that the measures proposed by EEPGL represent good international industry practice, and different/additional measures would not be proposed even if the risk rating were to be raised to Major.	No	Accepted	N/A	N/A
323	15-Dec-2021	Conservation International	An economic assessment and valuation of all resources which can potentially be impacted by an unplanned event should be conducted to ensure an accurate economic baseline exists should an unplanned event occur.	A baseline economic evaluation of resources that could be affected by a hypothetical spill scenario is neither practical (because the scope of such an event is impossible to predict and therefore the scope of an assessment cannot be defined) nor typical for an EIA.	No	Accepted	N/A	N/A

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324	15-Dec-2021	Conservation International	The Precautionary Principle should also be applied when assessing potential cumulative impacts, given the additional exploration projects projected by EEPGL and other companies. The project should actively manage, where feasible, the spatial and temporal overlap of their additional projects' activities.	See the responses to Comments #306 and 307, regarding application of the Precautionary Principle and cumulative effects. It is noted that the cumulative impact assessment (Chapter 10) makes specific recommendations relative to management of EEPGL's multiple development project and exploration operations—with the express purpose of reducing the additive potential for impacts associated with an increased activity level.	No	Accepted	N/A	N/A
325	15-Dec-2021	Conservation International	Ensuring costs of expected activities and social benefits, unplanned events and/or unanticipated post-decommissioning environmental and social risks are covered: Measures such as performance bonds, insurance agreements, escrow accounts, etc., should be considered to ensure costs of managing environmental and social risks from expected on-going events, unplanned events and/or unanticipated post-decommissioning risks will be adequately covered, as well as all promised social benefits are delivered.	Whether social benefits can ultimately be delivered as estimated by the Consultants is beyond the scope of the EIA. Regarding costs associated with potential environmental risks, the Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts. The co-venturers have the financial capacity to meet the responsibilities for an event including obligations under Guyanese law and the respective petroleum agreements. Regarding insurance, the Stabroek Block co-venturers have secured comprehensive insurance for petroleum activities as required by environmental permits. Under the existing legal framework and agreements with the government, there are extensive assurances of EEPGL's and co-venturers' commitments, including environmental protection measures to respond to operational incidents. The Government of Guyana has multiple mechanisms in place, including the Stabroek Block Petroleum Agreement and the environmental permits, to ensure that the companies would take responsibility for any adverse events. Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, should the Yellowtail Project receive necessary approvals, the co-venturers would have insurance coverage including Third Party Liability and the cost of regaining control of a well.	No	Accepted	N/A	N/A
326	15-Dec-2021	Conservation International	**Stakeholder Engagement** **Adopt permanent, meaningful and inclusive stakeholder engagement.** EEPGL has been engaging with different stakeholders in a variety of ways during the development of the various projects within the Stabroek Block. We recommend moving forward that for each of those engagements the Project demonstrates engagement through deliberative spaces and simple communication tools that are inclusive and tailored to the different audiences, as well as enable effective participation of vulnerable and underrepresented stakeholders.	EEPGL agrees that engagement is an ongoing activity that continues throughout the life of a project and that it should be appropriate and inclusive to the audience. EEPGL's and its consultants' engagement with communities, including indigenous communities, is described in the SEP (EIA Volume III). The SEP details the multiple years of engagement that have taken place by EEPGL and its consultants. The SEP also describes how EEPGL identifies and engages with vulnerable and underrepresented stakeholders. In response to comments received in other EEPGL project consultations about the complexity of the materials, the Consultants developed a highly-visual NTS, as well as other visual communication materials, to help in messaging the Project risks and benefits. This NTS was distributed at EIA disclosure meetings early in the EIA disclosure period to support an informed understanding of the Project within the public comment period. The Consultants also facilitated in-person and virtual meetings in all six coastal regions (including indigenous communities in Region 1), including non-technical presentations of the Project and EIA process/results, and question-and-answer sessions. EEPGL is committed to providing stakeholders with regular access to information about the activities as well as access to feedback mechanisms through which stakeholders may provide input and receive response to	No	Accepted	N/A	N/A

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				feedback. To date, in addition to active updates and information sharing on social media and traditional media channels, this has included, but is not limited to, oil spill management training in Regions 1 and 6, waste management training, capacity-building efforts and training, supplier forums, offshore oil and gas seminars through the CLBD, and community outreach events (e.g., job fairs, schools, informational booths) in Regions 1, 2, 3, 4, 5, 6, 9, and 10.				
327	15-Dec-2021	Conservation International	**Adopt ongoing reporting to potentially affected communities**. We also recommend that the project ensures ongoing reporting to potentially affected communities and transparency about consultation reports. These should capture stakeholder concerns and comments during all consultation activities and show how they were addressed or otherwise treated	EEPGL's engagement with affected communities is described in the SEP, which also includes a publicly disclosed summary of concerns and comments received during engagements. Furthermore, ongoing engagements and resulting actions are tracked by EEPGL through an automated, stakeholder engagement database. EIA Chapter 4 provides a summary of stakeholder concerns and comments received in relation to the Yellowtail Project, and how comments have been addressed.	No	Accepted	N/A	N/A
328	15-Dec-2021	Conservation International	**Ensure Informed Consultation and Participation (ICP) and Free, Prior and Informed Consent (FPIC).** The Project should ensure the ICP of the indigenous peoples about the potential risks, impacts and proposed mitigation actions pertaining to the possibility of an oil spill. This can be effectively achieved through guidance and relationships with partners, such as indigenous NGOs, who have great experience and expertise in effective engagement with these communities. According to IFC PS1, an oil spill stemming from offshore drilling would constitute "(ii) impacts from unplanned but predictable developments caused by the project that may occur later or at a different location." While the offshore drilling is not being developed on indigenous peoples' lands per se, its adverse impacts (an accidental spill) could significantly impact the lands and resources traditionally owned or under the customary use of indigenous peoples. Therefore, ICP is required, and the case for FPIC as the preferred course of action is a strong one, because of the following: • The potential unplanned event (oil spill) could impact the Indigenous	While the Yellowtail Project EIA is not subject to the IFC Performance Standards, EEPGL respects the rights and cultures of Indigenous Peoples and commits to conducting meaningful consultations with them, incorporating traditional knowledge and use into its plans, and seeking mutually beneficial long-term relationships. EEPGL further recognizes that Informed Consultation and Participation and Free, Prior and Informed Consent are processes by which accurate, accessible, and timely information is shared in regard to proposed developments, with opportunities for constructive and two-way dialogue. EEPGL's stakeholder engagement program has included (and continues to include) indigenous communities and Toshaos in Regions 1 and 2. EEPGL has been responsive to the questions, concerns, and interests of indigenous stakeholders and continues to work with these communities to identify opportunities to support local benefits. EEPGL further recognizes the importance of effective communication and engagement with Guyanese society (and especially potentially vulnerable communities) to obtaining and maintaining a "social license" to construct and operate the Project. The Consultants likewise recognize the importance of communication and engagement to the execution of a robust and defensible EIA. With these needs in mind and as described in the SEP, EEPGL has engaged in a multi-year engagement process with communities across the coast (including indigenous communities) and these engagements informed both the scope and findings of the EIA.	No	Accepted	N/A	N/A

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			Peoples' related natural resources (particularly the marine resource, given that they are fishing communities). • iFPIC would allow the project to develop more robust required emergency preparedness plans, mitigation plans, and compensation schemes. • The indigenous communities in question may fall into the particularly vulnerable status, thereby requiring extra measures per IFC PS1. • The benefit would outweigh the cost over the long-term.					
329	15-Dec-2021	Conservation International	**Environmental and Socioeconomic Management Plans** **Lessons from the Environmental and Social Management Plan (ESMP) implementation should inform policies and decision-making.** Considering the oil and gas sector within Guyana is in its infancy, we reiterate the recommendation that the ESMP and its implementation be used as an organizational learning process in which the lessons experienced are fed back into policy, institutions and subsequent project designs, thus building the country's capacity to better manage such large-scale projects in the future. We recommend having clarity on the institution and mechanisms responsible for implementing this.	This comment addresses recommended actions and policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana.	No	Accepted	N/A	N/A
330	15-Dec-2021	Conservation International	**The socioeconomic management plan should include important emphasis on local capacity for delivering sector related services**. The Project should ensure assistance to build capacity of local businesses (to an accredited level acceptable to EEGPL) to cater to the needs of the sector, e.g. Solid Waste Management (incineration services, solid waste disposal, treatment of hazardous chemicals, etc.), Oil Spill Wildlife Response	EEPGL along with the Stabroek block co-venturers launched the Greater Guyana Initiative (GGI) in 2021, a $100 million USD ($20.9 billion GYD) investment over 10 years to support capacity building, economic development, and diversification across all regions of the country. The CLBD, supported as part of GGI, builds capacity for local businesses including, but not limited to, mentoring for ISO 9001 certification. GGI also provides support to a variety of projects and programs at the University of Guyana as well as supporting a pilot program of capacity building with the Council for Technical and Vocational Education and Training. Capacity building and local content is covered in EEPGL's Local Content Plan, which is provided under separate cover to the government. The ESMP also includes related measures including employing Guyanese citizens having the appropriate qualifications and experience where reasonably	No	Accepted	N/A	N/A

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			(training at the University, schools of Veterinary Medicine and the Guyana Wildlife Conservation and Management Commission how to care for, clean and rehabilitate oiled wildlife).	practicable, partnering with select local institutions and agencies to support workforce development programs, proactively messaging Project-related employment opportunities, and procuring Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive. Additional information about EEPGL's Local Content Plan and local initiatives to support workforce and business development are provided in EIA Chapters 2 and 8.				
331	15-Dec-2021	Conservation International	**Decommissioning of equipment should ensure coral reef inoculation.** It is expected that upon decommissioning the drilling equipment, pipes and anchor piles will be disconnected and abandoned in place on the seafloor and we recommend that the strategy encourage coral reef inoculation on substrate metals or ensure that all EEPGL equipment will not pose danger to wildlife. While it is likely that natural ecosystem succession will occur, abandoning equipment on the seafloor would potentially reduce the aesthetic quality of the area and can create safety hazards, such as injuring wildlife (e.g. sharp metal edges. ingesting inedible materials, poisonous materials, and entanglement).	As described in the Preliminary End of Operations Decommissioning Plan included in Volume III of the EIA, a proposal for subsea infrastructure to remain on the seabed after decommissioning would be based on a case-by-case evaluation. The industry supports the use of a Multi-Criteria Decision Analysis (MCDA) as the facilities are approaching end of production life to holistically evaluate the decommissioning approach for the subject facilities. The MCDA evaluates the potential safety and health, environmental, social, and economic risks, as well as technological challenges/developments that may be needed for the decommissioning options analysis (including reefing). Given the length of expected operational timelines and potential advancements in technology, it is difficult to determine final disposition at this time. Industry general practice in these depths for SURF facilities is, at the time of initial installation, to plan for such facilities to remain in place at decommissioning; however, this will be re-evaluated as the field reaches end of life. Abandonment of selected equipment on the seafloor as part of decommissioning is thus currently proposed, but further approvals would be required before this plan could be implemented. If the approved alternative at the time of decommissioning calls for subsea infrastructure to remain on the seabed, given the length of time that the SURF would be in use, it is likely that encrusting benthic species would have colonized the equipment before decommissioning begins. This could make coral inoculation difficult to accomplish without disturbing the existing biological community; however, an assessment would be made at that time to identify the least disruptive/most beneficial method of decommissioning the subsea infrastructure.	No	Accepted	N/A	N/A
332	15-Dec-2021	Conservation International	**Monitoring should be carried out on three levels and ensure adaptive management.** In addition to the consultant's Environmental Management Plan, we would like to clarify a few best practice principles for biodiversity monitorization. These are • In field monitoring of relevant biodiversity values; • Monitoring of implementation and effectiveness of mitigation measures and management controls; and	The monitoring program described in the ESMP (Volume III of the EIA) is focused on the Direct AOI because the Direct AOI (specifically the immediate vicinity of the AOI and drill centers) is where the most significant Project-related environmental impacts would be expected to occur. In the Consultants' view, when taken in aggregate, the monitoring measures proposed in the ESMP are adequate to validate the findings of the EIA and support effective oversight by the EPA for several reasons. These reasons include inclusion of direct sampling and testing of physical parameters that can be compared to quantitative performance criteria that are widely used in the oil and gas industry and relevant to Guyana's environmental treaty obligations (e.g., residual oil on cuttings, oil content and temperature of discharged water, etc.), as well as a long-term focus on protected marine species (marine mammals and turtles) that can be considered indicators of general marine ecosystem health. The ESMP would be revised periodically to ensure that the various measures described in the plan remain aligned with Project needs and reflect current technologies, The "evergreen" nature	No	Accepted	N/A	N/A

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			• Monitoring of status of non-project related ongoing threats to biodiversity values in the project's vicinity and the extent to which the project might exacerbate them. • Finally, the Project should ensure adaptive management practices to adjust methodologies and practices to the ways ecosystems and biodiversity are being managed and monitored. Additionally, the following suggestions could ensure a robust and impactful monitoring programme: • Increased training for ANY vessels (not just EEPGL associated vessels) moving to and from the FPSO and drilling ships to identify marine mammals and adjust course/speed accordingly to prevent collisions. • Better preventative protocols in place to avoid an influx of invasive alien species from untreated ballast water. • Continuous monitoring of water quality surrounding FPSO by independent labs to determine temperatures, pollutants levels, algal blooms etc. iv. The inclusion of measures to enable community participation, especially Indigenous People and communities, in the project's research and monitoring would be of great value to effective monitoring, amongst other things.	of the ESMP reflects an adaptive management approach to management of Project-related impacts.				
333	15-Dec-2021	Conservation International	• Transboundary considerations and ability to respond • Support development of frameworks that clearly organizes roles, priorities and devote resources for responding to an unplanned event. There needs to be a clear plan with respect to who is responsible for cleanup activities, who funds initial response, who funds recovery	i. As stated in OSRP Section 1.2.3 (included in Volume III of the Yellowtail EIA), EEPGL has developed a system for working with appropriate representatives of other jurisdictions (in coordination with the Government of Guyana) to respond to a potential transboundary event. This system considers operational and administrative details including but not limited to communications, waste management (including the potential for transporting wastes across international borders and the legal ramifications thereof), movement of equipment and personnel between jurisdictions, and community involvement in affected jurisdictions. These preparations have been further operationalized through the preparations of Geographical Strategic Response Maps, examples of which are included in the OSRP.	No	Accepted	N/A	N/A

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			from culminative effects, who is responsible for loss of country revenue (sea/sand/sun product). • Establish an environmental bond for unplanned events. The very limited mechanisms in place for the regulatory agencies to deal with an oil spill, along with weak legal frameworks that exist within the region, suggest that impacted countries would be in a highly disadvantageous position, and highly dependent on the developer, to respond to a transboundary oil spill event. We reiterate the recommendation for the establishment of an environmental bond or the triggering of an immediate imposition of an early payment (within the fee structure of the environmental permit) that can be immediately used by the Government of Guyana to work with its neighboring countries and other affected parties in the event of an oil spill. We note that this matter becomes increasingly important as the number of wells increases. • We recommend the inclusion of a terrorist response scenario or plan for both offshore and shore-based sites. There are references to several emergency response plans triggered by events such as bomb threats or civil disturbances, however given Guyana's limited capacity to respond to a mass casualty event (medical, terrestrial security forces, mortuary services, emergency Coast Guard deployment, etc.), there needs to be a clear emergency plan which can be efficiently implemented.	ii. EEPGL recognizes the overall initiative the Government of Guyana has taken with the development of the National Oil Spill Contingency Plan (NOSCP) under the chairmanship of the Civil Defence Commission. Within the NOSCP, EEPGL would be considered the Responsible Party in the unlikely event of a spill from one of its offshore facilities, with obligations to provide notification to MARAD (as the National Focal Point—Marine) upon identification of an oil spill event. The EEPGL OSRP works in conjunction with the NOSCP, addressing how, as the Responsible Party, EEPGL would respond. Initially, EEPGL would appoint an Incident Commander to lead the Incident Management Team (IMT), utilizing the internationally recognized Incident Command Systems processes. An appropriately resourced IMT would be established in Georgetown, including relevant agencies. EEPGL would remain as the Incident Commander (either as overall, or as part of Unified Command with the Competent National Authority) unless the Competent National Authority considered it necessary to assume the Incident Commander role. Per the Yellowtail EIA Vol. 1, Section 9.1.9, in the unlikely event of an oil spill, EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. In addition, EEPGL and its co-venture partners have entered into agreements with insurance companies which require verification that adequate financial resources are in place to satisfy environmental obligations, including those in the unlikely event of a spill. iii. The Yellowtail EIA Vol. 1, Section 9.1.9 outlines the Claims and Livelihood Remediation Processes, which includes in the unlikely event of an oil spill causing losses to stakeholders that EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. Further, EEPGL and its co-venturers carry insurance coverage consistent with global industry practice to enhance their financial resources to respond in the event of a spill, and will comply with Guyana's regulatory requirements related to demonstration of financial responsibility. iv. ExxonMobil Global Security has conducted formal risk assessments on all operations in Guyana, which included the threat from terrorism. Emergency response plans for security incidents have been implemented. Additionally, shorebase and offshore assets fully comply with the International Ship and Port Facility Security Code. As stated in OSRP Section 3.3.1, EEPGL has a country-level (i.e., not specific to Yellowtail) Emergency Response Plan that describes the overall emergency response model utilized by EEPGL, with a focus on how emergencies are managed at the country level in Guyana. It provides structured processes, tools, and guidelines to assist the various management teams that exist within the company in effectively responding to an emergency that originates from or escalates into EEPGL operations. OSRP Figure 3.3-1 illustrates how EEPGL's Emergency Response Plan would integrate with other company or contractor plans in an implementation scenario.				
334	15-Dec-2021	Conservation International	**Additional studies** **Continue subsea noise pollution monitoring. We** acknowledge that monitorization efforts now also include a subsea noise pollution study component to gauge and track	Although the EIA includes a marine noise modeling analysis, it does not include a recommendation to monitor marine noise. The EIA does recommend that operational activities are conducted in accordance with good international oilfield practice regarding mitigation of noise impacts on marine mammals, including adherence to the JNCC guidelines during seismic	No	Accepted	N/A	N/A

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			potential impacts of sound arising from Liza and Payara project-related activities, as this was one of CI's recommendations from an earlier EIA review. Furthermore, we are pleased to learn that the deeper water at Payara lowers the sound levels, and therefore presents less danger to marine populations.	activities, which the Consultants consider adequate to manage noise impacts on marine mammals.				
335	15-Dec-2021	Conservation International	**Establish baselines for the Shell Beach Protected Area (SBPA).** Given the potential for significant impacts to the SBPA from unplanned events such as oil spills, we recommend that baselines be establish for the protected area, especially for the elements that would be the most affected by such events. The SBPA should also be included as part of the continuous biodiversity monitoring over the life of the project.	The Shell Beach Protected Area (SBPA) is unlike other portions of Guyana's coast in that it is the only large coastal area in the country that has been the subject of a formal, relatively recent biodiversity study (the 2011 Proposed Shell Beach Delineation Process Report). Although the 2011 delineation report is the most comprehensive government report on environmental aspects of the Region 1 coastline and contains valuable information on the biodiversity of the SBPA, this information, together with more recent survey data from other sites with similar habitats (coast beach, intertidal mud flats, mangroves, etc.), were deemed sufficient by the Consultants to credibly assess potential Project-related effects on the SBPA.	No	Accepted	N/A	N/A
336	15-Dec-2021	Conservation International	**Specific Recommendations and Observations** All specific recommendations are detailed and Attached in Appendix B (Stakeholder comments register- CI-Guyana - Yellowtail ESIA).	N/A	No	Accepted	N/A	N/A
337	15-Dec-2021	Conservation International (Appendix B)	• NTS – Impacts – p. 14 – Impacts to Marine Benthos • Vol. 1 – 3.1.2 – p. EIS-22 – Marine Geology / Sediment and Marine Benthos • Vol. 1 – 3.1.9 – p. EIS-24 – Ecological Balance and Ecosystems There is significant potential to disrupt and negatively impact the micro and macro organisms that form the basis of the fisheries and marine food chains from volume of drill fluids, wastewater, effluent and ballast water throughout the life of the project. . This coupled with the cumulative effects from other extractive activities (Liza1, Liza 2, Payara), the potential for irreparable damage to the foundation of these food chains is significant.	These comments refer to the summary information presented in the NTS and the EIS, both of which are intended as high-level summaries of the EIA content. The technical basis for the ratings of impacts on marine biota is included in EIA Chapters 6, 7, and 10.	No	Accepted	N/A	N/A

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338	15-Dec-2021	Conservation International (Appendix B)	• NTS – p. 18 - Socioeconomic conditions, employment and livelihoods • Vol. 1 – 3.1.12 – p. EIS-26 - Marine Use And Transportation There needs to be more evaluation on what effects Oil and Gas Support Infrastructure such as Shore bases and Deep-Water harbors will have on local artisanal fishing activities, loss of access to landing sites, increased traffic between FPSOs and Shore bases, etc.	Under the Environmental Protection Act, onshore support facilities require separate environmental permitting processes and associated environmental analyses to support those permitting processes. However, the EIA does assess impacts associated with project activities, including those from traffic between the FPSOs and shorebases. In addition, Chapter 10, Cumulative Impact Assessment, evaluates the combined impact of the Project with that of other developments, including potential cumulative impacts on artisanal fishing and vessel movements. Chapter 10 contemplates the impacts of other projects including but not limited to the West Demerara Shore Base and the Vreed en Hoop Port Facility. Finally, EEPGL's ongoing participatory fishing study includes the participation of fisherfolk at landing sites in all coastal regions. Findings of this study have informed the EIA and continue to comprise an important part of ongoing monitoring and stakeholder engagement activities. The most recent report is included in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, of the EIA (Volume II), including a profile of landing sites, fishing areas, targeted species, seasonal considerations, and biometrics. Findings of the participatory fishing study will continue to inform EEPGL's engagement and adaptive management activities.	No	Comment to be addressed in keeping with Redford group discussion (onshore support facilities and marine transportation)	See the response to Comment #17 in Table 2.	N/A
339	15-Dec-2021	Conservation International (Appendix B)	• NTS – p. 20 - Waste Management and Infrastructure Capacity • Vol. 1 – 3.1.14 – p. EIS-28 - Waste Management and Infrastructure Capacity This has been a deficit identified since the initial Liza1 discovery and EIA, yet there has been little significant effort by EEGPL to create a facility to process the hazardous waste created by their activities. While there are mentions of proposed facilities (applications to the EPA for creation and operation), the cumulative effects of Liza 1, Liza1, Payara and now Yellowtail developments highlight the increasing need for the creation of such processing facilities away from population centers to deal with the volume of hazardous and radioactive waste generated by these developments.	Wastes received from offshore are managed at TRG and the recently permitted SES, which are located at the GYSBI shorebase in Georgetown. Both of these waste management facilities have a design/processing capacity sufficient to manage hazardous wastes estimated from EEPGL's projects. Creating another waste management facility, when the current expectation is that these existing licensed facilities would have sufficient capacity for EEPGL's needs, would not be warranted. See the response to Comments #268 and 277 for additional information on hazardous waste facilities and measures employed to protect workers and the public. All radioactive sources used for EEPGL operations are managed in accordance with environmental permits and strict safety standards such as those set out by the International Atomic Energy Agency. EEPGL is not proposing treatment or disposal of radioactive wastes in Guyana.	No	Accepted	N/A	N/A
340	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – Introduction – p. EIS-8 - Project Life Cycle (2023-2032) • Vol. 1 – 3.1.2 – p. EIS-20 - Marine Water Quality The significant cumulative impact of drilling and installation activities on	These comments refer to the summary information presented in the NTS and the EIS, both of which are intended as high-level summaries of the EIA content. The technical basis for the ratings of impacts on marine mammals, turtles, and fish is included in EIA Chapters 6, 7, and 10.	No	Accepted	N/A	N/A

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			Marine life (mammals, fish, turtles). The continuous years of activities for each of these developments (Liza1, Liza2, Payara and Yellowtail) will cause significant disturbances to subsea life as well as migratory routes for sea turtles during nesting seasons.					
341	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 3.1.8 – p. EIS-24 – Marine Turtles While one FPSO and associated subsurface activities my pose negligible effects on sea turtle movements, the cumulative effects of 4-5 developments occurring at the same time across much of the length of the coast will pose significant negative effects on nesting females. There needs to be more monitoring than just a few tracked turtles to substantiate the data that the effects are negligible.	None of EEPGL's FPSOs are (or would be) installed near the coast—they all are/would be located more than 180 kilometers (112 miles) offshore. At this distance, the offshore developments currently envisioned would have little to no likelihood of affecting nesting activities, which occur at the coast.	No	Acceptable. However, clarity to be provided to avoid any misconceptions.	Clarifying language has been added to the EIS per the request.	p. EIS-26
342	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – Table EIS-7 – p. EIS-49 - Summary of Residual Impact Significance Ratings There is a positive rating for the effects of production operations and decommissioning activities on the Marine Benthos - contrary to ratings outlined in the text before.	The positive rating for marine benthos in Table EIS-7 is only for the production operations and decommissioning stages. The discharges and cuttings deposition at the seafloor (which would have negative effects on marine benthos, as described in EIA Section 7.9.3, Impact Assessment—Marine Benthos) would have ceased by this point in the project life cycle. The positive effects of increased hard substrate provided by the SURF would persist through the production operations and decommissioning stages and beyond. Taking these temporal aspects into account, the ratings depicted in Table EIS-7 are accurate.	No	The justification here provided in relation to the comment posed should be highlighted in the revised EIA for clarity	Further explanation has been added to the EIS as requested.	p. EIS-24
343	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 2.7.5.3 – p. 2-53 - Flare and Blowdown System There is no mention of minimum safe limits for flaring as compared to the proposed emissions guide throughout the project's life cycle. Additionally, the cumulative effects flaring from of Liza1, Liza2, Payara, and Yellowtail developments need to be examined. As emissions from all these developments will put Guyana in the realm of one of the largest polluters in the Caribbean.	As discussed in EIA Section 2.7.4.3, Flare and Blowdown System, the flare system will be designed to safely accommodate flaring of associated gas during start-up and shutdown; equipment maintenance and process upsets scenarios; emergency pressure relieving scenarios, including facility blowdown; and other non-routine flaring events, including blowdown of the subsea gas re-injection system. While the flare system is designed for no routine flaring of associated gas, the preliminary design includes a *de minimis* level of continuously flared sources including pilot gas, purge gas, and back-up gas systems critical to the safe and reliable operation of the flare; and primary vent gas from compressor dry gas seals, analyzers, cooling medium/heating medium/chemical tanks blanket gas and potentially other *de minimis* sources, which are not practical to recover for routing to the vapor recovery unit. With respect to cumulative effects of flaring, EIA Section 10.6.1.1, Air Quality, and Appendix G, Emissions Inventory and Air Quality Modeling Report, describe the air dispersion modeling performed for the cumulative emissions from the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail projects, as well as from two prospective future FPSO projects. This cumulative emissions modeling included estimated non-routine flaring for each of these projects.	No	Accepted	N/A	N/A

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344	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 2.7.10.3 – p. 2-59 – Ballast System Offloading of improperly filtered ballast water can bring the introduction of invasive alien species and upset the balance of micro organisms that form the basis of Guyana's marine food webs.	The EIA and ESMP recommend that all project vessels be required to comply with the provisions of the IMO's Ballast Water Management Convention (as applicable). Vessels to which the Regulation D-2 Ballast Water Performance Standard applies can meet this standard in a variety of ways, including but not limited to pre-discharge filtration. In addition, Project vessels would exchange ballast water just outside the Guyana EEZ.	No	Accepted	N/A	N/A
345	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 2.18.3.6 – p. 2-145 – Seawater Treatment Seawater treatments using nanofiltration, ultrafiltration and osmosis before returning to the open ocean - what are the options should filtration systems fail (similar to the flaring system). What other mechanisms are in place should a breakdown occur in the filtration system? And will this affect the functioning of systems onboard/	The seawater treatment systems are used to prepare water for cooling systems, wash water, and (primarily) water injection. There are multiple units and membranes, including sufficient sparing, in order to be able to maintain treatment system functionality.	No	Systems to ensure functionality of seawater treatment systems to be included in EIA	The reliability of the seawater treatment system is enhanced through the use of multiple units and membranes, including sufficient sparing, in order to be able to maintain treatment system functionality. The main flow path for seawater treatment is through coarse filtration, ultrafiltration, and a sulfate removal membrane unit before heading into a de-aeration column. In order to maintain capacity / availability, the coarse filtration, ultrafiltration, and sulfate removal units all have spares to allow continued operation in the event a unit needs to be taken out of service temporarily. Additionally, throughout the seawater treatment system, seawater lift pumps, feed pumps, and water injection booster pumps also have spares for the same purpose. This information has been added to Section 2.18.3.6 of the EIA.	p. 2-152

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346	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 2.19.3 – p. 2-149 – Internal and External Auditing There needs to be a more scope for Environmental auditing by independent firms (other than EPA), or the leeway for the EPA to outsource an environmental audit to a third party. EPA's capacity for environmental auditing of practices onboard the FPSO is lacking. Similarly, the time between notification of an assessment/ audit and execution of the audit needs to be minimal.	The EPA's capacity for environmental auditing or its ability to use an independent firm to conduct audits is beyond the scope of the EIA. EEPGL would comply with applicable legal requirements regarding audits and cooperate with the EPA in conducting environmental audits.	No	Accepted	N/A	N/A
347	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 4.7.1.3 – Engagement Strategy – Consultation The email address and contact number listed should be included on every bit of communication shared with the public. Meaningful stakeholder engagement about developments and their long-term benefits/disadvantages on communities need to be extended beyond EPA lead engagements.	As described in EIA Section 4.7, a robust stakeholder engagement process was undertaken to inform the EIA and document stakeholder concerns. This engagement included both EPA-led and Consultant-led engagements and included engagement intended to inform the development of the EIA, and disclosure of the EIA, including inquiry and discussion about Project-related benefits and adverse impacts on communities. EEPGL also maintains a separate, ongoing stakeholder engagement program and agrees that engagement is an ongoing activity that continues throughout the life of a project and that it should be appropriate and inclusive to the audience. A synopsis of stakeholder engagement topics, by stakeholder, is provided in Attachment B of the SEP (provided in Volume III of the EIA). The synopsis table provided in the SEP includes engagement directly related to the Yellowtail Project and 2021 socioeconomic baseline updates, as well as engagement from past development projects that has also informed the Yellowtail EIA. In addition, a summary of the public comments received from, and revisions made to the EIA in response to, consultation conducted during the 60-day public disclosure period is included in EIA Chapter 4; Detailed comments and responses are provided in Appendix U, Stakeholder Comments. The Consultants acknowledge the recommendation to include contact information on all communication materials, and will consider that suggestion in undertaking future engagement programs. EEPGL's contact information is broadly communicated and is shared on all project and operations information materials.	No	Accepted	N/A	N/A
348	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 6.4.3 – p. 6-102 - Impact Assessment—Marine Water Quality While the cumulative effects of associated Oil and Gas activities for Liza1, Liza 2, Payara and Yellowtail will not be known for years, it should be noted that the potential impact of changes to water quality and the associated negative effects (reduction of biodiversity, increased temperatures, degraded water	No transboundary impacts on water quality (or associated induced effects) would be expected as a result of planned Project activities or from the combined planned activities of the cited development projects. Unplanned events such as oil spills could have transboundary impacts on a variety of receptors, including but not limited to water quality. These potential impacts are assessed in detail in EIA Chapter 9.	No	Accepted	N/A	N/A

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			quality, etc) on our closest neighbours should also be considered. How can changes (negative or positive) in our water quality impact their livelihoods (fisheries, ecotourism, biodiversity - especially IBAs).					
349	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 7.1.3.1 – p. 7-16 – Protected Areas "The Project's only potential impacts on SBPA would be as a result of an unplanned event (i.e., an oil spill)" - While not impacting the PA itself, seismic exploration and subsurface activities will impact the routes nesting sea turtles take to approach the Protected Area. The resulting disturbances may negatively affect the turtle's trajectory as well as cause them to seek other less desirable nesting grounds. One solution would be to suspend activities during the height of the nesting season to reduce negative effects to these endangered species.	There is no credible evidence to suggest that marine turtles' ability to navigate while at sea would be negatively affected by seismic exploration or other subsurface activities associated with the Project. The primary effect pathway of seismic exploration is acoustic, and as described in EIA Section 7.7.3, Impact Assessment—Marine Turtles, impulsive underwater sound from vertical seismic profiling is expected to attenuate to injury thresholds at maximum horizontal distances of 73 meters (239.5 feet) from the seismic source. The area of ocean within this radius is insignificant at the ecosystem level, and soft-start procedures as recommended in the ESMP would further reduce the potential for injury or significant disturbance-level impacts from seismic activities.	No	Accepted	N/A	N/A
350	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 8.1.2.4 – p. 8-23 - Economic Conditions- Marine Fisheries It is uncontested that there is a significant decline in marine fisheries production. Perhaps as an offset to unscheduled flaring, an in-depth study of commercial marine fish and seabob population numbers and ecosystem health.	Please refer to the discussion regarding declining fisheries provided in the response to Comment #207. Fish and fisheries were described from both a socioeconomic perspective (Volume II, Appendix D, Participatory Fishing Study Final Report January 2019–March 2020) and a biological perspective (Volume II, Appendix M, Nearshore and Offshore Fisheries Study Summary). These studies are complete and although an additional year of the participatory study is currently being conducted, the data provided in the existing study reports provide ample baseline data to conduct the EIA.	No	Accepted	N/A	N/A
351	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 8.9.2.6 – p. 8-198 - Summary of Findings by Region - Figure 8.9-3 Map illustrating Ecosystem Services in Region 1 can benefit from updating, especially concerning the Carbon Sequestration potential. There has been a recent study by Conservation International that highlights most of coastal Region 1 as a hotspot for global irrecoverable carbon.	EIA Section 8.9.2, Existing Conditions—Ecosystem Services, explores the ecosystem services that are potentially present along the coastlines and shorelines in Regions 1 through 6. Using a combination of local knowledge and field mapping, teams followed a screening and scoping process to determine whether a service was likely to be present in each coastal or shore zone and create an ecosystem services baseline. Findings related to ecosystem services were validated and, where relevant, updated through targeted engagement efforts in 2021. While a carbon sequestration inventory is beyond the scope of the EIA, the aforementioned process included mapping the location of mangroves and characterizing their condition. This inventory would be used to direct any oil spill response activity, in the unlikely event of a major spill, to protect the mangroves (see the response to Comment #359). No impacts to mangroves would be expected from planned Project activities.	No	Accepted	N/A	N/A

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352	15-Dec-2021	Conservation International (Appendix B)	• Vol. 1 – 9.1.4 – p. 9-56 - 9.1.5.3. Scenario 15—Loss-of-Well-Control Resulting in 30-Day Subsea Release of Crude Oil at 177,157 BPD (28,345 m3; Maximum WCD)- Figure 9.1-20b: (Zoomed In) Deterministic Map for Scenario 15 In all scenarios run, there will be heavy impacts on the Shell Beach Protected Area (both from oil spills and clean-up activities). It is proposed that an economic analysis be completed to VALUE the Ecosystem services provided by this area as well as a VALUE assigned to the lost livelihoods and ecotourism potential. This should be completed soon as there are now 4 major oil extraction sites managed by Exxon, thus multiplying the risk to the SBPA by 4.	The oil spill scenarios modeled are intended to show the worst-case (probable and maximum) scenarios in the exceedingly unlikely event of an oil spill. If an event were to occur, the factors influencing the extent and duration of an impact are varied and complex, and economic analysis of a hypothetical scenario would not prove useful to response or recovery. Additionally, in accordance with EEPGL's OSRP, areas of high importance for ecosystem services, livelihoods, and/or ecotourism would be prioritized for protection in the event of an oil spill, so as to minimize impacts on these values and receptors. EIA Section 9.1.9, Claims and Livelihood Remediation Processes, describes claims and livelihood remediation processes. More details are provided in the response to Comment #44.	No	Accepted	N/A	N/A
353	10-Dec-2021	EAB	**Oil Spill** With respect to oil spill discharge scenarios, how were possible impacts outside of Guyana's EEZ considered?	Potential impacts of an oil spill outside of Guyana's EEZ are discussed in EIA Section 9.24, Transboundary Impacts. This section discusses how other countries may be affected from a modeled WCD loss-of-well-control scenario, including a discussion of coastal resources that could potentially be affected. EIA Table 9.24-1 summarizes the countries with a predicted risk of oil landfall for both unmitigated and mitigated loss-of-well-control modeling scenarios.	No	Accepted	N/A	N/A
354	10-Dec-2021	EAB	**Environmental Impacts** Offshore lighting is seen as an attractant of food sources for marine mammals. Isn't the lighting and apparent abundance of food a disruption to the natural feeding patterns of these mammals?	The lighting and increase in abundance of food would represent changes to the natural environment in the immediate vicinity of the FPSO. While these changes would represent departures from baseline conditions in a small part of the AOI, it is the Consultants' opinion that concentrating food resources for a predator would represent an overall benefit to the predator species. This potential impact is described in EIA Section 7.5.3.5, Characterization of Impacts—Artificial Lighting.	No	Accepted	N/A	N/A
355	10-Dec-2021	EAB	• The idea that birds will use these vessels to rest has been classified as a positive. • Where would these birds normally go in the absence of the vessels? Rather than the vessels being seen as a positive, won't it be more accurate to describe what you observed as a disturbance to the birds natural behavior?	1. The answer depends on the species. Some species would have to go to a landmass such as an island to rest, as they are not able to rest on the water. For these species, the vessel would serve as a place where they can rest over their taxing migration—representing a benefit. Some species are able to rest on the ocean surface, and for these species the presence of the vessels would likely represent a negligible benefit. 2. If birds were to use the FPSO as a resting or foraging area, this would be expected to alter their distribution, but not their natural behaviors, as they would continue to forage by diving and swimming, and they would continue to rest by perching in sheltered areas; they would simply do these things in a place that they didn't previously do them (i.e., on or around the vessels). The potential effect of disorientation at night from vessel lights would be a type of disturbance because it would create a new, unnatural flight pattern around the vessel.	Yes	Accepted	N/A	pp. 7-93 to 7-94

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				Additional detail regarding the above has been added to EIA Section 7.4.3.2, Magnitude of Impacts—Seabirds.				
356	10-Dec-2021	EAB	Please indicate the times for the eight air quality studies; when were these sessions done?	Four onshore and four offshore air quality monitoring campaigns have been conducted. These are described in EIA Section 6.1.2.1, Existing Conditions—Air Quality. The offshore monitoring campaign dates include October 2016, April 2018, May 2018, and April 2019. The onshore monitoring campaign dates include Berbice (New Amsterdam)—October 2018-December 2018; Georgetown (Carifesta Ave.)—August-October 2018 and December 2018-March 2019; and Georgetown (New Guyana School)—April 2019-August 2019.	No	Accepted	N/A	N/A
357	10-Dec-2021	EAB	Would the rating/risk change for cumulative impacts when other operations are considered?	The impact significance ratings provided in EIA Chapters 6 through 8 correspond to ratings of potential impacts from planned activities of the Project only. Potential cumulative impacts resulting from the impacts of the Project combined with the impacts of other non-Project activities are rated in terms of priority ratings. These cumulative impact priority ratings are discussed in EIA Chapter 10. Table 10.6-2, Summary of Cumulative Impact Assessment, summarizes the priority rankings for all resources. Since cumulative impact priority ratings consider the combined impacts from the Project plus other non-Project activities, they differ from impact significance ratings for the Project alone.	No	Accepted	N/A	N/A
358	10-Dec-2021	EAB	Would the gas to shore project have an impact on flaring from this project?	No—the proposed Gas to Energy Project would not impact flaring for the Yellowtail Project because the associated gas from the Yellowtail Project is not part of the proposed Gas to Energy Project.	No	Accepted	N/A	N/A
359	10-Dec-2021	EAB	Is there an interconnectivity between oil spill models and the biological resources e.g. sea turtles and mangroves?	EIA Section 9.1.6, Coastal Sensitivity Mapping, discusses the coastal sensitivity mapping completed for coastal areas identified in the oil spill modeling as having the potential for oiling as a result of modeling of an unmitigated marine oil spill scenario. As described in this section, the mapping included characterization of a number of environmental and socioeconomic resources, including protected areas, mangroves, shoreline types, seagrass beds, coral reefs, coastal fish habitats, coastal bird habitats, and other sensitive habitats. This information is intended to enable EEPGL to prioritize the mobilization of emergency response resources (personnel and equipment) to those areas most sensitive to a spill. The coastal sensitivity maps are provided in Appendix O, Coastal Sensitivity Maps. Additionally, as outlined in OSRP Section 5.6.2 (included in Volume III of the EIA), Geographical Strategic Response Maps have also been developed to define the equipment needs in specific coastline areas of portions of the geographic response area, considering sensitive areas, access points, and likely response actions. Examples of these Geographical Strategic Response Maps are provided in OSRP Appendix E.	No	Recommends adding language to further address this point more specifically	Additional detail consistent with the response has been added to Section 9.1.6 of the EIA.	p. 9-60
360	10-Dec-2021	EAB	What is the current capacity of the landfill? How will waste from future FPSOs be disposed of?	As discussed in EIA Section 8.6, Waste Management Infrastructure Capacity, at current disposal rates, Cell 2 is expected to last for approximately 4 to 6 years. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next 5 years. There remain two additional cells at the site (Cell 3 and Cell 4) for future	No	Accepted	N/A	N/A

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				development. Each cell is 6.5 hectares (16 acres) in size and each could be anticipated to extend landfill capacity by 5 to 6 years. The currently available landfill capacity appears sufficient over the near term based on Cell 2 having entered service in March 2021, even considering the forecasted growth in waste volumes from industrial use. Presuming Cells 3 and 4 would be constructed, the future HBL landfill capacity also appears reasonable for the long term (up to 10 years). Waste from future development projects, if proposed and approved, would likely be managed using the same or similar processes and facilities as those that would be utilized for the Yellowtail Project.				
361	10-Dec-2021	EAB	Was any study/research done to show any correlation to oil field development and the fishing industry in other countries?	The most recent Bank of Guyana report related to fisheries that the Consultants reviewed was from 2020, which indicated that declines in finfish and shrimp production were due to decreases in demand due to COVID-19 restrictions (fish) and weather conditions combined with an extended closed season for shrimp fishing (shrimp). Several comments were received during the EIA disclosure process indicating that fish catches had declined significantly in recent years. EIA Section 8.1.2, Existing Conditions—Socioeconomic Conditions, identifies several possible causes for perceived declines in catches over the last several years, including interference with fishing activities by sargassum, inclement weather, unsustainable/illegal fishing practices, and more recently COVID-19-related declines in fishing effort, based on baseline information collected through literature reviews as well as selected studies and key informant interviews referenced in responses to Comments #364 and #365. Additional information was added to EIA Section 7.8.2.2, Targeted Surveys of Continental Shelf Fish Community, to further address this issue.	Yes	Accepted	N/A	7-193 to 7-194
362	10-Dec-2021	EAB	**Other** Some impacts are described as short term, what timeline can be reasonably described as short term?	The definitions of the terminology used for duration are included in Chapter 4, Methodology for Preparing the Environmental Impact Assessment. As outlined in EIA Section 4.8.1.1, Predicting Magnitude of Impacts, “short-term” is used for any impact with a duration from instantaneous up to less than a week in aggregate. “Medium-term” is used for any impact with a duration that is more than week, but less than a year in aggregate. “Long-term” is used for any impact with a duration that is more than one year in aggregate.	No	Should be addressed following discussions with Redford group	The Consultants have reviewed the Redford group comments, and based on this review the Consultant team considers their original response to be responsive to the EAB’s comment.	N/A
363	10-Dec-2021	EAB	A complaint was received by the EAB on the local consultant’s name being used on the non-technical summary. What steps are being out in place to ensure that this does not happen again? Can you confirm that the persons listed on the EIA did conduct the study?	The Consultants did not engage with or involve the referenced individual to provide support to the Yellowtail Development Project EIA. The referenced individual's signature was inadvertently included on the cover of the version of the EIA NTS for the Yellowtail Development Project that was posted on the EPA’s website. A corrected version of the NTS has been posted on the EPA website in place of the incorrect version. To avoid this type of error in the future, signatures will not be included on submitted documents unless necessary and the name of the individual and the role they played will be incorporated where signatures are determined to be necessary. The individuals listed in Appendix A, List of Preparers (Volume II of the EIA), contributed to the preparation of the EIA.	No	Accepted	N/A	N/A

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364	10-Dec-2021	EAB	Were the studies done as a part of the Yellowtail EIA, or was the information presented from permit conditions of previous projects?	The following studies were conducted between 2017 and 2018 to satisfy conditions of the Environmental Permit issued for the Liza Phase 1 Development Project, and the results of these studies, where relevant, and were used to support the Yellowtail EIA: • Final Environmental Baseline Assessment of Sediment Quality Along the Continental Shelf Guyana—Phase 2 • Remotely Operated Vehicle Imagery Analysis • PSO Surveys (Year 1) • 2018 Turtle Tagging and Telemetry Program (Year 1) • Marine Bird Study (Year 1) • Enhanced Coastal Sensitivity Mapping—Biodiversity and Ecosystem Services (Regions 1–4) • Nearshore and Offshore Fisheries Study Summary Report 2017–2018 (Year 1) In addition, EEPGL elected to extend most of the Permit condition-driven studies beyond the timeframes required by the Liza Phase 1 Environmental Permit. Further, several new studies have been completed by EEPGL or its contractors since the Permit condition-driven studies listed above were completed. The data from the original Permit condition-driven studies, from the extended portions of these studies, and from the new studies have been considered—where relevant—in development project EIAs completed since the Liza Phase 1 Development Project EIA, including the Yellowtail Development Project EIA. Baseline information from several studies (including some of those that originated as a permit condition but have since been expanded beyond the timeframes required by the Liza Phase 1 Environmental Permit, and several others) was utilized for EIA purposes for the first time in the Yellowtail EIA. These studies were not used in any prior EEPGL EIA and are being provided to the EPA and the public for the first time in the Yellowtail EIA. These study reports include the following, each of which are included as an appendix to the Yellowtail EIA (Volume II): • Marine Bird Study Report: Marine Bird Survey Year 2 (Volume II, Appendix K) • Coastal Bird Survey Report: Coastal Bird Study Year 2 (Volume II, Appendix L) • Shell Beach Sea Turtle Tracking Study Year 2 (Volume II, Appendix Q) • Nearshore and Offshore Fisheries Study Year 2 (Volume II, Appendix M) • Environmental Baseline Survey and Habitat Assessment: Continental Slope AUV Survey, Hammerhead Development, Offshore Guyana (Volume II, Appendix I) • Environmental Baseline Survey ExxonMobil Hammerhead Development Offshore (Volume II, Appendix I) • ExxonMobil Multi-AUV Geophysical Survey: Seabed Constructor and Normand Frontier (PSO Report) (Volume II, Appendix N) • Enhanced Coastal Sensitivity Mapping—Ecosystem Services (Regions 5 and 6) • 2Q-4Q Participatory fish data (1Q data were reported in the Payara EIA).	No	Accepted	N/A	N/A

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365	10-Dec-2021	EAB	What were the actual studies done to conduct the EIA?	In addition to utilizing the information from the several studies provided in Volume II of the EIA for the first time in the Yellowtail EIA (see response to Comment #364), baseline and other data collection efforts conducted exclusively to support the Yellowtail EIA included the following, consistent with various Yellowtail EIA Terms and Scope requirements to "update existing information where appropriate" and assess Project-related impacts: • Collection of various socioeconomic data via key informant interviews (topics covered in interviews summarized in Chapter 4; data referenced throughout EIA Chapter 8) • Air Quality Modeling Analysis (Volume II, Appendix G) • Water Quality Modeling Analysis (Volume II, Appendix C) • Oil Spill Modeling (EIA Section 9.1.5) • Vehicular Traffic Study (Volume II, Appendix T) • Underwater Noise Analysis (Volume II, Appendix H)	No	Accepted	N/A	N/A
366	25-Oct-2021	Public	What oil spill response equipment is in Guyana and what has to be imported, which will lead to a delay in response?	Table 6-1 of the OSRP provides detail on the specific types and quantities of oil spill response resources and their locations within and outside of Guyana. Table H-8 (in Appendix H of the OSRP) provides a day-by-day plan for implementation of various response activities, taking into account lead times for assets that would need to be imported (as applicable).	No	Accepted	N/A	N/A
367	25-Oct-2021	Public	After the Project is decommissioned, what if something happens the day after Exxon leaves? Who will be liable for the clean-up?	As indicated in Section 8 of the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects (included in Volume III of the EIA), the relevant Guyanese regulators would have access to the work site during the decommissioning activities to monitor and witness the final completion of the work. After the completion of well plugging and abandonment (P&A) and facilities decommissioning work, EEPGL would submit a final decommissioning report to the relevant Guyanese regulators that would include a description of the scope of work performed, work logs, final inspection reports, videos, and photos, as applicable. As described in the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects, decommissioned wells are plugged and abandoned such that the well is secured against future leaks. Based on the question, in the unlikely event that shortly after decommissioning a leak occurred indicating that the plugging and abandonment work was potentially defective, EEPGL would be responsible to address the leak and clean up the oil.	No	Accepted	N/A	N/A
368	25-Oct-2021	Public	Will EEPGL share detailed design information with the EPA?	EIA Chapter 2, Project Description, includes Project design information with sufficient detail to support the EIA; further, EEPGL has indicated its willingness to provide the additional available information the EPA requires to inform its review of the EIA.	No	Accepted	N/A	N/A
369	27-Oct-2021	Public	I have been a fisherman in my community for four years and, in the last 1.5 years, I have noticed the amount of fish decreasing as well as a lot of weeds and water coming ashore along the Demerara River and the water smells similar to diesel.	Several participants in the participatory fish study included in Volume 2 of the EIA indicated recent declines in catches. EEPGL is currently conducting additional participatory fish survey work with the goal of detecting long-term trends in fish catches across the coast. The Consultants are aware of the recent increasing trend of sargassum in Guyana's coastal waters; Section 7.8 of the EIA discusses the prevalence of sargassum incursions in Guyana and elsewhere, and its potential role in declining fish catches. The complaint of odors in the water has been noted and communicated to EPA and EEPGL.	No	Accepted	N/A	N/A

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370	27-Oct-2021	Public	I am concerned about the assistance for fishermen in the community. In the event of an oil spill, we would not have any response equipment as it is being stored in Georgetown.	In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated as appropriate based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss. It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would consider establishing an independent implementation entity as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts may potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as defined by the duration of spill impacts. Yellowtail Development Project EIA Volume III Oil Spill Response Plan Chapter 6 Table 6-1: lists or otherwise describes the international, regional, and local resources available to EEPGL for each potential response strategy. Tables 6-2 through 6-7 provide a further summary of the representative oil spill response equipment in Guyana. Based on the expected duration of time (6.5 to 8.5 days) that it will take oil to travel from the proposed Project location to the Guyanese shoreline, the time needed to mobilize oil spill response equipment and personnel from Georgetown is ample to implement oil spill recovery and shoreline protection strategies. For example, in 2019 a mobilization of equipment was carried out from Georgetown to Region 1 (Waini Point near Mabaruma) in less than 48 hours. In addition, by centralizing the storage of the oil spill equipment in the Georgetown area, the preventive maintenance schedule of oil spill equipment is streamlined and more efficient EIA Section 9.1.9 describes claims and livelihood remediation processes.	No	Accepted	N/A	N/A
371	27-Oct-2021	Public	Is there a reason the government is not developing Essequibo Port?	The Consultants acknowledge the question. The question is outside the scope of the EIA.	No	Accepted	N/A	N/A
372	27-Oct-2021	Public	Overall, I feel that fishermen are often overlooked in our community, despite the fishing sector being one of the largest in Guyana. When I have reached out to the EPA that we need more	The Consultants acknowledge the question. The question is outside the scope of the EIA.	No	Accepted	N/A	N/A

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			community centres and high schools, I have never received a response.					
373	27-Oct-2021	Public	While I don't doubt what is being said during this presentation, I'm curious why I should believe it? I am a rice farmer and am having a hard time following the technical material.	The Consultants acknowledge that much of the material is technical and complex in nature. The EIA was prepared by an experienced and qualified team of technical experts. The Non-Technical Summary (NTS), posters (for in-person events), and EIA Summary Presentation are intended to share the outcomes of the EIA with a non-technically oriented audience. Please also see the response to Comment #326.	No	Accepted	N/A	N/A
374	27-Oct-2021	Public	Will you be providing any security in terms of cash liquidity in case something happens?	Please see the response to Comment #53.	No	Accepted	N/A	N/A
375	27-Oct-2021	Public	We seem to have the worst deal in the world in terms of the percentage of money that Guyana receives. Can you share the interest rates with us if you were to put the money up front?	The Consultants acknowledge the question. The question is outside the scope of the EIA.	No	Accepted	N/A	N/A
376	27-Oct-2021	Public	I can recall the Mexico spill when they had a lot of oil on the beach. What are you going to do if there is an oil spill? Region 2 is a coastal belt below the sea level and the majority of our population lives on the coast. I am concerned about border security if, in the event of an oil spill, oil drifted north to Venezuela, as it would become an international issue.	Details on oil spill response measures are described in EIA Volume III, Oil Spill Response Plan. Impacts to other countries from an oil spill, if one occurs, would be a function of the size of the spill, but would be mitigated by the response tools and resources EEPGL has in place for such an event. As described in EIA Chapter 9, EEPGL would work with the Government of Guyana and other countries as appropriate to coordinate such a response.		Accepted	N/A	N/A
377	27-Oct-2021	Public	What if someone's water well is contaminated by an oil spill reaching shore?	Please see the response to Comment #44.	No	Accepted	N/A	N/A
378	27-Oct-2021	Public	When you drill, 40+ species of animals will move in different directions. Animals, such as the many species of turtles at Shell Beach, are vital to our tourism. What happens if they move away?	Section 8.1.2.4 of the EIA recognizes the value of ecotourism to the Guyanese economy and that, with additional investments in supporting infrastructure, the potential for ecotourism (and the value of attractions such as the sea turtles) could grow in the future. As stated in Section 7.7 of the EIA, Project effects on sea turtle movements and habitat usage are expected to be negligible, so sea turtles are not expected to move because of the Project activities and no significant impacts on tourism are expected.	No	Accepted	N/A	N/A
379	27-Oct-2021	Public	You said you invest a lot in Guyana, but do you truly think this profit sharing is good for us as a country?	As discussed in Section 12.1, Planned Project Activities, the EIA predicts that Project would generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, an increase in employment, and in-country Project purchasing of goods and services from Guyanese businesses.	No	Accepted	N/A	N/A
380	27-Oct-2021	Public	There is a lot of fishing around the Demerara, and I'm curious how fishermen will be able to work when	Section 8.4 of the EIA describes the assessment of potential impacts on marine use and transportation, including potential impacts to fishing vessels. As detailed in this section, Project-related vessel activity in Georgetown	No	Accepted	N/A	N/A

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			there are big ships coming and disrupting the water. Fish catches are already decreasing, which is not good for fishermen, so what will Exxon do to prevent that from getting worse? The installation of the fiber optic cable has also restricted fishing in some areas.	Harbour is expected to increase the existing marine traffic in Georgetown Harbour by approximately 2 to 4 percent. This level of increased traffic is not expected to have a lasting adverse effect on fishing activities. As discussed in Section 7.8.2 of the EIA, Marine Fish Existing Conditions, there are many potential factors contributing to declining fish catches, but oil and gas activities are not likely to be driving these declines. See additional information in the response to Comment #207. EEPGL continues to monitor the fishing sector through its ongoing participatory fishing study, which includes the participation of fisherfolk at landing sites in all coastal regions. Findings from this study informed the Yellowtail Development Project EIA and continue to comprise an important part of EEPGL's ongoing monitoring and stakeholder engagement activities for all its projects. The most recent report is included in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, of the EIA (Volume II), including a profile of landing sites, fishing areas, targeted species, seasonal considerations, and biometrics. Findings of the participatory fishing study will continue to inform EEPGL's engagement and adaptive management activities.				
381	27-Oct-2021	Public	What protection will Exxon offer rice farmers facing heavy rain or fishermen whose fish may move away because of underwater noise? Exxon needs to help the fishermen because we're not getting enough fish and we think it's because of the company.	As mentioned in the response to Comment #270, EEPGL has in place a transparent, accessible, and consistent CGM that would apply to the Yellowtail Project prior to onset of Project activities and throughout its lifecycle. The CGM is described in EEPGL's SEP (EIA Volume III). EEPGL periodically evaluates the CGM effectiveness and the CGM would be updated going forward as necessary.	No	Accepted	N/A	N/A
382	27-Oct-2021	Public	Why are water and gas injected back into the well rather than just water?	As discussed in Section 2.18.2.4, Associated Gas Management Alternatives, subsurface studies have established that the associated gas in the Yellowtail and Redtail fields is miscible with the reservoir fluid for several of the developed reservoir segments, meaning that use of gas re-injection—particularly as part of a water-alternating-gas strategy (i.e., a strategy that employs injection of both water and gas)—results in considerable uplift in recovery. This is typical of offshore production operations around the world.	No	Accepted	N/A	N/A
383	27-Oct-2021	Public	Are the GHG emissions and rising sea level good for Guyana? With another mega project such as this, we need to receive enough money to be able to move to higher ground because we are still poor.	As discussed in the response to Comment #238, while the EIA cannot assess potential impacts of the Project emissions on climate / climate change, EIA Section 6.1.2.3, Current Scientific Understanding of Consequences of Climate Change, provides a discussion of the current scientific understanding of consequences of climate change, including a discussion of potential sea level rise.	No	Accepted	N/A	N/A
384	27-Oct-2021	Public	I hope that the president and government of Guyana come to a good resolution for Exxon and the people of Guyana.	The Consultants acknowledge the comment. The comment is directed to the Government of Guyana.	No	Accepted	N/A	N/A
385	27-Oct-2021	Public	There is only a short period to review the EIA.	Please see the response to Comment #90.	No	Accepted	N/A	N/A
386	29-Oct-2021	Public	I hope the EPA makes informed decisions based on a factual basis.	The Consultants acknowledge the comment. The comment is direct at the EPA. However, various baseline studies of physical, biological, and socioeconomic resources that could potentially be affected by the Yellowtail Project were conducted, as described in Chapters 6, 7, and 8. These studies	No	Accepted	N/A	N/A

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				were augmented by research of existing information and data. Data from baseline studies and research were used to inform the impact assessment for the Project. Please see the response to Comment #108 for additional details.				
387	29-Oct-2021	Public	For future meetings, it would be helpful to share the presentation and the NTS a month in advance so that the Moruca District Council and National Toshaos Council could meet with members of our villages. We need to be able to explain the information to our members and more training would be helpful for doing so. We have had a resource person work in our village in the past, and more funding is needed so that we can do so again.	Please see the response to Comment #90. The question of funding is beyond the scope of the EIA.	No	Accepted	N/A	N/A
388	29-Oct-2021	Public	We need people trained by the EPA who can collect on-the-ground information in our villages. Some of the information that has been presented here, but it may have been more accurate if we can share it with the villagers.	The comment is directed to the Government of Guyana. However, please see the responses to Comment #121 and Comment #330 for information on EEPGL education, training, development, and local capacity-building initiatives.	No	Accepted	N/A	N/A
389	29-Oct-2021	Public	After the oil is extracted, would there be issues in the future? As you know, much of our shoreline is below sea level. If there was even a small tremor, the land would collapse, particularly in Georgetown.	Please see the response to Comment #150.	No	Accepted	N/A	N/A
390	29-Oct-2021	Public	Are our people from Region 1 being employed? I know there are not many people with degrees, but we have a lot of people who know the environmental science. Future studies must involve our people.	Please see the response to Comment #139.	No	Accepted	N/A	N/A
391	29-Oct-2021	Public	Who conducted the EIA? Did the report take into account the flaring of other vessels? Can Exxon provide assurance that there will be no flaring?	As described in Section 1.1, Purpose of this EIA, the EIA, including studies and data gathering, was conducted by a team of consultants approved by the EPA. With respect to cumulative effects of flaring, EIA Section 10.6.1.1, Air Quality, and Appendix G, Emissions Inventory and Air Quality Modeling Report, describe the air dispersion modeling performed for the cumulative emissions from the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail projects, as well as from two prospective future FPSO projects. This cumulative emissions modeling included estimated non-routine flaring for each of these projects. As noted in the response to Comment #64, EIA Section 2.7.1, General Description, states that the FPSO would be designed to re-inject associated gas under routine conditions—except that which would be used as fuel gas, flare pilot gas, and background flare gas (e.g., purge, compressor seals) for	No	Accepted	N/A	N/A

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				FPSO operations and other *de minimis* sources not captured by the Vapor Recovery Unit (VRU)—back into the reservoir except during times of injection / compression system unavailability, which would require temporary, non-routine flaring during maintenance/repair. Flaring of associated gas would occur on a non-routine basis during start-up and shutdown; equipment maintenance and process upsets scenarios; emergency pressure relieving scenarios; and other non-routine flaring events.				
392	29-Oct-2021	Public	Is there a point in which we will begin noticing the socio-economic benefits? Exxon has been in Guyana for some time, but we're an indigenous community and have not benefited from anything related to EEPGL directly. We want to see benefits and change in our lifestyle, but you've been coming here for some time and we have not seen any of that.	As summarized in Section 12.1, Planned Project Activities, and further detailed in Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, the EIA predicts that the Project would generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, an increase in employment, and in-country Project purchasing of goods and services from Guyanese businesses. Whether social benefits can ultimately be delivered as estimated by the Consultants is beyond the scope of the EIA.	No	Accepted	N/A	N/A
393	29-Oct-2021	Public	You say you are doing this training for students at the Santa Rosa school. Can it be more publicized so that we know more about it? We have 12 villages and it would be good if they could know about it and be able to participate.	Please see the responses to Comment #140 and Comment #326.	No	Accepted	N/A	N/A
394	29-Oct-2021	Public	How are we rated in terms of global oil production?	The Consultants acknowledge the question. The question is outside the scope of the EIA.	No	Accepted	N/A	N/A
395	1-Nov-2021	Public	Has this project compiled a registry of fishermen in this region to say what they used to catch and what they catch now so that you can compare any effects and provide compensation for lost livelihoods? I noticed in the NTS on page 19 that there is marine use and transportation and could be potential residual impact with the disturbance from commercial fishing vessels and disturbance from subsistence vessel movement, albeit a minor/negligible amount.	The Participatory Fish Study provided a baseline of the types of fish caught and the methods used to catch them in each region, but did not create a complete registry of all fisherfolk in every region or a history of catches for each person involved in the fishing industry. With respect to compensation for lost livelihoods, please see the response to Comment #303.	No	Accepted	N/A	N/A
396	1-Nov-2021	Public	Will I get answers to these questions? I've asked EEPGL for a recording, and they said to ask the government who I received no response from.	Please see the response to Comment #327.	No	Accepted	N/A	N/A

Comment	Date	Stakeholder	Comment	Response	EIA Edit?	EPA Response	Consultant Response	Page Numbers with EIA Edit
397	1-Nov-2021	Public	I submitted my question about monitoring to the government and cc'd the EPA but did not get a response. If the EPA is monitoring, why are they not reporting this to citizens?	The comment is directed to the Government of Guyana. However, please see the responses to Comments #166 and #327.	No	Accepted	N/A	N/A
398	1-Nov-2021	Public	There was a significant drop in aquacultural production last year. Sea-bob fishery has significantly dropped and artisanal fishers report a similar drop in white belly shrimp by as much as 90%. These drops are causing them to believe that oil production is responsible.	The Consultants are aware of the decline in fisheries productivity. Many potential causes have been suggested including incursions of sargassum seaweed, increased market competition, and restrictions imposed to control the COVID-19 pandemic. Recent media reports in Guyana have cited Guyanese fisherfolks' suspicions that declines in whitebelly shrimp catches could be due to changes in salinity of coastal waters or poor fisheries management. Section 8.1.2.4 of the EIA notes that the largest decline in seabob landings in the most recent 6 years for which the Department of Agriculture has landing data occurred from 2013 to 2014, well before oil production began in Guyana. The Consultants further note that shrimp catches increased from 2014 through 2018, when exploration activities were occurring. Without a longer term data set to establish longer term trends, it is impossible to assign causes for these recent declines in catches, but additional information has been added to the EIA to describe these recent trends. As discussed in the response to Comment #369, EEPGL is currently conducting additional participatory fish survey work with the goal of detecting long-term trends in fish catches across the coast.	Yes	Accepted	N/A	7-193 to 7-194
399	1-Nov-2021	Public	What provisions are in place for environmental impact and will people be compensated accordingly if an event occurs?	Please see the response to Comment #44.	No	Accepted	N/A	N/A
400	1-Nov-2021	Public	These meetings are often a show of public consultation. I have been here before and asked questions and was told that I would get an answer later but never did.	Please see the responses to Comment #36 and Comment #327	No	Accepted	N/A	N/A
401	1-Nov-2021	Public	I work in the fishing industry and we can see the effects of industry on our fishing and marine life. Are you going to establish data systems for fisher folk so that we can later determine what the impacts were?	Information on total economic productivity of the sector over the last several years, estimated size of the artisanal fishing fleet, and various economic concerns affecting the industry are described in EIA Section 8.1, Socioeconomic Conditions, and Appendix D, Participatory Fishing Study Final Report January 2019–March 2020 (Volume II of the EIA). As discussed in several responses above, EEPGL is currently conducting additional participatory fish survey work with the goal of further describing long-term trends in fish catches across the coast.	No	Accepted	N/A	N/A
402	1-Nov-2021	Public	What contributions are you making to institutions like this to train people, without a requirement that they come work for EEPGL?	Through the Greater Guyana Initiative, EEPGL and its Co-Venturers are working closely with University of Guyana on a variety of educational initiatives and are supporting a pilot program at several TVETs in Guyana focused on safety, electrical and welding programmes. In addition, EEPGL's contributions programs provide support to a variety of education, training, development, and capacity building initiatives across Guyana. For example, at Leonora, the Institute has been a part of the TVET initiative through a safety training program, and other locations have been encompassed by the broad reach of this program. Through the Centre for Local Business Development (CLBD), EEPGL has also conducted several regional outreaches to foster greater awareness of	No	Accepted	N/A	N/A

Comment	Date	Stakeholder	Comment	Response	EIA Edit?	EPA Response	Consultant Response	Page Numbers with EIA Edit
				ExxonMobil's operations in Guyana and how Guyanese businesses can become suppliers to the O&G sector. These programs are meant to upskill Guyanese in areas would could benefit the O&G as well as other sectors. EEPGL believes in supporting efforts that generate broad and sustainable economic development for Guyana. There is no requirement that participants in community initiatives supported by EEPGL or GGI come to work for EEPGL or its contractors.				
403	1-Nov-2021	Public	Is there a plan to protect the plants, animals, and fishes?	The ESMP, which is included in Volume III of the EIA, is a compendium of all measures recommended by the independent Consultants to manage impacts on all resources, including biological resources.	No	Accepted	N/A	N/A
404	2-Nov-2021	Public	I went through Volume 1 of the EIA. Although we hope there will be no spill, it is still possible. In the Volume, I notice that the chance of an oil spill is expected to be 5-40%, which is higher than what was predicted for Liza 1, which was 5-10% chance. Despite the lower probability, there was also a recent issue with Liza 1. It is evident that production is higher than the maximum safety level – 8.3% increase. What guarantees can you make that it will be safe given the significant strain on the equipment you're using?	To clarify, the referenced range of 5-40% refers to the probability, based on stochastic modeling, of an unmitigated spill reaching the Guyana shoreline in Region 1 – in the highly unlikely event that a loss-of-well-control scenario equivalent to the Most Credible Worst Case Discharge or the Maximum Worst Case Discharge scenario were to occur. This range does *not* refer to the probability of a loss-of-well-control occurring. The production rate for the Liza Phase 1 Project is not within the scope of the EIA. With respect to the production rate for the Yellowtail Project, please see the response to Comment #5.	No	Accepted	N/A	N/A
405	2-Nov-2021	Public	The waters of Guyana and all of the rivers interlock. So, if the water is polluted anywhere, it would affect all of the water in Guyana. You say that the water flows away from our shoreline but the fish can travel anywhere so we can still be affected.	As described in Chapters 6 and 9 of the EIA, the trajectory of a pollution plume from the Project would depend on the dominant currents and metocean conditions at the time of the release. Under some modeled scenarios, an oil spill could reach Guyana's coast, but as described in Chapter 9 such a scenario is very unlikely. Although seasonal connections between some watersheds in Guyana exist, that does not mean that the effects of pollution originating or entering one river would reach another. It is true that fish would be able to enter and exit the mixing zone around the FPSO and that if an unplanned event created additional pollution, fish could also move in and out of the affected area at will. However, for the reasons stated in Section 9.12 of the EIA, fish would be expected to have relatively low exposure to such an event.	No	Accepted	N/A	N/A
406	2-Nov-2021	Public	How much flaring and air emissions will come from this project?	Estimated emissions to air from the Project are summarized in Table 2.13-5: Estimated Annual Atmospheric Emissions Summary. As described in Section 2.7.5.3, the Project FPSO has been designed to re-inject associated gas under routine conditions, except that which will be used as fuel gas, flare pilot gas, and background flare gas (e.g., purge, compressor seals) for FPSO operations and other *de minimis* sources not captured by the VRU. The estimated flaring volumes from FPSO commissioning and start-up through the end of the production operations stage are presented in Table 2.7-2: Estimated Flaring Volumes during Yellowtail Commissioning, Start-up, and Production Operations Stages.	No	Accepted	N/A	N/A

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407	2-Nov-2021	Public	We have been told about compressors, but from the beginning of this project they have had a compressor that wasn't activating. Why, as such a big company, does Exxon not have the right systems in place to avoid this?	Compressor design for the Yellowtail Project has taken significant steps to incorporate lessons learned from other projects, including Liza Phase 1. The Yellowtail FPSO would incorporate two trains of export / re-injection gas compression in normal operation plus a spare with a total design basis of 3 x 50% capacity (three at 50% capacity each), where the export gas compressor and injection gas compressor would be driven by a common mechanical drive. The 3 x 50% design was selected so that when one train is down, the other trains could continue to operate until the installed spared compressor train is online. This three-train configuration was selected to enhance the facility's safety, minimize flaring, and reduce production down time.	No	Accepted	N/A	N/A
408	2-Nov-2021	Public	Exxon is going to give Guyana a lot of tax revenue, but it is going to be the Guyanese people who end up paying the taxes.	Any tax-related agreements between the Stabroek Block co-venture partners and the Government of Guyana are beyond the scope of the EIA and should be referred to the Government of Guyana.	No	Accepted	N/A	N/A
409	2-Nov-2021	Public	Where are the fish going?	As stated in the response to Comment #207, EIA Section 8.1.2, Existing Conditions—Socioeconomic Conditions, identifies several possible causes for perceived declines in catches over the last several years, including interference with fishing activities by sargassum, inclement weather, unsustainable/illegal fishing practices, and more recently, COVID-19-related declines in fishing effort. Additional information was added to EIA Section 7.8.2.2, Targeted Surveys of Continental Shelf Fish Community, to further address this issue.	Yes	Accepted	N/A	7-193 to 7-194
410	2-Nov-2021	Public	Why was all of the information you're sharing now not shared during Phase 1 but rather, during Phase 4?	While the Yellowtail engagement program benefited from the learnings of past development projects, much of the environmental and socioeconomic data that is included in the EIA was collected prior to the Yellowtail Project and shared with the public in prior EIAs. Technical reports that were shared as part of previous EIAs were not attached to the Yellowtail EIA as technical appendices, but at the time the Yellowtail EIA was published all technical appendices from the Liza Phase 1, Liza Phase 2, and Payara EIAs were available to the public on the EPA website.	No	Accepted	N/A	N/A
411	2-Nov-2021	Public	Will this project help improve recycling in Guyana?	While the development of recycling capability in Guyana is not within the scope of the EIA, Chapter 8.6, Waste Management Infrastructure Capacity, describes that several additional private waste management facilities have come online or are expected to come online in the near-term for waste treatment. These are expected to further expand the capacity of onshore waste management infrastructure to manage waste storage, processing, treatment, and/or recycling needs.	No	Accepted	N/A	N/A
412	2-Nov-2021	Public	Is this project contributing to the bad weather and sea levels that the rice farmers have been experiencing?	As described in the response to Comment #117 and in EIA Section 6.1.3.4, Management Measures—Air Quality, Climate, and Climate Change, potential climate / climate change impacts are a global concern and stem from cumulative worldwide GHG concentrations. The Global Circulation Models used to predict climate impacts from global concentrations are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project such as the Yellowtail Development Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate using observed data, and can be used to estimate future local climate changes based on the results of Global Circulation Models. However, the reverse approach of predicting the impact of local GHG emissions on global (or local) climate change is not feasible due to the multiple factors—beyond	No	Accepted	N/A	N/A

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				that of a single project—that drive global climate change predictions. It is also noted that the Yellowtail Project has not been approved or constructed yet, so would not have had contributed to any past impacts to resources.				
413	2-Nov-2021	Public	Why isn't the contract going into the public domain?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
414	2-Nov-2021	Public	You mention that the impacts will be focused on Georgetown, but we all rely on Georgetown and would experience subsequent impacts.	As indicated in Chapter 8 of the EIA, while some impacts may be felt principally in Region 4, impacts would also be realized in other regions as people from other regions also rely on many of the same services and infrastructure.	No	Accepted	N/A	N/A
415	2-Nov-2021	Public	Why are there no stakeholder engagement programs for Region 5, only for Georgetown?	Notice of all engagements related to the Project EIA were published in local newspapers, advertised on radio and televisions channels, and communicated by howlers ahead of the engagements. The Consultants facilitated in-person and virtual meetings in all six coastal regions, and EEPGL's ongoing stakeholder engagement program includes outreach throughout Guyana, including Region 5. For additional information, please see the response to Comment #326 and refer to Chapter 4 of the EIA.	No	Accepted	N/A	N/A
416	2-Nov-2021	Public	All of these activities will eventually come to a head and we will be left with no fish.	Please see the response to Comment #207.	Yes	Accepted	N/A	7-193 to 7-194
417	2-Nov-2021	Public	In case of a decline in harvesting is there any consideration of inland fish farming?	The ESMP does not envision freshwater aquaculture as a management measure because the EIA does not predict significant declines in fish catches as a result of the Project.	No	Accepted	N/A	N/A
418	3-Nov-2021	Public	I have 3 plantations that have been in shrimp production since the 1980s. Since starting my plantation, I have seen consistent reduction in the loss of fish catch. The focus is always on the oil spill, but I find that the oil exploration causes a lot of other problems for the fish like slurry from drillings and blocking the channels.	The EIA describes potential impacts to marine water quality, marine sediments, and marine life associated with drilling, including deposition of drill cuttings on the seafloor and temporary increases in suspended solids concentrations in the water column. The EIA includes computer modeling of these impacts, the results of which indicate the extent of minor impacts remains well offshore.	No	Accepted	N/A	N/A
419	3-Nov-2021	Public	The fishers from the Upper Correntyne area have been experiencing very low catches for the last two years. There is a lot of speculation, but since oil production has started, our catches have been declining.	Please see the response to Comment #207.	Yes	Accepted	N/A	7-193 to 7-194
420	3-Nov-2021	Public	On October 10, 2021, there was a mid-year financial report in one of the newspapers that stated that white-bellied shrimp populations declined by 75%, and finfish by 23% - changes that were due to chemical shifts in the ocean. The chemicals	As stated in the response to Comment #207, EIA Section 8.1.2, Existing Conditions—Socioeconomic Conditions, identifies several possible causes for perceived declines in catches over the last several years, including interference with fishing activities by sargassum, inclement weather, unsustainable/illegal fishing practices, and more recently, COVID-19-related declines in fishing effort. Additional information was added to EIA Section	No	Accepted	N/A	N/A

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			being used to cool the drills are said to be water soluble. However, no studies have been done to show what chemicals are released when the drills go into the earth's crust. Proper studies need to be done and we call for drilling to cease until those studies are completed, as it impacts our once-profitable fishing business.	7.8.2.2, Targeted Surveys of Continental Shelf Fish Community, to further address this issue. The only materials that would be released to the environment based on planned activities during drilling would drilling fluid and drill cuttings. The physical and chemical composition of the seafloor (which would influence the composition of the cuttings in the early stages of drilling) is described in Chapter 6 of the EIA. The compositions of the aqueous and non-aqueous drilling fluids are described in Chapter 2. As described in that chapter, during subsequent stages of the drilling process when non-aqueous drilling fluid would be used, EEPGL would implement cuttings management techniques to reduce the amount of non-aqueous base fluid retained on cuttings to less than 6.9 percent by weight, which is good international oilfield practice for offshore discharge.				
421	3-Nov-2021	Public	We used to bring in 1 tonne of shrimp per day but that amount has declined tremendously. Whatever is in the earth's crust (cyanide, cadmium, selenium) is being brought up by the drilling and affecting the water. You say that the water won't affect us in the Correntyne because the currents go the other way, but the ecosystem is connected. My 1500 acres of tree plantation that meet the water is directly in front of the Stabroek Block and will be directly impacted.	Please see the response to Comment #207 regarding concerns related to declining fisheries production. With respect to impacts on coastal resources, as discussed in Sections 6.3.3 and 6.4.3, the impacts of the Project on marine sediments and water quality are expected to be limited to the vicinity of the FPSO and not to extend to coastal areas. This analysis is supported by the results of hydrodynamic modeling analyses which are explained in detail in Appendix C.	Yes	Accepted	N/A	7-193 to 7-194
422	3-Nov-2021	Public	I have not yet heard acknowledgement about whether or not the increased activity in the open sea could be causing more muddying of the water. Since our shrimp are the smallest they may be the most susceptible to impacts. So, while there may not be direct drilling impacts, the increased activity on the open sea may be impacting shrimp populations.	As discussed in Section 7.8.1.3 of the EIA, turbidity is expected to temporarily increase in the immediate vicinity of the wells during the drilling and installation phase of the Project, but this temporary effect would not be expected to extend to the relatively shallow areas where shrimp are harvested.	No	Accepted	N/A	N/A
423	3-Nov-2021	Public	Are they dredging on the Berbice?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
424	3-Nov-2021	Public	There is no area of the shoreline that is not inundated with mangroves. I hope the final analysis will include a concerted effort to trace whether some species are moving to other habitats.	The EIA did not conclude that the Project will cause any coastal species to move into new or different habitats, and Consultant does not recommend monitoring of habitat usage by coastal species.	No	Accepted	N/A	N/A

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425	3-Nov-2021	Public	What assurances can you give to us as fishermen in case the fish larvae and eggs are impacted by drilling?	Please see the response to Comment #303.	No	Accepted	N/A	N/A
426	3-Nov-2021	Public	750 KBD a day will lead to increases in traffic. You need to ensure that human resources tests sobriety for captains and all other positions.	Section 2.3 of the ESMP (Volume III of the EIA) describes EEPGL's Operations Integrity Management System, its framework for managing safety, security, health, and environmental risks. In accordance with OIMS, the placement of personnel into key positions is subject to verification that personnel meet the identified competencies, undergo appropriate medical and security screening, meet regulatory and license requirements, complete any needed training and experience, and demonstrate the required competencies in the performance of their job responsibilities. The selection and placement criteria are also consistent with EEPGL's Alcohol and Drug Policy. Additionally, OIMS job-specific requirements are defined and communicated to third parties during the contracting process and included in third party contracts. These requirements include EEPGL's Alcohol and Drug requirements.	No	Accepted	N/A	N/A
427	3-Nov-2021	Public	The lopsided contract requires Guyana to pay Exxon for operating costs, despite the company saying it will make the country a lot of revenue.	The Consultants acknowledge the comment. The question is beyond the scope of the EIA.	No	Accepted	N/A	N/A
428	3-Nov-2021	Public	We are not adequately protected in the event of an oil spill – the proposal is not feasible, it is vague and unsubstantiated.	Please see the response to Comment #44.	No	Accepted	N/A	N/A
429	3-Nov-2021	Public	Recent weather patterns show the effects of climate change, and fishing is at the mercy of this. When Exxon Mobil flares, it not only impacts the fishermen but we are also not seeing the financial benefits of projects such as these.	As described in the response to Comment #117 and in EIA Section 6.1.3.4, Management Measures—Air Quality, Climate, and Climate Change, potential climate / climate change impacts are a global concern and stem from cumulative worldwide GHG concentrations. The Global Circulation Models used to predict climate impacts from global concentrations are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project such as the Yellowtail Development Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate using observed data, and can be used to estimate future local climate changes based on the results of Global Circulation Models. However, the reverse approach of predicting the impact of local GHG emissions, including those from flaring, on global (or local) climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions.	No	Accepted	N/A	N/A
430	5-Nov-2021	Public	How will multiple projects at the same time cumulatively affect air quality?	EIA Section 10.6.1.1, Air Quality, and Appendix G, Emissions Inventory and Air Quality Modeling Report, describe the air dispersion modeling performed for the cumulative emissions from the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail projects, as well as from two prospective future FPSO projects.	No	Accepted	N/A	N/A
431	5-Nov-2021	Public	If you were to have to pause production because of something like the global pandemic, would the rapid re-start impact the environment? If all the fish and	The Project is not expected to cause wildlife to vacate the area around the FPSO during normal production operations. Should the Project be temporarily shut down and then re-started, the restart would effectively re-institute the conditions that previously existed during normal operations, so	No	Accepted	N/A	N/A

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			animals return, they may be impacted when operations start up again.	re-starting the Project after a temporary shutdown would not be expected to cause wildlife to move away from the FPSO.				
432	5-Nov-2021	Public	We have limited access to internet so, when you put things online, you're not catering to all areas. Some people lack the technology, literacy, or general abilities to access the information. We need to have more engagement in person, do not rely on the internet. To share information, I recommend printing information in a booklet, speaking on the radio, and generally diversifying information distribution away from the internet.	The Consultants acknowledge the comment. These recommendations will be considered when planning future community engagement programs. For the Yellowtail EIA disclosure, printed flyers and printed copies of the EIA were distributed to RDCs and NDCs in Regions 1 to 6 in advance of in-person meetings. Eight in-person meetings were held (including 1-2 meetings in each of Regions 1 6) including presentations and question/answer sessions. Printed non-technical summaries of the EIA were available at these meetings. The dates and locations of meetings, and the opportunity to review and comments on the EIA, were also communicated through RDCs, NDCs, and howlers in communities.	No	Accepted	N/A	N/A
433	5-Nov-2021	Public	Since COVID, there has been a lot of change of how people access classes/education but many don't have computers or internet. Is Exxon able to provide sponsorships for people from Region 1 to go the University of Guyana?	The Consultants acknowledge the question. The question is beyond the scope of the EIA.		Accepted	N/A	N/A
434	11-Nov-2021	Public	If Yellowtail is not going to reinject the produced water, then that appears to contradict clause 12 of the PSA 2016. And if XOM can unilaterally change the PSA 2016, you would agree that the government also change its mind on specific items in the PSA? Is the EPA willing to hold Exxon to reinjecting the produced water versus its preference for easier work in just releasing the water into our marine habitat? The EIS 3 table does not document the minimum acceptable standards for each of these discharges, just cites regulatory bodies. So we do not know the expected pollutants of different kinds which will be discharged.	The first part of the comment should be referred to the EPA. Table EIS-3 is an executive summary of production discharges. Additional detail regarding Project-related discharges, including discharge criteria, is provided in Table 6.4-8: Summary of Project-Related Discharges.	No	Accepted	N/A	N/A
435	11-Nov-2021	Public	Exxon's gas compressor problems have resulted in excessive flaring for a long time and is not quite inspiring, but ERM is predicting it will be okay.	Compressor design for the Yellowtail Project has taken significant steps to incorporate lessons learned from other projects, including Liza Phase 1. The Yellowtail FPSO would incorporate two trains of export / re-injection gas compression in normal operation plus a spare with a total design basis of 3 x 50% capacity (three at 50% capacity each), where the export gas	No	Accepted	N/A	N/A

Comment	Date	Stakeholder	Comment	Response	EIA Edit?	EPA Response	Consultant Response	Page Numbers with EIA Edit
				compressor and injection gas compressor would be driven by a common mechanical drive. The 3 x 50% design was selected so that when one train is down, the other trains could continue to operate until the installed spared compressor train is online. This three-train configuration was selected to enhance the facility's safety, minimize flaring, and reduce production down time.				
436	11-Nov-2021	Public	But what about cumulative effects? Fish, mammals, and birds will be affected by all the bilge and waste water and other toxic discharges into the sea water around these multiple floating oil rigs.	As indicated in Table 10.5-3 of the EIA, changes in water quality and temperature would be expected from liquid effluent discharges from other EEPGL development projects. Section 4 of the Water Quality Modeling Report, Appendix C of the EIA, presents the results of modeling discharges from the four EEPGL development projects, including the Yellowtail Project. None of the modeled plumes showed potential for overlap during simultaneous FPSO operations, and the individual produced water plumes experience rapid dilution and mixing. Embedded controls and mitigation measures proposed for the Project are considered to be sufficient to address potential cumulative impacts to marine water quality. Based on these results, cumulative effects of degraded water quality on marine wildlife were given a low priority ranking.	No	Accepted	N/A	N/A
437	11-Nov-2021	Public	Are Guyana taxpayers subsidizing landfills for a company that pays no taxes?	Any tax-related agreements between the Stabroek Block co-venture partners and the Government of Guyana are beyond the scope of the EIA and should be referred to the Government of Guyana	No	Accepted	N/A	N/A
438	11-Nov-2021	Public	Where are the preventative measures described for oil spills?	A list of embedded controls associated with oil spill preparedness and response, many of which include preventative measures, is provided in the Oil Spill Response Plan. The Oil Spill Response Plan is included in Volume III of the EIA.	No	Accepted	N/A	N/A
439	11-Nov-2021	Public	What is a "legitimate cost" regarding insurance?	The cost of insurance is determined by the insurance company. For more information on insurance, please see the response to Comment #163. For more information regarding a claims process, please see the response to Comment #44.	No	Accepted	N/A	N/A
440	11-Nov-2021	Public	Do the consultants have details about the quantities and how they're flowing?	The Yellowtail FPSO key design rates are described in Table 2.7-1: FPSO Key Design Rates. Production streams' flows are shown on the production flow diagrams included in Chapter 2 of EIA Volume 1.	No	Accepted	N/A	N/A
441	11-Nov-2021	Public	This EIA must be shared with other Caribbean countries. This is not only about the impacts to Guyana. One of the models shows the oil will sweep along the northern coasts of Trinidad, up to the Dominican Republic, and to many other countries. The EIA is very long and it needs to have enough time to be addressed by other countries. Let the governments communicate about it.	Please see the response to Comment #235.	No	Accepted	N/A	N/A
442	11-Nov-2021	Public	When you speak about insurance, I want to see trans regional insurance to cover for the tourism sector. We have 50,000 dependents. I also	Please see the response to Comment #163.	No	Accepted	N/A	N/A

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			want an insurance that covers for biodiversity loss. What is the long term bond or the emergency response capacity and who bares the costs for events after the well has been decommissioned? Cradle to grave					
443	11-Nov-2021	Public	The Guyanese should be receiving royalties from this project. We risk our ecosystems, health, heritage, etc.	The Consultants acknowledge the comment. The comment is beyond the scope of the EIA and should be referred to the Government of Guyana.		Accepted	N/A	N/A
444	11-Nov-2021	Public	What are legitimate costs? That is an ambiguous term. Does it include the tens of thousands of fishermen, tourist industries in other countries, etc.?	EEGPL would implement claims and livelihood remediation processes in the unlikely event of an oil spill causing losses to stakeholders. In addition, EEPGL has in place a transparent, accessible, and consistent Community Grievance Mechanism that would apply to Yellowtail, both prior to the onset of Project activities and throughout its life cycle. Please see the responses to Comment #44 and Comment #303 for additional information.	No	Accepted	N/A	N/A
445	11-Nov-2021	Public	What is the process of the consultations?	Please see the response to Comment #326.	No	Accepted	N/A	N/A
446	11-Nov-2021	Public	What is the methodology of arriving at your ranking of the risk assessment? I cannot see where the scientific rigor of the EIA is. The question of cost and benefits has not been addressed. There is not a robust description of costs, you only focus on the benefits. For every barrel of oil, what are we dealing with as the public? What are the toxins that are coming into our water, air, etc.?	Please see the responses to Comment #211, Comment #231, and Comment #325.	No	Accepted	N/A	N/A
447	11-Nov-2021	Public	The amount of ballast water on these ships? Where does the produced water go?	Regarding ballast water, please see response to Comment #70. Regarding produced water, the Yellowtail Development Project proposes to manage produced water via treatment and discharge overboard in accordance with good international oilfield practices.	No	Accepted	N/A	N/A
448	11-Nov-2021	Public	Will the region be fully covered if there is a spill?	With respect to insurance coverage in the event of a spill, please see the response to Comment #53. With respect to the areas of Guyana that could be affected (i.e.; “covered”) by oil coming ashore from a marine oil spill, stochastic modeling of the Most Credible Worst Case Discharge and Maximum Worst Case Discharge indicates a 5 to 40 percent probability of an unmitigated spill reaching the shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the shoreline in Region 2, depending on wind and current conditions at the time of the spill. These scenarios and probabilities are explained in further detail in Section 9.1.5.	No	Accepted	N/A	N/A
449	11-Nov-2021	Public	For the record: a baseline is something you collect before doing a project or activity that alters the conditions that you can come back	As described in the response in row #380, EEPGL continues to monitor the fishing sector from a socioeconomic perspective through its ongoing participatory fishing study. The most recent report is included in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, of the	No	Accepted	N/A	N/A

Comment	Date	Stakeholder	Comment	Response	EIA Edit?	EPA Response	Consultant Response	Page Numbers with EIA Edit
			to later on to see how things have changed. The fish studies were ecological, not socioecological studies. And that is not a baseline. The absence of the baseline absolves you of responsibility when there are issues later on.	EIA (Volume II), including a profile of landing sites, fishing areas, targeted species, seasonal considerations, and biometrics. Findings of the participatory fishing study will continue to inform EEPGL's engagement and adaptive management activities. As described in the response in row #169, fish were described from a biological perspective in the Volume II, Appendix M, Nearshore and Offshore Fisheries Study Summary. Both of these studies were initiated before the first offshore development project (Liza Phase 1) became operational, and although subsequent work on both studies continued after production operations began and an additional year of the participatory study is currently being conducted, the data provided in the existing study reports provide ample baseline data to support the Yellowtail EIA.				

Table 2: Final Matrix of Compiled Comments and Responses—Yellowtail Development Project (25 February 2022)

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
1.	EIA Scope and Context	The EIA is very comprehensive and contains a significant amount of support detail, but it lacks conclusive summaries of key commitments and management actions for key environmental and social risks	Tables 13.1 and 13.2 provide comprehensive lists of commitments that have been incorporated in the Project design as embedded controls, and mitigation measures that have been suggested by the Consultant, respectively. Tables 3.1-1, 3.1-2, 3.2-1, 3.2-2, 3.2-3, and 3.2-4 of the Environmental and Socioeconomic Management Plan (ESMP) together provide additional details regarding the planned implementation of these measures. However, recognizing that there are additional Project commitments within other portions of the EIA that would reduce/mitigate environmental or socioeconomic impacts, the Consultants have created a combined commitments register, which has been added to the EIA as Appendix V.	Response noted. Please see attached Project commitments register Volume 3 Appendix J for format and guidance.	The Commitment Register in Appendix V has been organized using the example provided as a guide.	Appendix V (new)
2.	Adequacy of Impact Assessment Process	The assessment of project impacts follows standard practice, however only four criteria were considered in the assessment of project impacts - geographical extent, intensity, frequency, and duration. Consideration of uncertainty and reversibility as impact criteria is good EIA practice and should have been incorporated into the impact assessment and prediction process. Similarly, the mitigation hierarchy was presented in the EIA but only to the extent of mitigation to reduce impact severity. Consideration of compensation and offsets beyond mitigation efforts was not presented in the EIA and leaves the impression that all impacts can be adequately mitigated by embedded controls and prescribed mitigation measures.	The Consultants believe that the criteria that were rated individually for each potential impact (i.e., geographical extent, intensity, frequency, and duration) were sufficient for the purpose of assigning significance ratings. That said, the Consultants acknowledge that uncertainty and reversibility are relevant factors in an impact assessment. While the process employed did not include individual ratings for these factors, the concepts of uncertainty and reversibility were incorporated into the impact assessment process. For example, the resource-specific definitions used for impact intensity and resource/receptor sensitivity typically include components related to the degree to which a resource/receptor is expected to be able to recover from a particular impact (i.e., effecting the same endpoint as a reversibility rating). With respect to uncertainty, the general approach taken in the EIA is to conservatively assume that a specific planned Project activity will result in an associated impact, and then to assess the significance on that basis. Acknowledging there will always be some level of uncertainty as to the response of a resource to an impact, the Consultants applied professional judgment to assess the response that could reasonably be expected to occur.	Closed	N/A	N/A

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		Residual impacts need to be more fully addressed in the EIA. A strategy for managing these residual impacts, including compensatory and offset mitigation efforts to achieve net gain. This will be particularly important when considering impacts to important biodiversity components.				
3.	Air Quality	Air quality and climate impacts are not considered for local Guyana or project related activities. The air quality impact assessment was limited to consideration of potential onshore community receptors.	The EIA does assess the impacts of Project-related activities on air quality in Guyana. These impacts were assessed at the coastline rather than "locally" – i.e., at the Project itself – because the receptor of air quality impacts (the general public) is located on land rather than on the open ocean over 200 kilometers offshore, where the Project will be located. Although the EIA did not assign a magnitude rating to climate impacts as is done for other resources assessed in the EIA, it did assess the significance of impacts on climate. The significance of impacts on climate as rated in the EIA is based on consideration of Project GHG emissions with respect to Guyana's GHG emissions, in addition to considering regional and global increases in GHG emissions.	Closed	N/A	N/A
4.	Waste Management	Waste management risks regarding current and future onshore waste capacity and treatment options are not adequately discussed in the EIA. The Comprehensive Waste Management Plan (CWMP) is not fully developed.	Since the initial draft of the EIA was submitted, the Comprehensive Waste Management Plan (CWMP) has been completed and approved by the EPA. The current version of the EIA has been edited to reflect this current status. Between the Cradle-to-Grave Waste Analysis (referenced in the CWMP) conducted by EEPGL, the other parts of the CWMP, and the discussion of potential impacts to waste management infrastructure capacity in the EIA, the Consultants believe that potential risks regarding waste management capacity in Guyana have been adequately identified. The EIA concludes that the currently available landfill capacity appears sufficient for the short-term (2 to 3 years), even considering forecasted growth in waste volumes from industrial use and, presuming the additional HBL cell(s) would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years). Recognizing the fact that these conclusions are dependent on these presumptions, the EIA provides mitigation measures for waste management infrastructure capacity within both Chapter 8 and Chapter 10 (Cumulative Impact Assessment).	Closed	N/A	pp. 2-79, 8-165, 8-166

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
5.	Drill Cuttings	The EIA does not present a robust alternative analysis concerning the disposal of drill cuttings on shore and defaults to the argument that only discharge to sea is viable. The limits used to assess the disposal of cuttings in the EIA should be re-evaluated. Limits for Total Suspended Solids (TSS) used to interpret the modeling should be based on the recent literature and/or deviation from baseline conditions. The assessment of alternatives for disposal of drill cuttings should follow a holistic approach considering feasibility, cost, health, and safety as well as environmental and social issues. This assessment should be quantitative or semi quantitative. The option to dispose of cuttings to shore is also not assessed in detail and there is no economic appraisal of the disposal options.	The Consultants acknowledge that the EIA does not include details of a multi-factor analysis demonstrating the pros/cons of onshore vs offshore drill cuttings management. The alternatives analysis provides a summary conclusion that while transport to land may limit the impact offshore, transportation, emissions from transportation, treatment, and disposal onshore have an impact on the environment and require infrastructure for transportation, handling, and treatment of the cuttings. That said, the Consultants' opinion is that treatment of drill cuttings to an international performance criterion followed by offshore discharge is consistent with global drilling practices in other jurisdictions, and the EIA therefore focused on alternatives for achieving this criterion. With respect to the TSS threshold selected for the EIA, the Consultants believe this is a valid threshold based on scientific studies. Modeling predicts that TSS concentrations above this threshold will occur mostly during drilling of the initial well sections, and these instances are confined to within a localized area around the well locations, near the seafloor. In the case of bottom-hole well sections involving overboard cuttings discharges, only slight exceedances above the threshold are predicted to occur near the surface, also over a very localized area. Further, modeling indicates TSS concentrations will be reduced to below the threshold through settling and dispersion within approximately 12 hours of cessation of drilling for top-hole well sections and within approximately 2 hours of cessation of drilling for bottom-hole well sections. The Consultants are not aware of alternative thresholds that are substantially lower than the one used in the EIA. On this basis, it is expected that use of an alternative threshold would not change the conclusions of the EIA with respect to this potential impact.	Closed	N/A	N/A
6.	Discharge Standards	While reference is made to numerous discharge standards for project emissions, no single source of reference standard is presented in the EIA. Rather than set specific standards, where none currently exist, and also in light of the time requirements to do so, it is recommended that Project adopt a risk-based approach to defining project standards in the	In the absence of a single source of standards for all Project emissions and discharges, the Consultants identified several internationally used environmental and socioeconomic performance criteria (see Table 2.4-1 in the Environmental and Socioeconomic Management Plan). The Consultants believe these are appropriate criteria to apply to the Project. The Consultants acknowledge that the referenced MARPOL standard dates from 2006, but these requirements are still in effect and widely used by the marine industry.	Closed	N/A	N/A

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		context of the local baseline environmental and social sensitivity. These should be benchmarked against contemporary best practice standards for specific oil and gas operating regions, with an emphasis on examples from Central and South America. Some standards are clearly outdated - e.g., use of MARPOL applied to total suspended solids standards on drill cuttings.				
7.	Baseline Data	Lack of adequate and multiyear baseline data is a common problem in EIA and the Yellowtail Development project EIA is no different in this regard. While multiple studies have been conducted as part of previous project level EIAs (Liza and Payara) and the studies cited in the EIA provide general data on the broader area of influence, further surveys specific to the Yellowtail Project development footprint should be undertaken where potential impacts have been identified, or where there are uncertainties in data availability or impact prediction. Such studies will provide an explicit current and future baseline against which further changes in environmental parameters can be identified. The focus of these studies should be on parameters that will be directly affected by the	The physical and biological baselines in the EIA are supported by multiple (EEPGL-sponsored) studies that have been conducted within the last several years (e.g., multiple EBS studies, Ambient Air Quality Studies, Protected Species Observer Surveys, Marine and Coastal Bird Studies, Enhanced Coastal Sensitivity Mapping, and Nearshore and Offshore Fisheries Studies). The Consultants have addressed similar concerns about the baseline data in previous comments on the EIA, and at the EPA's request, the Consultants have added text to the EIA describing why the prior studies are representative and appropriate for inclusion in the EIA, and adequate to describe the environmental conditions that currently exist in the Project AOI. The environmental monitoring measures included in the ESMP are intended to track environmental conditions as they change over time. Data provided from the monitoring program will indicate the effectiveness of the management measures and changes in ambient conditions over time.	Closed	N/A	N/A

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		development, or are at high risk (e.g., special status species).				
8.	Good International Oil Field Practice	Throughout the EIA, the use of the term, good international oilfield practice, is made extensively. This term is misleading in that there are no specific standards or practices listed in the EIA nor are there reference examples to back it up or define the context to which it is applied. This term typically represents a compilation of multiple standards without specific reference to best available technology (BAT), best available control technology (BACT) or specific jurisdictional reference and supporting examples. Where good practices are cited, they should reference the jurisdiction or context and a justification as to why they have been used.	The term good international oilfield practice is typically used in the EIA in cases where the Project is not applying a specific regulation, standard, or guideline, or is characterizing the Project's approach as a general matter where the context does not call for discussion of specific applicable standards. Where appropriate, the EIA identifies the specific regulation, standard, or guideline applied by the Project. The term good international oilfield practice means petroleum industry practices generally accepted in the global petroleum industry that are considered prudent, safe, and efficient in conducting petroleum production operations, including those necessary and appropriate to minimize impacts to the environment. EEPGL's design draws on ExxonMobil affiliates' many decades of experience developing and producing oil and gas resources, as well as global industry experience. Application of good international oilfield practices is consistent with Regulation 6 of the Petroleum (Exploration and Production) Regulations 1986, the Petroleum Production License granted for e.g. the Payara Project, and is required by Article 28 (Social Responsibility and Protection of the Environment) of the Stabroek Block Petroleum Agreement. In response to the comment, the Consultants have reviewed the instances in the EIA where the term good international oilfield practice is used, and have added reference to a related jurisdiction or source, where applicable. With respect to BAT, the EIA contains a discussion of this topic in Section 2.18.3.	Where the EIA uses the term "good international oilfield practice," evaluate its usage and, where possible, replace or cross-reference the term with a more specific standard or term. Consultant's proposal also accepted.	The Consultants have evaluated every instance where the term "good international oilfield practice" is used. In cases where the term is used as general reference to a specific standard, the Consultant team has added a reference to the source document for that standard.	EIS-22, EIS-23, 1-5, 2-15, 2-18, 2-20, 2-25, 2-69, 2-77, 2-94, 2-103, 2-143, 2-146, 2-131, 2-136, 2-150, 6-45, 6-79, 6-81, 6-106, 6-115, 10-7
9.	Analysis of Alternatives	The analysis of alternatives presented in the EIA is not robust and is structured to justify the project rather than adequately discuss all possible alternatives that could be considered in the project. A number of alternatives were rejected at the start rather than subject to detailed assessment, particularly relating to cutting and produced water disposal.	The requirements of the Guyana Environmental Protection Act are that the EIA outlines the main alternatives studied by the developer and an indication of the main reasons for the developer's choice, taking into account environmental factors. To this end, the purpose of the EIA was not to present the details of the alternatives analysis performed by EEPGL, but instead to summarize the alternatives considered and present the principal reasons that drove the selected alternative. Please see above regarding drill cuttings disposal alternatives. With respect to produced water management alternatives, comprehensive studies were completed as part of the Payara Production License including a Produced Water Reinjection Study. This study has informed the design of the Yellowtail Project. As an	Revise and strengthen the analysis of alternatives in keeping with Section 5.4 (page 21) of the ToR, which doesn't ask for a summary but a detailed analysis. Including detailed reasoning for the selection of the proposed project compared to other options. The analysis should be specific to Yellowtail and not previous projects. In reference to PW the analysis should focus on the data for Yellowtail rather than Payara/previous projects.	The Consultants believe that the discussion of alternatives for drill cuttings and produced water management alternatives provides sufficient information to support the EIA, with respect to a description of the key alternatives for these aspects of the Project, and the reasoning for selection of the preferred alternatives. Based on the Consultants' experience, and the fact that the same management alternatives have been selected for the previously permitted projects, it is unlikely that the requested assessment would change the conclusions of the Yellowtail EIA. That said, if the EPA requires additional information on these topics, the Consultants recommend that EEPGL conduct such assessments when the necessary data become available.At the current	N/A

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		The assessment of alternatives should follow a holistic approach considering feasibility, cost, health, and safety as well as environmental and social issues. This assessment should be quantitative or semi quantitative in nature. The project should adopt a risk-based approach to impact assessment, and if economic feasibility is claimed as an important decision-making factor, then it needs to be supported by economic data and analysis.	example, the Produced Water Reinjection Study assessed global experience in produced water reinjection, environmental impacts of reinjection compared to treated water discharge overboard, reservoir and facility implications of reinjection, and lifecycle costs. As a component of the Payara Produced Water Reinjection Study, a produced water discharge environmental risk assessment was completed based on predicted concentrations of constituents and compounds in the treated produced water to be discharged from the Payara FPSO. The results of the risk assessment indicate that risk to marine organisms from exposure to the produced water discharge from the FPSO is low. Based on this study's conclusions, treatment and overboard discharge of produced water to international standards is proposed for Yellowtail.		Project stage, the technical data required to conduct the requested quantitative or semi-quantitative Yellowtail-specific drill cuttings or produced water management studies are not available. In the unlikely event the assessment identifies different alternatives with significant environmental and socioeconomic benefits over the selected alternatives, EEPGL and the EPA could then discuss these alternatives with respect to application for the Project and other similar EEPGL activities in Guyana.	
10.	Environmental and Social Management Plans	The level of detail of environmental and social management plans presented in the EIA is poor and more could be expected at this level of project development and engineering. Provision should be made for the subsequent development of specific detailed management plans as a license condition – e.g., a) sediments, b) light, noise and vibration c) biodiversity (specific species) d) fisheries management e) OHS f) fuel and chemical g) drilling waste (need more specific) h) construction management h) GHG management i) monitoring and follow-up plan (note this is a preliminary list and should be further discussed and developed.	The ESMP is intended to be an "evergreen document" and will be updated as appropriate prior to initiation of activities that could have impacts on environmental or socioeconomic receptors and periodically thereafter.	Closed	N/A	N/A
11.	Monitoring and Compliance Framework	The EIA as presented does not include a comprehensive monitoring and follow up framework for a) assessing the credibility	It is the Consultants' position that the scope of monitoring recommended in the ESMP is commensurate with the impacts predicted in the EIA. The ESMP provides the framework for monitoring environmental and socioeconomic conditions going forward, and comparing the data to the baseline data	Closed	N/A	N/A

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		of impact predictions b) assessing the effectiveness of mitigation measures and c) expanding the environmental and social baseline condition and assessing the impacts of project activities on important environmental and social components. develop a comprehensive monitoring and follow-up mechanism to assess mitigation effectiveness and to address gaps in baseline data. This should include specification of key performance indicators and fixing the frequency of reporting for non-compliance.	in the EIA will be critical to assessing the ways and extent to which environmental and socioeconomic conditions change over time, but the ESMP is not intended to establish future baselines. As such, comparison of data provided from the monitoring program with the baseline data provided for receptors of concern in Chapters 6, 7, and 8, as well as the technical appendices in Volume II of the EIA, will be vital to assessing the effectiveness of the management measures recommended in the EIA. As described in the response to RG-7, these data will also indicate the effectiveness of the management measures and changes in ambient conditions over time.			
12.	Oil Spill Risk and Response Plan	Oil spill risks as presented in the EIA focus on spill trajectory and potential consequence and do not quantitatively assess the likelihood of occurrence. This gives an incomplete and partially subjective assessment of the overall oil spill risk. Unplanned events should leverage quantitative data from publicly available sources such as IOGP and, were available detailed risk assessments, QRAs, HAZIDs etc.	While the unplanned event risk assessment in the EIA does not include a quantitative analysis of the expected frequency at which an unplanned event would be expected to occur, the oil spill modeling includes a quantitative analysis of the likelihood that a particular location would be impacted in the event of a loss-of-well-control event. Consistent with the typical approach taken for assessment of unplanned events, a risk assessment approach was taken in order to incorporate the aspect of likelihood (i.e., to distinguish from assessment of an event which is planned or practically certain to occur). Likelihood was estimated on the basis of experience and/or evidence that such an outcome has previously occurred. The consequence/severity element of the risk rating was assigned based on the sensitivity of the resource/receptor and the magnitude of the impact – assuming the event occurs (however unlikely). Accordingly, there are a number of resources for which the consequence/ severity of an oil spill would be high, and many of the resources have therefore been assigned the highest consequence/severity rating. That said, the likelihood of an oil spill of sufficient magnitude to produce this type of consequence is very low and it is therefore appropriate to assign a likelihood rating of Unlikely – even if this is assigned qualitatively. It is further noted	Closed	N/A	N/A

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			that the measures proposed by EEPGL to prevent and respond to an oil spill represent good international industry practice, and different/additional measures would not be proposed even if the likelihood factor were quantified in terms of a numerical probability. However, in response to the comment, the next revision of the OSRP (which will be prepared after the final Yellowtail EIA and submitted to the EPA separately from the Yellowtail Development Project EIA) will include an assessment of the frequency of oil spill scenarios, based on global experience in the industry.			
13.	Marine Traffic Risk	management approach is taken to mitigate potential collision impacts which are estimated as unlikely. Risks to marine traffic in the port area and vicinity are not clearly addressed particularly for those smaller vessels that are much more vulnerable to collisions and lacking radar or collision avoidance systems. It is also not clear that a HAZID or risk assessment of potential vessel collision with the FPSO has been done. A more detailed HAZID assessment of marine traffic risk from the port to the FPSO and the potential for collision with the FPSO should be more fully evaluated.	The Consultants acknowledge that a quantitative analysis (i.e., including determination of the statistical probability of a vessel collision) has not been conducted as part of the assessment of the potential unplanned event of a Project vessel collision with a third-party vessel. However, quantitative data have been collected to characterize the increase in existing marine traffic in Georgetown Harbour that would be expected as a result of the Project (i.e., on the order of 2 to 4 percent). Accordingly, it is reasonable to expect that a more detailed statistical probability determination would not yield data that would change the measures recommended to prevent or reduce the consequence of such a collision. With respect to a collision of a vessel with the FPSO, Chapter 9 of the EIA provides the basis by which quantitative modeling of spills from a collision between the FPSO and an offloading tanker or the FPSO and another third-party vessel are not considered reasonably foreseeable. That said, from an environmental perspective, the impact of collision resulting in a breach of the FPSO's crude oil storage tanks would be covered – in terms of potential quantity of oil released – by the modeling conducted for the Worst Case Discharge events described in Chapter 9. However, in response to the comment, the Consultants have updated the EIA with additional information from MARAD's process for managing these types of risk, to provide further context for the risk assessment process that will be undertaken in relation to the Yellowtail FPSO.	Closed	N/A	N/A
14.	Public Consultation and Engagement	The level of public consultation and engagement undertaken in the EIA is not adequate for a project of this scale and complexity, regardless of whether it is located far offshore. The scope, extent and	EEPGL's and its consultants' engagement with various stakeholders communities is described in the SEP (EIA Volume III). The SEP details the diverse range of stakeholders engaged, including vulnerable and underrepresented groups, and the multiple years of engagement that have taken place by EEPGL and its consultants.	The record of consultation as presented in the EIA should meet requirements stated in the Terms and Scope as follows (p. 24): These records shall also contain details on the manner in which the public was notified, the groups targeted, a description of the stakeholder consultation process, a list of all	Detailed records of consultation made during the development of the EIA have been provided in Appendix W of the EIA. Together with the stakeholder consultation process and summaries provided in Chapter 4 and the attached SEP and SEP Attachment A, these records include the manner in which the public was notified, the groups targeted, a description of the stakeholder consultation process, listing of all stakeholder	Appendix W (new)

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		frequency of consultation should be extended in a wider and more inclusive approach geographically and include a broader consideration of potential onshore effects. Stakeholder mapping should be fulsome and geographically demonstrated with evidence of proof, as required. Once developed, the Stakeholder Engagement Plan should systematically allow for engagement records for all interactions with stakeholders to be documented. Stakeholder feedback must be fully integrated into EIA documents by demonstrating session reports in an Appendix rather than only providing a roll-up of findings in a table format in the EIA.	Engagement occurred during EIA scoping, development, and disclosure phases, and broad consideration was given to potential concerns and impacts of the Project both on and offshore. The Consultants facilitated in-person meetings in all six coastal regions (including indigenous communities in Region 1) as well as broadly accessible virtual meetings in light of the Covid-19 pandemic, including non-technical presentations of the Project and EIA process/results, and question-and-answer sessions. EEPGL is committed to continuing to provide stakeholders with regular access to information about the activities as well as access to feedback mechanisms through which stakeholders may provide input and receive response to feedback. To date, in addition to active updates and information sharing on social media and traditional media channels, this has included, but is not limited to, oil spill management training in Regions 1 and 6, waste management training, capacity-building efforts and training, supplier forums, offshore oil and gas seminars through the CLBD, and community outreach events (e.g., job fairs, schools, informational booths) in Regions 1, 2, 3, 4, 5, 6, 9, and 10. Chapter 4 of the EIA provides a summary of stakeholder concerns and comments received in relation to the Yellowtail Project, and how comments have been addressed. EEPGL's engagement with affected communities is also described in the SEP, which includes a publicly disclosed summary of concerns and comments received during engagements. Furthermore, ongoing engagements and resulting actions are tracked by EEPGL.	stakeholder groups included in the process, the number of meetings held, location of the meetings, dates held, minutes of all meetings, a copy of the survey questionnaires used (if any), and the results of surveys. Records presented should detailed and thorough and attributed to each consultation session. These records can be presented in such a way where privacy concerns can be respected. Particular attention should be paid towards presenting the full minutes of all meetings rather than in a roll-up summary.	groups included in the process, the number of meetings held, location of the meetings, dates held, and minutes of all meetings. Personal information including specific names of participants have been withheld to respect the privacy of those involved. No surveys were performed.	
15.	Grievance Mechanism	A more detailed grievance mechanism as to how compensation of damages or impacts should be assessed and mitigated is required. The grievance mechanism should be developed following a World Bank approach, one that is practical, inclusive, and accessible for all project affected stakeholders and that it is shared in appropriate manner and used effectively. It should allow for anonymous complaints, provide a	EEPGL's Community Grievance Mechanism (CGM) is an integral part of the Company's stakeholder engagement program, and is aligned with international guidance including the World Bank. The CGM is referenced in Section 3.3.2 of EEPGL's Stakeholder Engagement Plan for Guyana Operations (included in Volume III of the Yellowtail EIA), and Project-specific detail is provided in the ESMP (also included in Volume II of the Yellowtail EIA). Grievances are evaluated in accordance with the 5-step grievance management procedure including investigation, resolution, and response. Compensation for damages or impacts may be considered as part of this process, and would be considered on a case-by-case basis with the involvement of affected parties.	Closed	N/A	N/A

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		multi-level dispute resolution mechanism and provision of compensation for damages and project related impacts.	An important element of any grievance mechanism is to incorporate local input into the nature and design of the mechanism. Accordingly, EEPGL's CGM has evolved over recent years, as it has been publicly disclosed and subject to comments for the Yellowtail EIA and earlier EIAs (Payara, Liza Phase 2, and Liza Phase 1), and has been iteratively updated to reflect this input. Grievances are tracked via EEPGL's internal ESMS and compliance systems to ensure follow-up. Anonymous submissions are allowed and the process to address them is described in the CGM. As described in the CGM, potential grievances can be communicated to EEPGL through various means of communication, including phone, email, and in-person. The CGM applies to communications that occur directly with EEPGL, as well as via contractors or government agencies. EEPGL also tracks concerns and issues that are raised through Facebook and other social media outlets, so that relevant issues can be registered and addressed via the CGM.			
16.	Applicable Project Regulatory Standards	The EIA and Supporting Management Plans contain numerous sections referencing legislative and regulatory frameworks. While in some cases this formatting is consistent with that requested in the Final Terms and Scope for the Conduct of the Environmental Impact Assessment, there is not one aggregate accumulation of all of the legal references and commitments made in the report (see above). This should be included as a separate section or Appendix. The description of the legislative and regulatory framework in Chapter 3 is very brief and may not be complete. The legislative references in Chapters 6-	Chapter 3 reviews the laws and regulations in Guyana that are relevant to the assessment of potential environmental and social impacts arising from the Project. Additionally, Chapters 6, 7, and 8 include sections that summarize the legislation, policies, or treaties that are related to the subject covered by the specific section. However, in response to the comment, the legislation, policies, and treaties information in Chapters 6, 7, and 8 has been added to Chapter 3, so that all administrative framework information can be reviewed in one place in the EIA.	Include information from administrative framework tables in Chapters 6-8 and 11 in Chapter 3	The legislation, policies, or treaty commitments from Chapters 6 through 8 have been compiled and added to Chapter 3 in Table 3-1.	pp. 3-10 to 3-22

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		8, 11 and the Management Plans could be more detailed.				
17.	Onshore Impacts	As in many EIAs of offshore oil and gas projects, the potential impacts onshore are not fully assessed and justification is often given that due to its distance from shore, offshore oil and gas projects will not have onshore impacts. This is far from the case as shore-based activities are required to support offshore oil and gas development and the extent and frequency of these activities is only expected to increase in future with the expansion of EEPGL activities and the arrival of other offshore players. This is further compounded when assessing the cumulative impacts of a range of onshore development projects and activities independently. A further assessment of onshore impacts should be considered as an addendum to the EIA. Onshore impacts associated with supply bases and logistics routes should also be more fully addressed as part of this effort. There should also be a greater effort taken to assess onshore socio-economic and livelihood impacts and their mitigation and management and dedication of specific sections within the EIA.	The distance of the Project activities from the coast is only factored into impact ratings when the distance acts as a control on the mechanism of impact. This occurs in cases where the specific Project activity that would generate the impact would only occur offshore, and the distance between activity and receptor effectively eliminates the potential impact pathway (e.g., impacts on ecosystem services provided by mangroves). It can also occur where an impact mechanism exists despite the distance, but the distance between activity and receptor implies a degree of dilution, dissipation, or assimilation that significantly affects impact magnitude at the receptor's location (e.g., air quality impacts on human health). The Consultants recognize that although the Project is fundamentally an offshore project, there will be impacts on shore-based receptors, and the EIA reflects this. Most of the shore-based receptors that would be affected are socioeconomic, which is why all of the socioeconomic receptor discussions in Chapter 8 rate at least one impact (and many rate several impacts) that will occur onshore. Additionally, under the Environmental Protection Act, permitting of third-party onshore support facilities, including shorebases and waste management facilities, is a separate process from the Yellowtail EIA and authorization process.	Impacts of third-party facilities outside of Yellowtail Project Development needs to be addressed in the EIA.	As indicated by a map in Chapter 5, Scope of the Environmental Impact Assessment, the Direct Area of Influence within which impacts were assessed includes the marine/aviation transit corridor between the FPSO and the Guyana shorebases that will be used by the Project. Chapter 10, Cumulative Impact Assessment, discusses potential cumulative impacts on several resources from the anticipated cumulative marine vessel movements. The Consultants did not include a more detailed evaluation of onshore impacts from third-party owned onshore facilities for the following reasons: 1) The Yellowtail Project does not have a dedicated onshore shorebase and would utilize existing and separately approved onshore shorebases. Under the Environmental Protection Act, permitting of such facilities has been conducted by the EPA under separate evaluation processes. 2) The onshore shorebases planned to be utilized by the Project are existing facilities and their impacts onshore are already factored in to the baseline for the Yellowtail Development Project EIA. If the EPA requires an analysis of the impacts from third-party facilities, the Consultants recommend that the EPA and EEPGL conduct a separate study to assess the overall environmental and socioeconomic impacts from these facilities. In order to support such a study, the following information would need to be obtained: • Project summaries submitted to the EPA in support of Applications for Environmental Authorisation for these facilities; • Supporting analyses submitted as part of these Applications (e.g., EIA, EMP, EA&MP, etc.); • Recent compliance or monitoring reports submitted to the EPA by operators of these facilities; and • Any relevant supplemental environmental performance information submitted to the EPA for these facilities.	N/A

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18.	Produced Water	The assessment of options for disposal of produced water claims in part an economic justification but no economic analysis is provided. It is also mentioned that discharge to sea is consistent with Good Industry Oil Field Practice but data from the International Association of Oil and Gas Producers (IOGP) indicates that 56% of produced water is re-injected (although it is not indicated whether this is offshore or onshore). The discharge limit for oil in water is 29 mg/L (Monthly Average 42 mg/L (daily Maximum). This is high relation to OGP average data for offshore of 20 mg/L (2019)[i].	With respect to produced water management alternatives and the consideration of economic factors, comprehensive studies were completed as part of the Payara Production License and Environmental Permit, including a Produced Water Reinjection Study. This study has informed the design of the Yellowtail Project. The Produced Water Reinjection Study assessed global experience in produced water reinjection, environmental impacts of reinjection compared to treated water discharge overboard, reservoir and facility implications of reinjection, and lifecycle costs. With respect to oil-in-water concentrations in discharges, EEPGL is committed to operating in compliance with the prescribed limits while striving for continuous improvement. For example, Destiny's average daily oil-in-water content in produced water discharge in 2021 was consistently below the oil-in-water limit. While EEPGL is operating well below the limits established by international standards and adopted by the Project, use of these standards provides some level of operational flexibility in case of unforeseen equipment upsets.	A commitment to use a risk-based approach to produced water discharge standards must be included in the EIA.	An additional mitigation measure recommending completion of FPSO effluent discharges characterization and environmental risk assessment has been added to Chapters 6, 7, and 13, and Appendix V.	pp. 6-119, 6-120, 7-99, 7-131, 7-179, 7-223, 7-273, 7-287, 13-13, App V p. V-5
19.	Transboundary and Cumulative Impacts	The scope of planned transboundary impacts is restricted to the Guyana EEZ. Impact of transboundary spill (estimated to be Trinidad and Tobago, Venezuela, Aruba, Bonaire, Curaçao, Barbados, St. Lucia, Grenada, St. Vincent and the Grenadines, the Dominican Republic, Haiti, and Jamaica) is estimated as Unlikely. Spill from loss of well control event would affect three regions a) Trinidad/Tobago, northern south American coast, and ABC b) southern lesser Antilles islands and southwestern Greater Antilles. The extent of the spill extent depends on the season.	The Consultants agree with the reviewers' summary of the EIA's findings with respect to transboundary impacts. Section 10.7 of the EIA recommends a three-tiered framework for managing cumulative impacts. The first tier focuses on managing the Project's contribution to cumulative impacts. The second tier focuses on managing contributions to cumulative impacts at the company level, across all of EEPGL's activities. The third level focuses on managing cumulative impacts at the regional level, through working groups and/or industry organizations. The second and third tiers of the management framework are not as detailed as the first tier in terms of specific measures and implementation plans, because the EIA is focused on activities that are part of the Yellowtail Project, and the scope of the EIA does not include development of detailed management plans for other projects or other proponents' activities, because EEPGL does not have influence over the impacts management at the projects operated by others. Nevertheless, Section 10.7 of the EIA identifies the resources that could benefit from management of cumulative impacts and	Closed	N/A	

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		Cumulative impacts are described but largely restricted to existing EEPGL project development plans. No detailed framework is presented as to how cumulative impacts should be managed. Temporal boundaries are not adequately assessed into the future.	the types of activities that could lead to these impacts at a company-wide level. As described in Section 10.3.4 of the EIA, the temporal boundary of the cumulative impacts assessment is different for EEPGL and non-EEPGL projects, and reflects the differences in certainty concerning future EEPGL projects as compared to non-EEPGL projects.			
20.	Fisheries: Data and Potential Impacts	The EIA notes that fish catches declined in the two years studied by EEPGL and this was noted during public consultations. The EIA states that more data is needed to scientifically establish whether fish abundance is declining and to identify potential causality. The EIA attributes the potential causes to interference with fishing activities by sargassum, inclement weather, unsustainable/illegal fishing practices, and more recently, COVID-19-related declines in fishing effort, rather than due to oil and gas activity. There is a lack of supporting evidence and a lack of public confidence in this conclusion.	The EIA acknowledges a sustained decline in fishery production since 2013. Although some stakeholders may question the potential causes for these declines identified in the EIA, the Consultants would emphasize that the potential causes cited in the EIA were identified by knowledgeable sources in Guyana, including the Bank of Guyana and fisherfolk participating in the Participatory Fishing Study. As indicated in previous responses to similar comments on the EIA, the timing of the initial declines in 2013 (two years before EEPGL's first oil exploration well was drilled in Guyana) strongly suggests that oil and gas activity did not drive the initial decline. Increases in certain fisheries since 2013 (e.g., growth in fish and shrimp outputs in 2016 and increases in fish catches in 2019) concurrent with increased oil and gas activity and the start of oil production (also in 2019), coupled with the Ministry of Agriculture's recent announcement that overall fish production increased by more than 10 percent last year, also suggest that oil and gas is not driving declines in fisheries production. In response to the comment, the EIA has been updated to include additional information regarding the ongoing Participatory Fishing Study.	Closed	N/A	
21.	Terminology	There are important discrepancies in language between the legislation/Terms and Scope for EIA and the actual EIA report with regards to terminology regarding the extent of environmental impacts. Of note - the legislation and Section 4 (g) of the Terms and Scope for EIA require that the EIA include a "description of	Please see response to RG-9 with respect to the alternatives analysis in the EIA. Tables 13.1 and 13.2 provide comprehensive lists of all commitments that have been incorporated in the Project design as embedded controls, and mitigation measures that have been suggested by the Consultants, respectively. Section 4.1 of the EIA describes the types of impacts assessed in the EIA, including a definition of the term "impact." This definition of "impact" incorporates by direct citation the term "adverse effects" as defined in the Environmental Protection Act. As indicated in Section 4.1 of the EIA, potential Project effects that	Closed	N/A	

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		the measures which the proposed developer intends to use to mitigate any adverse effects (defined term) and a statement of reasonable alternatives (if any) and reasons for their rejection." While the EIA does assess the risks of an extensive list of items to the environment, the EIA and Supporting Management Plans do not seem to tie their assessment, risk classification or conclusions back to the EPA term "adverse effects" which is a defined legislative term and is a term used in the Terms and Scope for EIA. In Chapter 4, section 4.1 Types of Potential Impacts, the EIA sets out the EPA's definition of "Adverse effects". The latter part of Chapter 4, being Section 4.8 proceeds to describe the classification system and terms used in the EIA to assess and categorize impacts. However, it does not appear that these classifications tie back to the legislative/TOR term "adverse effects". It would seem that this will make assessing the compliance of environmental impact assessments against the legislative requirement challenging. Note that Environmental Protection Act Section 4(1)(g) also charges the	met the legal definition of an "adverse effect," were considered "impacts" and were considered for scoping into the EIA. The terms used in the subsequent "assessment, risk classification, or conclusions" in later sections of the EIA and/or ESMP were not used to modify or constrain the meaning of the term "impact" as defined in Section 4.1 of the EIA. These terms were used to describe the attributes of specific impacts in a consistent fashion that allowed the significance of those impacts to be rated systematically. Section 4.1 has been updated to provide additional clarity on this topic.			

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		EPA with a responsibility to ensure that any development activity (defined term) which may cause an adverse effect (defined term) on the natural environment (defined term) be assessed before such activity is commenced and that such adverse effect be taken into account in deciding whether or not such activity should be authorized.				
22.	Defined Terms from the EIA	The EIA and Supporting Management Plans contain a variety of Defined Terms (Terms that are explained in their first occurrence and then identified as a defined term in their subsequent use in the documents through the use of Capital Letters or Abbreviations). While the EIA and Supporting Management Plans include a Glossary as requested in the Terms of Reference, there does not appear to be a Definitions Section which contains a listing of all Defined Terms (Term name and its definition) contained throughout the documents. Furthermore, the EIA includes instances where a term is defined but then not subsequently identified as having been defined through the use of Capital Letters. An example can be found on page 4-2 in Chapter 4: "For the purposes of the EIA, an impact is defined as any alteration of	The EIA uses acronyms throughout the document - which are capitalized, as well as defined terms - which are not acronyms and are not capitalized. The beginning of the document includes a list of acronyms along with a separate glossary that lists defined terms and their corresponding definitions. In response to the comment, the EIA glossary has been updated to include definitions of key terms from the Act that are used in the EIA.	Closed	N/A	

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		existing conditions (adverse or beneficial) caused directly or indirectly by the Project."				
23.	1.3 Goal and Objectives of the EIA (pg. 101)	Under Bullet 2 on Page 101, include after production, maintenance activities (inclusive of preventative maintenance, planned shutdown and unscheduled repairs) also. **Note:** With the addition of this major element the implications to the environment (including social aspects such as worker health and safety etc.) will also have to be assessed.	The EIA has been edited to include the requested additional text in the bullet that reads "Production operations, including offloading tankers." The Consultants have considered the scope of normal FPSO operations (inclusive of routine maintenance) in the assessment of potential impacts from the production stage of the Project. That said, the scope of the EIA excludes consideration of occupational health and safety aspects for workers. EEPGL addresses the safety, security, and health of its employees and contractors by employing a robust and effective management system to protect its Project workforce. EEPGL will implement its OIMS during each Project stage. This program is designed to manage occupational risks to Project workers.	Closed	N/A	
24.	2.1 Project Area	Page 115 Para. 2, Lines 1 and 2 - The exact locations of the Yellowtail development wells should be stated and made available in the form of longitude and latitude coordinates of each of the six (6) drilling center positions. For illustrative purposes, it would be useful to also make available within this section of the document the Proposed Drawings for the New Infrastructure Layout and Locations of the development wells with exact georeferenced positions for each of the elements to be installed on the seafloor. **Note:** For greater clarity reference Table 2-1 on Page 17, and Figures 2-3 and 2-4 on Pages 22 and 23 respectively of the Van Gogh Infill Development Phase II	The Consultants believe that the preliminary layout of the subsea infrastructure – inclusive of drill centers and wells, as well as other SURF infrastructure – presented in the EIA is sufficient for the purpose of informing the assessment of potential impacts associated with these Project features. Please note that the exact coordinates of development wells – when they are drilled - will be provided to the EPA as part of routine well completion reporting and are present in Field Development Plan Table 6-1.	Closed	N/A	

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		(VGID2) Installation Environmental Plan at https://docs.nopsema.gov.au/A772352				
25.	2.4.2 Applicable Codes, Standards and Management Systems	Page 123 - In the absence of local environmental guidelines which dictate how the Exploration and Production activities of the Oil and Gas Sector ought to be done, International Guidelines, Standards and Industry Practice will be applicable and should be included. All O&G Companies operational in Guyana will be expected to conform to the requirements contained within the following: a. World Bank EHS Guidelines (General and Industry Specific) o EHS Guidelines for Onshore Oil and Gas Development o EHS Guidelines for Offshore Oil and Gas Development o EHS Guidelines for Ports, Harbors and Terminals b. International Petroleum Industry Environmental Conservation Association (IPIECA) Guidelines International Association of Oil and Gas Producers (IOGP) Guidelines	The Consultants are not aware of a specific regulatory requirement for oil and gas projects to conform to the World Bank EHS Guidelines, IPIECA, or IOGP Guidelines. In the absence of a single source of standards for all Project emissions and discharges, the Consultants identified several internationally used environmental and socioeconomic performance criteria (see Table 2.4-1 in the Environmental and Socioeconomic Management Plan) The Terms and Scope identifies World Bank EHS Guidelines, IPIECA, or IOGP Guidelines as examples of "international standards and guidelines" to which the EIA must adhere in three specific areas: organization of the EIA, selection of the preferred alternative, and water quality. The World Bank EHS Guidelines for Offshore Oil and Gas Development are non-prescriptive in terms of EIA organization. They include specific numerical standards for certain effluent streams, most of which the Project has committed to achieving. The EHS guidelines allow alternative performance standards to be applied if they are shown to be protective of human health and the environment. The impact assessment in Chapter 6 of the EIA provides a robust analysis of impacts on human health and the environment for all anticipated effluent streams. The Oil Spill Response Plan in Volume III of the EIA incorporates the relevant IPIECA and IOGP guidelines by reference as appropriate. References to the additional "Good Practice" guides that were jointly developed by IPIECA, IOGP, and/or the American Petroleum Institute will be considered for the next revision of the OSRP.	Closed	N/A	
26.	2.5.3 Drilling Fluids and Handling Systems	In other more progressive jurisdictions such as within the Mediterranean Region operators are	EEPGL provides a drilling and completion fluid additive inventory list at the start of each development campaign and in the end of well compliance reports for each well. All chemicals	Closed	N/A	

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	(Pgs. 128-132)	required to do the following once they are engaged in the use and disposal of drilling fluids and cuttings: a. Prepare and submit a Chemical Use Plan (CUP) which must quantify and assess the environmental risk of each chemical additive that may be potentially used during the drilling, cementing and completion of the well. Subsequent well operations, including well interventions, workover, suspension and abandonment operations will be subject to similar requirements. This plan must include all chemicals onboard the drilling unit comprising of operational as well as contingency chemicals. **Questions:** Has a detailed Inventory of all the chemicals onboard the MODU that is to be used as articulated above been made available to the Competent Authority in Guyana for approval? Has each chemical additive been subjected to an assessment of its environmental risk? 3. Has this information been presented to the Competent Authority? b. Each chemical additive used within the drilling fluid must be approved by the	anticipated at this point to be used in the drilling and completion process are provided in the EIA, and the fates of these chemicals have been provided to the Agencies. Further, all chemicals ultimately selected for the Project will be registered with the Pesticides and Toxic Chemicals Control Board as required. EEPGL is committed to chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. EEPGL's chemical selection process includes a number of components, which are explained in EIA Section 2.13.1.			

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		Competent Authority. In order for approval to be granted by this CA each chemical must be tested for its toxicity, bioaccumulation and biodegradability. In the absence of such capacity, the Offshore Chemical Notification Scheme (OCNS) Chemical List used by the UK and the Netherlands is used by proxy. **Questions**: Has each chemical additive been subjected to an assessment of its environmental risk as articulated above? Has the result of this comprehensive assessment of each chemical been presented to the Competent Authority for review?				
27.	2.5.3 Drilling Fluids and Handling System	**Question 3:** What is the Total Aromatic Hydrocarbon Content and Polycyclic Aromatic Hydrocarbon (PAH) Content of the Non-Aqueous Drilling Fluid (NADF) to be used? **Question 4**: Is diesel-based drilling fluid going to be utilized?	EEPGL utilizes IOGP Group III base fluids in its NADF systems. These contain a total aromatic hydrocarbon content <0.5 wt% and a polycyclic aromatic hydrocarbon (PAH) content <0.001 wt%. No use of diesel-based drilling fluid is planned.	Closed	N/A	
28.	2.7.4 FPSO Process Systems (pgs. 147-164)	Format the following diagrammatic representations: Figure 2.7-3 Simplified Oil Processing Schematic on Page 148 can be enlarged to make it more readable. Figure 2.7 -4 Simplified Desanding Schematic on	The Consultants acknowledge the comment. A new appendix to the EIA has been added to include larger versions of the noted diagrams. To preserve the flow of Chapter 2, the current versions have been maintained in this chapter.	Closed	N/A	

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		Page 149 can be expanded to make it more readable. Figure 2.7-5 Simplified Flash Gas Compression System on Page 150 can be expanded to make it more readable. Figure 2.7-6 Simplified Main Gas Compression System on Page 151 can be expanded to make it more readable. Figure 2.7-7: Simplified Gas Treatment System on Page 152 can be expanded to make it more readable. Figure 2.7-8 Simplified Export/ Reinjection Gas Compression System on Page 153 can be expanded to make it more intelligible. Figure 2.7-9: Simplified Produced Water Treatment Systems on page 156 can be expanded to make it more intelligible. Figure 2.7-10: Simplified Seawater Treatment System on Page 158 can be expanded to make it more intelligible. Figure 2.7-11: Slop System Process Flow Diagram on Page 159 can be expanded to make it more intelligible. Figure 2.7-12: Process Flow Diagram for the Aft Machinery Space Bilge System on Page 161 can				

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		be expanded to make it more intelligible. Figure 2.7-13: Process Flow Diagram for the Cargo Area Bilge System on Page 162 can be expanded to make it more intelligible. Figure 2.7-14: Process Flow Diagram for the Bilge System on Page 164 can be expanded to make it more intelligible.				
29.	2.7.4.5 Produced Water Treatment (Pgs. 155-157)	Produced water as is discussed in the identified section of the document is deliberately oversimplified since literature on the subject indicates to the reviewer that this waste stream contains much more than water and just hydrocarbons as we are being led to believe. Its physical and chemical properties vary widely depending on the geological age, depth and geochemistry of the hydrocarbon bearing formation, as well as the chemical composition of the oil and gas phases in the reservior, and the process chemical added during production. According to Kenneth Lee and Jerry Neff in Produced Water - Environmental Risks and Advances in Mitigation Technologies, produced water contains inorganic salts, metals, radioisotopes and a wide variety of organic chemicals, primarily hydrocarbons.	Comprehensive studies were completed as part of the Payara Production License including a Produced Water Reinjection Study. This study has informed the design of the Yellowtail Project. As a component of the Payara Produced Water Reinjection Study, a produced water discharge environmental risk assessment was completed based on predicted concentrations of constituents and compounds in the treated produced water to be discharged from the Payara FPSO. The results of the risk assessment indicate that risk to marine organisms from exposure to the produced water discharge from the FPSO is low. Based on this study's conclusions, treatment and overboard discharge of produced water to international standards is proposed for Yellowtail. Results of the Payara produced water risk assessment not withstanding, EEPGL is working with the EPA on a program for sampling and risk assessment of effluent discharges – inclusive of produced water.	Please refer to EPA's response in Item 9 above. Further , please note that comment must be addressed in Revised ESIA. The Payara Produced Water Study is specific to the Payara Development Project. How are they relevant to Yellowtail?	Please see responses to Comments #9 and #18 of Table 2.	

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		It therefore means that since only one constituent (i.e. oil content) of the produced water waste stream is being treated onboard the FPSO to bring its concentration down to the legally defined allowable limits, all of the other constituents which pose considerable environmental risk are virtually untreated and simply discharged into the ocean over the productive life of the well. Given the above reality we have the following questions in relation to the chemical composition of the produced water before and after treatment at point of discharge with the technologies onboard the FPSO: 1. What are the concentrations of the following elements/ inorganic ions present in the produced water: Sodium, Chloride, Calcium, Magnesium, Potassium, Sulfate, Bromide, Strontium, Ammonium, Bicarbonate, Iodide, Boron, Carbonate and Lithium? 2. What are the concentration of the following parameters (i.e. Biological Oxygen Demand, Total Organic Content, Nitrate, Nitrite, Ammonia, Orthophosphate and Total Phosphorus which help to				

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		determine Total Organic Carbon of the Produced Water? 3. What are the Organic Acids present within the produced water and what are their respective concentrations? Please note that information has to be presented for Low molecular weight organic acids, aliphatic and aromatic acids. 4. What are the concentrations of Total Oil and Grease, Total Petroleum Hydrocarbons, Benzene, Toluene, Ethylbenzene and Xylenes (BTEX), Polycyclic Aromatic Hydrocarbons (PAH) and Total Phenols present with the Produced Water? 5. What are the concentrations of the following metals (i.e Arsenic, Barium, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Vanadium and Zinc) present within the produced water? 6. What are the most abundant naturally occurring radioactive elements that are likely to be present in produced water coming from the Yellowtail and Redtail Wells? And what are their rate of radioactive decay expressed in				

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		Picocuries/L (pCi/L) or becquerels/L(Bq/L) What are the concentrations in mg/l of specialty additives (treatment chemicals) added to a typical well to enhance oil recovery that may become manifested in Produced Water? Was any modeling done to estimate environmental impact factors (EIF) for individual chemicals				
30.	2.7.5.1 Process Cooling (Pgs. 164)	What is the final discharge temperature for produced water likely to be? Express response in degree Celsius? What is the ambient temperature of seawater within the PDA during the day and during the night?	Design specifications for the cooling water and produced water discharges were not finalized at the time of the EIA; modeling was conducted based on the preliminary design, with a single discharge point for each discharge, and discharge temperatures of 50°C and 55°C for cooling water and produced water, respectively. Modeling for these configurations/temperatures showed that the temperature rise above ambient conditions drops to less than 3°C (5.4ºF) at less than 10 meters from the discharge points. Based on final design, the discharge configurations could differ from what was modeled (e.g., the cooling water discharge could be configured through several smaller-flowrate discharges), and discharge temperatures could be higher than the temperatures modeled. Prior modeling for other EEPGL development projects has shown adherence to the "less than 3oC temperature rise at 100 meters" standard for a range of discharge configurations and for higher temperatures. It is thus anticipated that the final designs for these discharges will demonstrate adherence to the thermal standard as well. This will be confirmed once the discharge designs are finalized. With respect to the ambient temperature of seawater in the PDA, Appendix C describes the analysis of ambient temperatures for the FPSO location conducted based on data available from the HYCOM model. A frequency distribution analysis was completed to evaluate the range of temperatures in the PDA and to develop exceedance percentages. Selected ambient temperatures consisted of two bounding cases (1 percent and 99 percent) and a typical case (50 percent). The cases are summarized as follows, in degrees Celsius (Table 3-1 in Appendix C):	Closed	N/A	

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			<table><tr><td>Cumulative Frequency</td><td>Temperature at FPSO Location</td></tr><tr><td>Low (1%)</td><td>26.07</td></tr><tr><td>Typical (50%)</td><td>27.68</td></tr><tr><td>High (99%)</td><td>29.89</td></tr></table>			
31.	3. Administrative Framework (Pages 263-271)	See Comment at Section 2.4.2 Above	Please see response provided to comment MNR-3.	Closed	N/A	
32.	5.1 Area of Influence (Page 318)	There are three (3) Direct AOIs stated in the EIA document. The third AOI is defined as the City of Georgetown. It in my view would have made more sense to narrow it down to the areas which have the storage facilities, wharves, Shorebase facilities, waste treatment and disposal facilities etc are located. Impacts are likely in areas proximal to locations where these facilities are located	To clarify, Section 5.1 of the EIA states that there is a single Direct AOI, and the Direct AOI has three components: the Project Development Area (PDA), the marine and aviation transit corridors between the PDA and onshore activity centers in Guyana, and the City of Georgetown. Narrowing the third component to only the locations where Project activities will occur as suggested in the comment would constrain the analysis and ignore the effects of the Project on the larger community. Under the Environmental Protection Act, permitting of third-party onshore support facilities, including hazardous waste management facilities, is a separate process from the Yellowtail EIA and authorization process. **Certain socioeconomic effects assessed in Chapter 8 that will not be confined to an active Project facility (e.g., impacts on vehicular traffic) would be scoped out of the analysis if the boundaries of the AOI were to be confined to active Project facilities, so the Direct AOI was defined as including all of Georgetown in order to capture these effects in the analysis.**	Closed	N/A	
33.	**5.2.2 Assessment of Potential for Acoustic Impacts from Vessel Noise in Georgetown Harbour (Page 325)**	It would have been more useful for the assessment to focus on the impacts of marine vessel noise, specifically the cumulative effect of underwater acoustic noise from operational marine vessels offshore to be assessed for effects on marine life within the	The noise analysis in Section 5.2.2 of the EIA was included in response to a prior comment from the EPA regarding potential impacts on human receptors. **Analyses of acoustic impacts on marine receptors are included in EIA Sections 7.5.3 and 7.8.3. These analyses examined the impacts of several types of marine sound on marine mammals and fish, including vessel noise. The acoustic modeling analysis referenced in the EIA**	Closed	N/A	

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		Project Development Area (PDA)	**modeled up to eight vessels of various types operating within the PDA at once, to simulate installation of the FPSO with numerous support and installation vessels operating in close proximity to each other. The Consultants consider this scenario a reasonable upper bound for the cumulative effects of multiple sound sources operating simultaneously.**			
34.	**6.2.2.2 Characterizing Existing Conditions in the PDA (Underwater Sound) (Page 390)**	One major deficiency of this section of the EIA is its exclusive reliance on Literature Review, as opposed to a site-specific baseline assessment to characterize existing underwater sound levels within the Project Development Area.	As noted in the response to comment MNR-11, the noise modeling analysis referenced in the EIA considered up to eight vessels of various types operating within the PDA at once, in close proximity to each other within the model domain. It is highly unlikely that addition of an ambient sound level factor into the model in a portion of the ocean as remote as the Stabroek Block would increase sound exposure levels to the point that it would materially change the outcome of the modelling analysis.	Closed	N/A	
35.	**6.4.2 Existing Conditions – Marine Water Quality (page 428 – 444)**	The reviewer is of the view that the evaluation of the baseline marine environmental conditions of the area of potential impact from the planned activities should be conducted via desktop review and supplemented by field-based studies. From the information presented in the identified section of the EIA no field-based study was conducted within the project development area and if it was done it was too limited to arrive at a conclusion about conditions within the PDA. Instead, there has been heavy reliance on several dated studies from other areas within the Stabroek block to characterize conditions within the project development area.	The Consultants acknowledge that not all the EBS data referenced in the comment were taken from within the PDA, but as described in responses to previous comment on the adequacy of the environmental baseline in the EIA, multiple EBSs have been conducted in the Stabroek Block, and as depicted in Figure 7.9-1 the 2019 EBS included a sample along the northern boundary of the Yellowtail PDA. Marine water quality in the Stabroek Block (including but not limited to the Yellowtail PDA) are greatly impacted by the conditions within and oscillations of the Guiana Current, which controls marine conditions at a regional scale. Based on the amount of recent water quality data collected from the southern Stabroek Block and their proximity to the Yellowtail PDA, the spatial and temporal similarity in these data as summarized in Section 6.4.2.2 of the EIA, and the regional nature of the Guiana Current's influence, the Consultants consider the existing baseline data contained in the EIA sufficient to support a robust assessment of the Project's potential impacts on marine water quality, inform development of appropriate embedded controls and mitigation measures, and provide a reasonable basis for the EPA to make decisions regarding authorization of the Project.	Closed	N/A	
36.	**Row 1 of Table 3.1-2: Water Quality Managemen**	Produced water as a waste stream according to K. Lee and J. Neff, 2011 in Produced Water – Environmental Risks and	Please see response to comment MNR-7. EEPGL is working with the EPA on a program for sampling and risk assessment of effluent discharges – inclusive of produced water – and this program includes provisions for assessing discharge characteristics	Please refer to response in Item 29.	Please see response to comment #18.	

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
	t Measures on Page 34 **Table 3.8-1: Environmental and Socioeconomic Monitoring Measures (Water Quality) on Pages 69 - 71**	Advances in Mitigation Technologies, has many constituents which are potentially toxic to the receiving environment. These include: inorganic salts, organic acids, hydrocarbons, metals, radioisotopes and even specialty additives (treatment chemicals) which will be added over time. The FPSO will be moored offshore Guyana for the productive life of the Yellowtail field and will discharge continuously over that timeframe produced water into the oceanic waters offshore Guyana for disposal. In my mind, given that produced water has other more toxic and harmful contaminants other than oil that may have adverse effects on the receiving environment, these elements have to be brought down to safe levels for discharge. Therefore, my question is what mitigative measures will be integrated into EEPGLs operations (by virtue of its inclusion in the ESMP) to monitor and to ensure that effluent discharges offshore meets safe levels of all chemical constituents (i.e.) Salts and Inorganic Ions, Total organic carbon, Organic acids, Petroleum Hydrocarbons, namely BTEX and Benzenes, Polycyclic Aromatic Hydrocarbons (PAH) and Phenols, Metals in dissolved and	against applicable criteria and taking action, as needed, based on these assessments.			

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		microparticulate forms, Naturally Occurring Radioactive Material (NORM) namely Radium 226 and Radium 228 and a number of specialty additives (treatment chemicals) injected into the reservior ?				
37.	*EIS-13* *EIS-41*	Will a separate Decommissioning Plan be produced for the EIA apart from what is currently included in the FDP? Expounding on damages that can be incurred on benthos? **Background/Rationale:** The lifespan of the project is approximately 20yrs. Oil equipment could be left underground after work is completed Subsea equipment (SURF) will be disconnected after it is flushed and prepared As such, can an estimate of potential mechanisms/ steps be identified to pinpoint how the aforementioned will be dealt with respectively? Feasibility study or estimated budget?	The Preliminary Decommissioning Plan is part of EIA Volume III. As stated in this document, several years prior to commencement of decommissioning), it is envisioned that this plan will be revised to cover the ultimate decommissioning of the facility in compliance with applicable laws and regulations in effect at that time, while also considering the technology and infrastructure available at that time. As explained in Section 7.9.5 of the EIA, for the purposes of the EIA, it was assumed that regardless of the proportion of SURF that would be abandoned in place, some elements of the SURF would remain on the seafloor, and that those elements remaining on the seafloor would represent a net increase in the amount of hard substrate available to benthos for colonization relative to baseline conditions, and that the net effect on benthos would therefore be positive relative to baseline conditions.	What about capped wells with potential for legacy leaks? How is this addressed?	As indicated in Section 8 of the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects (included in Volume III of the EIA), the relevant Guyanese regulators would have access to the work site during the decommissioning activities to monitor and witness the final completion of the work. After the completion of well plugging and abandonment (P&A) and facilities decommissioning work, EEPGL would submit a final decommissioning report to the relevant Guyanese regulators that would include a description of the scope of work performed, work logs, final inspection reports, videos, and photos, as applicable. As described in the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects, decommissioned wells will be plugged and abandoned such that the well is secured against future leaks. In the unlikely event that shortly after decommissioning a leak occurred indicating that the plugging and abandonment work was potentially defective, EEPGL would be responsible to address the leak and clean up the oil. Section 4.3 of the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects has been updated to include this information.	Decom. Plan p. 9
38.	Sections 9-16 9-224	Amendments to the OSRP **Background/Rationale:** Given the lack of current baseline data relating to the marine environment in sight of new discoveries and the OSRP, it was observed that mostly references were made to spillages reaching the coast of Guyana.	In the unlikely oil spill event that would have transboundary impacts on the neighboring Caribbean countries, EEPGL would work through the Ministry of Foreign Affairs, at the direction of the Government of Guyana, to establish appropriate claims and/or livelihood remediation processes.	Why plans/actions taken to engage Ministry of Foreign Affairs to commence them?	An oil spill that crosses an international boundary would be by definition an international incident. As such, the response to such an incident would need to be guided by, and be consistent with, commitments made between governments. EEPGL would work through the proper channels (in this case, Guyana's Ministry of Foreign Affairs) to confirm that its response activities would be consistent with governmental communications between Guyana and neighboring countries.	N/A

<table>
<tr><th>Item #</th><th>Issue/Gap</th><th>Review Finding</th><th>Consultants' Comments / Response</th><th>EPA Response</th><th>Consultant Response</th><th>Page Numbers with EIA Edits</th></tr>
<tr><td></td><td></td><td>However, based on the multiplicity of factors (viscosity, wind direction, current, containment etc.), should a spill affect our neighboring countries who will compensate the aggrieved stakeholders considering they are dependent on the tourism & fisheries sector?
Does the Polluter pay principle still apply?
Will aspects of the FUND agreement be utilized?</td><td></td><td></td><td></td><td></td></tr>
<tr><td>39.</td><td>Section 9-164</td><td>Containment of Hydrocarbons (General)

Background/Rationale:
The use of dispersants is outlined in all EIAs and the drafted Oil spill plan and this is understood. However, why is it allowed for Corexit- 9500 to be used as a potential dispersant when it was banned in the UK and Australia due to its potential to cause harm to the marine environment and workers.

Additionally, in-situ burning is a strategy to be used in the event of a spill. This particular aspect should be cause for concern since stochastic maps and the spill models clearly show oil will travel in a northerly direction (Amazon-Orinoco) AOI which is home to a plethora of ecology (threatened and endangered). So why is this being considered?</td><td>As informed through the Net Environmental Benefit Analysis, the use of dispersants and in-situ burning can help mitigate the impacts of spilled oil after evaluating the tradeoffs.

Corexit 9500 is approved for use in the UK and Australia.

United Kingdom
https://www.gov.uk/government/publications/approved-oil-spill-treatment-products/approved-oil-spill-treatment-products

<table><tr><th>Product name</th><th>Product nature and type (if valid)</th><th>Approved use</th></tr><tr><td>Corexit EC9500A</td><td>D – 2/3</td><td>Sea</td></tr><tr><td>Corexit EC9500B</td><td>D – 2/3</td><td>Sea</td></tr></table>
Australia
Register of oil spill control agents (amsa.gov.au)
<table><tr><th>Product name</th><th>OSCA Type</th><th>Applicant Name</th></tr><tr><td>Corexit EC9500A</td><td>Oil Dispersant Type 2/3</td><td>Corexit Environmental Solutions</td></tr></table>
However, in reference to Corexit EC9527A, is not on the approved list in the UK and has a transitional acceptance in Australia. "Transitional acceptance applies to a limited list of dispersant products held in AMSA and AMOSC stockpiles as of 1 January 2012 that are deemed to be OSCA registered on the basis that they have met previous acceptance requirements. These may be made available and</td><td>Closed</td><td>N/A</td><td>N/A</td></tr>
</table>

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
			used for National Plan responses until used or disposed of." As for why Corexit EC9527 is not listed in the UK is two-fold. **First**, all products approved after 1 April 1996 *had* been required to pass both the Sea/Beach and Rocky Shore Toxicity Tests. Any products coming up for renewal that have only passed the Sea/Beach toxicity test in the past *were* required, before they can be renewed, to pass the Rocky Shore Test also. Corexit 9527 and 9500 were removed from the list on 30/07/1998. *However, as of 18 May 2010, existing stocks of Corexit 9527 and 9500 may still be used away from rocky shorelines in appropriate conditions. Approval should be sought from the relevant licensing authority before any proposed use*. Since their removal date, the guidance was adjusted and dispersants could be classified for use for sea, beach, and rocky shore or a combination. As identified in the table above, Corexit EC9500A/B has been re-listed in the UK. **Second**, following the Deepwater Horizon incident, the global response community aligned on three primary dispersants (Corexit EC9500A, Total OSR 52, Slickgone NS) for a Global Dispersant Stockpile to be available to Oil Spill Response Limited (OSRL) members (Dispersant Stockpiles (oilspillresponse.com). Orders for Corexit EC9527 are no longer favored as most would choose one of the dispersants listed in the GDS. Corexit 9527 continues to be listed on the United States Environmental Protection Agency – National Contingency Plan Product Schedule (December 2021) - https://www.epa.gov/emergency-response/ncp-product-schedule-products-available-use-oil-spills. Additional information on oil spill dispersant information for health professionals from the United States Center for Disease Control can be found here (Oil Spill Dispersant.pdf (cdc.gov). **Controlled in-situ burning of spilled oil** Prior to the use of in-situ burning, a determination will be made on the appropriateness of in-situ burning. It was not until Deepwater Horizon that ISB demonstrated its benefits to a response. As outlined in the following Good Practice Guide - Controlled in-situ burning of spilled oil | Ipieca, "ISB can rapidly reduce the volume of spilled oil, and thus greatly reduces the need to collect, store, transport and dispose of recovered oil. ISB can also shorten the overall response time, thus aiding environmental recovery." Human health and environmental			

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
			concerns will be considered and are integral to the decision making process.			
40.		NEBA for Yellowtail Project **Background/Rationale:** A NEBA for done for other developments in the Stabroek Block, especially Payara, however, one was not clearly defined for Yellowtail. Is this a study in the pipeline? If yes, when will it be available for disclosure?	Leveraging results from Net Environmental Benefit Analyses for selection of response technologies is vital to the response decision making process. Three (3) different scenarios were summarized in Appendix H – Oil Spill Scenarios and Net Environmental Benefit Analysis of Response Technologies. These scenarios were selected from the possible releases that represent the risk of spills from a project, and more accurately, the expanding operations in the Stabroek Block. These scenarios provide a range from a Tier III worse case discharge crude oil release of 202, 192 barrel per day to Tier II single release of 2,500 bbl of crude oil. **Scenario 1**: A Tier III worst case discharge (WCD) crude oil release from a loss of well control at a Payara well—202,192 barrels (bbl) per day (initial rate) for 30 days, for two seasons (Maximum WCD per US GoM practice). **Scenario 2**: A Tier III WCD crude oil release from a loss of well control at a Payara well—20,000 barrels (bbl) per day for 30 days, for two seasons (Most Credible WCD). **Scenario 3**: A Tier II crude release at the FPSO resulting from a loading hose malfunction—2,500 bbl, for two seasons Most importantly, in the event of a release, EEPGL and ExxonMobil technical experts will complete a revised NEBA in real time predicated on the current metocean conditions, location and nature of the release for review and discussion with the Guyana EPA and Civil Defense Commission (CDC) as soon as practical.	Closed	N/A	N/A
41.	Section 9.24	Socioeconomic Studies of Transboundary Impacts **Background/Rationale:** Apart from identifying the countries that may be affected, it was not clearly defined that any joint studies were done with these countries in the event of economic losses…refer to Item 3.1.2.	The Consultants acknowledge that there were no socioeconomic studies performed in other countries that could be affected by a transboundary oil spill event. An extensive coastal sensitivity mapping exercise was carried out for a previous offshore development EIA, and the baseline information on coastal sensitivities in Section 9.24 of the EIA draws on these geospatial data as well as more recent updates gathered through a desktop literature search conducted for this project. These data included information of economic significance, including fishing areas and centers of tourism activity. This level of detail on transboundary baseline conditions is commensurate with prior oil and gas development	Closed	N/A	N/A

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		This is our legal obligation for safeguarding and security purposes should a lawsuit be filed in event of pollution.	EIAs in Guyana and consistent with the requirements of the Terms and Scope for the Yellowtail Development Project.			
42.		Compensation/ Insurance Coverage (Not clearly defined apart from other EIAs for the Stabroek Block) **Background/Rationale:** Has there been any changed with respect to compensation to stakeholders through the parent company, or is Exxon still stating that the subsidiaries will bear the cost of oil spills and related environmental disasters? Will this be amended in the EIA?	The Stabroek Block co-venturers' first priority is to put in place mitigations and processes that prevent adverse events. In the unlikely case of an adverse event, the co-venturers would immediately minimize and rectify any impacts. The co-venturers have the financial capacity to meet the responsibilities for an event including obligations under Guyanese law and the respective petroleum agreements. Regarding insurance, the Stabroek Block co-venturers have secured comprehensive insurance for petroleum activities as required by environmental permits. Under the existing legal framework and agreements with the government, there are extensive assurances of EEPGL's and co-venturers' commitments, including environmental protection measures to respond to operational incidents. The Government of Guyana has multiple mechanisms in place, including the Stabroek Block Petroleum Agreement and the environmental permits, to ensure that the companies would take responsibility for any adverse events. Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, should the Yellowtail Project receive necessary approvals, the co-venturers would have insurance coverage including Third Party Liability and the cost of regaining control of a well.	Closed	N/A	N/A
43.	**Stakeholder Engagement Strategy and Planning – 4.7**	The stakeholder engagement strategy was deficient and not comprehensively aligned with the framework provided in the terms and scope for Yellowtail development project. The following gaps were identified:	The Consultants believe that the planning, approach, and execution of the stakeholder engagement strategy were aligned with the framework provided in the terms and scope for the Yellowtail Project. Detailed responses are provided below.	Response is noted	N/A	N/A
44.	**SEP-1**	Summary of previous stakeholder activities – this component of the EIA did not specifically identify details of previous engagements, specifically how the concerns raised by previous are being addressed through a	EIA Section 4.7 provides a summary of Stakeholder engagement activities conducted for the Yellowtail Project EIA, including public engagement meetings during Scoping and EIA disclosure, as well as engagement with community- and organization-level engagements that supported baseline research and EIA development.	Please note that disclosures are separate from the consultation process required in the Terms and Scope.	The comment is acknowledged. In addition to the information provided in Section 4.7, the SEP included in Volume III of the EIA includes an overview of previous engagement activities as well as a detailed synopsis of those activities in Attachment A. Section 4 of the SEP includes dates, times, and locations of previous engagements.	N/A

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
		grievance redress mechanism. Evidence should be provided relative to dates, times, locations etc.	Concerns raised through EIA engagements were not addressed through EEPGL's grievance redress mechanism; rather, these concerns related to the EIA, supporting studies, and proposed management measures, and as such were addressed by the Consultants through the EIA comment-and-response process. The dates, locations, and times of the public Scoping and Disclosure meetings (in May/June 2021 and Oct/Nov 2021, respectively) are included in EIA Section 4.7. In the course of other engagements, the Consultants documented the means of communication, location (including virtual meetings), dates and times, attendance, summary of discussion, issues raised, and action items. In respect of the privacy of participating individuals, this information is not included in the EIA. However, the outcomes of these engagements are summarized in Section 4.7.3.2, including discussion topics and concerns. These engagements occurred in August and September 2021, and the engagement plans were shared with the EPA in advance of these activities.			
45.	**SEP-2**	The EIA states there is an email, telephone number and regular communication on social media, this is not adequate for come vulnerable groups, especially indigenous communities. What systems are in placed to address stakeholder matters in an efficient and systematic manner?	As described in EIA Section 4.7.1, consultation or dialogue activities involve a two-way flow or exchange of information between stakeholders and EEPGL or the Consultants. Consultation activities for the Yellowtail Project have included one-on-one and small-group meetings, public meetings including question and answer sessions, in addition to the telephone, email, online, and social media communications. EEPGL and the Consultants recognize the challenges of online/phone communications in rural areas, including but not limited to indigenous communities. Therefore, efforts were made to disseminate information in a variety of ways, including but not limited to distribution of flyers, howlers announcing local meetings/engagement opportunities, and communication via local representatives. In addition, EEPGL regularly visits and engages with communities in Regions 1 to 6 through ongoing outreach and engagement programs, community investment initiatives, the Participatory Fishing Study, and other programs.	Response is noted	N/A	N/A
46.	**SEP-3**	Identification of stakeholders – The EIA lacked the model/models utilized to profile and map stakeholders who will be directly or indirectly impacted by the project.	EIA Volume III SEP Section 3.2 describes Stakeholder Identification Methodology, which includes the model used to map stakeholders based on the anticipated impact and influence (in accordance with recognized good practice for stakeholder engagement, including guidance from the World Bank and IFC).	Response is noted	N/A	N/A

Item #	Issue/Gap	Review Finding	Consultants' Comments / Response	EPA Response	Consultant Response	Page Numbers with EIA Edits
		Further, there is no evidence of considerations made for profiling such as capacity to engage, cultural context, level of influence etc.	In respect of the privacy of participating individuals, the details of this process and results are not included in the EIA. However, the Consultants shared this information with the EPA in July 2021 as part of the stakeholder engagement plan supporting the EIA development. As noted in Appendix 3 of the Terms and Scope, this information was to be shared with the EPA, and was not required to be included in the EIA.			
47.	**SEP-4**	While indigenous communities, women and fisher folks were mentioned as vulnerable groups, the EIA was not explicit in how project risks and benefits will be distributed among stakeholders.	The text referenced in the comment refers to how the identification of stakeholders—and development and implementation of engagement plans—should consider potentially vulnerable groups and seek to understand how risks and benefits may be distributed. This was a focus of engagement activities during EIA development, including engagement with community-level stakeholders in Regions 1 to 6 (as summarized in EIA Chapter 4, Table 4.7-6). Among other things, the Consultants sought to understand how factors such as the COVID pandemic, recent flooding, and ongoing offshore activities have affected wellbeing and vulnerability in all coastal regions. The EIA explicitly recognizes potentially vulnerable populations, and how impacts may differ for these groups, in the relevant sections of the EIA. For example, the assessment provided in Section 8.1.3 recognizes that individuals of lower socio-economic standing may be more vulnerable to economic changes. Accordingly, the assessment concluded that this impact would be of greater significance for this vulnerable group, as compared to the general population.	Response is noted	N/A	N/A
48.	**SEP-5**	Many of the categories of stakeholder identified in the terms and scope were not captured in the EIA such as Transport and Habours department, Pesticide and Toxic Chemical Board, the Guyana Defence Force etc.; Seawalls and Beyond and other environmental groups; some categories of stakeholders under the private sector, academic institutions, professional, business and workers associations and the media.	The stakeholder categories identified in Appendix 3 of the Terms and Scope formed the basis for the Yellowtail Project engagement program. Categories include regulatory/government organizations; community groups; vulnerable groups; NGOs; private sector; and others. Specific stakeholders listed in this section of the terms and scope are clearly noted to be examples within each category, for reference. All stakeholder categories were considered in the engagement planning for the EIA, although not all of them are explicitly mentioned in the EIA or the ultimate subject of outreach. Stakeholders were considered with respect to potential impact, influence, and interest in the Project. This mapping informed the identification of stakeholders for engagement during EIA development, as well as ongoing engagement, communication, and outreach efforts for the	Response is noted	N/A	N/A

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			Yellowtail Project and EEPGL's ongoing activities in Guyana.			
49.	**SEP-6**	For the stakeholder mentioned in the EIA, the methods consultation needs to be validated as the appropriate method for the target audience.	The methods of consultation and engagement are summarized in the SEP (EIA Volume III: Attachment A – Synopsis of Previous Stakeholder Engagement Activities). Methods have been determined based on the engagement objective and stakeholder participants (as well as access to various engagement fora/methods). Importantly, methods of engagement for the Yellowtail EIA considered public health risks and restrictions related to the global COVID-19 pandemic. Scoping meetings included virtual meetings, as well as in-person meetings in Regions 1, 4 and 6. Disclosure meetings included in-person meetings in Regions 1 through 6, plus a virtual meeting to accommodate the then existing circumstances associated with the pandemic. For the EIA development including engagement to support baseline research, many engagements were held by phone or videoconference, where these services were accessible to stakeholders and in consultation with stakeholders to determine the preferred format. In-person meetings/interviews were accommodated in many cases, particularly for community-level stakeholders including NDCs and CDCs. The Consultants worked with participating stakeholders to determine the appropriate method for the target audience.	Response is noted	N/A	N/A
50.	**SEP-7**	Documentation of consultation activities – this Apart from the scoping and disclosure meetings schedules, the schedule for consultation during the conduct of the EIA as well as the evidence of consultation such as minutes, registration forms etc. are missing.	The Terms and Scope requires that public consultation results be documented and relevant records included in the EIA (or appendices). Public consultation activities comprise the scoping and disclosure meetings, for which the meeting schedules, supporting materials, and outputs (comment/response records) are described in EIA Section 4.7, the SEP (EIA Volume III), and Appendix U (Stakeholder Comments). The Consultants conducted other engagements in the course of baseline studies and EIA development. These engagements occurred in August and September 2021, and summaries of stakeholders engaged, and issues raised, are provided in Section 4.7 and the SEP. In respect of the privacy of participating individuals, the details of specific interviews or meeting minutes are not included in the EIA, although relevant information is incorporated in the relevant sections of the EIA and cited accordingly.	Evidence of the specifics on consultations during the conduct of the EIA is still missing. Meeting registrations forms, notes on the persons who were in attendance.	Detailed records of consultation made during the development of the EIA have been provided in Appendix W of the EIA. Together with the stakeholder consultation process and summaries provided in Chapter 4 and the attached SEP and SEP Attachment A, these records include the manner in which the public was notified, the groups targeted, a description of the stakeholder consultation process, listing of all stakeholder groups included in the process, the number of meetings held, location of the meetings, dates held, and minutes of all meetings. Personal information including specific names of participants have been withheld to respect the privacy of those involved. No surveys were performed.	Appendix W (new)

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51.	**SEP-8**	Grievance Redress Mechanism – The Grievance Redress mechanism needs to be more explicit and capture the tenets of a Grievance Redress Mechanism in keeping with international best practices. The existing Community Grievance Mechanism should be elaborated to provide evidence of status and trends in accordance with the terms and scope and how this system will be enhanced for Yellowtail Development Project?	EEPGL's Community Grievance Mechanism (CGM) is an integral part of the Company's stakeholder engagement program. The CGM is referenced in Section 3.3.2 of EEPGL's Stakeholder Engagement Plan for Guyana Operations (included in Volume III of the Yellowtail EIA), and Project-specific detail is provided in the ESMP (also included in Volume II of the Yellowtail EIA). An important element of any grievance mechanism is to incorporate local input into the nature and design of the mechanism. Accordingly, EEPGL's CGM has evolved over recent years, as it has been publicly disclosed and subject to comments for the Yellowtail EIA and earlier EIAs (Payara, Liza Phase 2 and Liza Phase 1), and has been iteratively updated to reflect this input. Grievances are tracked, monitored, and reported via EEPGL's internal ESMS and compliance systems to ensure follow-up. These systems allow for an analysis of trends in stakeholder interest and concern, which help EEPGL design further engagement programs and activities. As described in the CGM, potential grievances can be communicated to EEPGL through various means of communication, including phone, email, and in-person. The CGM applies to communications that occur directly with EEPGL, as well as via contractors or government agencies. EEPGL also tracks concerns and issues that are raised through Facebook and other social media outlets, so that relevant issues can be registered and addressed via the CGM.	Response is noted	N/A	N/A
52.	**SEP-9**	Monitoring and reporting – The EIA states there is ongoing consultations, however it doesn't provide evidence of an integrated system for monitoring and reporting throughout the life of the project. What are systems to address the high impact, high influence groups of stakeholders for example?	EEPGL has a program of ongoing stakeholder engagement and community outreach in Regions 1 through 6, and is regularly in touch with stakeholders to provide updates about projects, offshore activities, community investment initiatives, and other matters. Documentation of stakeholder engagement activities, and related monitoring, evaluation and reporting is managed through EEPGL's environmental and social management system (ESMS). This system provides for the consistent and centralized documentation of records , integrated within EEPGL's management systems, and verifies that follow-up actions are assigned and completed. Engagement planning efforts include targeted engagement and participatory opportunities to address high impact / high influence stakeholder groups. For example, recognizing the importance of	Justifications provided must be included in the Revised ESIA.	This information has been added to Section 4.7.1 of the EIA.	pp. 4-8 to 4-9

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			fishing livelihoods and communities, EEPGL supports the Participatory Fishing Study (PFS), which began in 2019 and is ongoing. The PFS involves local fisherfolk (a high priority stakeholder group) in Regions 1 through 6, including representatives at landing sites along the coast, and on-board fishing vessels, to monitor changes in fish catch and fishing effort. Engagement that occurs through the PFS (and other engagement programs targeted at high impact/high priority stakeholders) is tracked through the ESMS, as for other engagements. Issues and concerns raised by these groups are tracked, responses are provided, and follow-up actions are verified through this centralized, integrated management system.			

Table 3: Items for inclusion in the Revised ESIA (25 February 2022)

Topic	Updates to Revised EIA	Consultants' Responses	Page Numbers with EIA Edits
Oil Spill Response	• Net Environmental Benefit analysis scenario to be corrected to include Yellowtail "Most Credible" WCD 88,728bpd • Include First Response Toolkit in all appropriate sections • Ensure risk assessment includes increased risk of multiple events • Sufficient dispersant required in Guyana for surface spraying Day 1 and sub surface injector Day 2.	• The Net Environmental Benefit Analysis component of the OSRP has been updated to clarify that the example prepared for the Payara Project is representative for an FPSO project and results would be consistent with other FPSO projects, including Yellowtail. Additionally, the OSRP has been updated to reflect that in 2022, EEPGL will be conducting a qualitative NEBA process to better inform initial decision-making and response planning. • Table 6-8, summarizing the First Response Toolkit, has been added to the OSRP. • An assessment of the frequency of oil spill scenarios, based on global experience in the industry, will be prepared in 2022. • As summarized in Section 5.7 of the OSRP, vessel-mounted systems are available to begin to apply dispersant on the surface once the EPA concurs to their use. If the release is subsea, there are adequate resources in-country (see Table 6-7: Oil Spill Dispersant (Guyana)) to begin application at the wellhead. The dispersant in-country would be complemented with the cascading of dispersants from the Global Dispersant Stockpile (Table 6-13) which would start to arrive on Day 2.	• OSRP p. 272 • OSRP pp. 58-61 • N/A • OSRP pp. 57, 68
Produced Water	• Reinjection analysis for Yellowtail to be strengthened to give emphasis on the environmental benefits of reinjection.	Please see response to Comment #9 in Table 2.	N/A

[i] https://www.iogp.org/bookstore/product/environmental-performance-indicators-2019-data/

APPENDIX V

Commitment Register

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Chapter 2	Target an initial local content (Guyanese workforce) of 25 percent and increase to approximately 75 percent by the end of 8 years of operation. Partner with select local institutions and agencies to support workforce development programs targeted to in-demand skillsets, and proactively message Project-related employment opportunities.
Chapters 2, 6, 9 and 13	Use a portion of the associated gas produced from the reservoir onboard the FPSO as fuel gas, with the remaining balance—excluding other *de minimis* sources not captured by the Vapor Recovery Unit (VRU)—re-injected back into the reservoir via the gas re-injection wells.
Chapters 2 and 9	Implement the following key aspects of well control during the Project drilling campaign: • Design wells and drilling procedures based on site-specific data and integrated pore pressure prediction; • Plan fluid densities to control reservoir pressure; • Install a blowout preventer (BOP) system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained; • Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 21 days or as operations allow); • Specialize training, equipment, and procedures that meet or exceed regulatory requirements; and • Install redundant well-flow monitoring devices and implement strict well-monitoring practices to maximize the likelihood of detecting and shutting in a hydrocarbon influx prior to surface release.
Chapter 2	Perform drilling using an overbalanced drilling fluid weight[1] to control the well.
Chapter 2	Monitor and control the subsea system from the FPSO, using a control system connected to the FPSO through umbilicals that also supply power, hydraulic fluid, and chemicals to the subsea manifolds and wellhead trees[2]. The hydraulic fluid for operating the subsea control system will be a low-toxicity, water-soluble hydraulic fluid. Design the SURF system to withstand the full shut-in pressure from the production wells, and the gas re-injection / water injection components to withstand the highest required injection pressures. Provide overpressure protection on the FPSO, in accordance with good international oilfield practice, to protect the subsea systems.
Chapters 2, 6, 7 and 13	Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Measure oil and grease content of produced water (grab sample once per day). Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.
Chapter 2	Utilize the slop system for treating slop water (via heat-assisted two-stage gravitational separation) such that the overboard discharge will not exceed 15 parts per million (ppm) oil content. Continuously monitor the oil content in the slop tank with a dedicated meter.
Chapters 2 and 6	Fit each cargo oil tank with a stripping eductor. Use water from the slop tanks to drive the stripping eductors and strip the cargo tanks below 100 millimeters (4 inches) to prepare the cargo tank for entry. Route back the resulting oily water mixture from the

[1] In overbalanced drilling, the pressure exerted by the drilling fluid column exceeds formation pressure, preventing formation fluids from entering the well.

[2] Assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production

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	bottom of the tank to the slop tanks for treatment and discharge, in accordance with slop water discharge specification (less than 15 ppm oil-in-water content).
Chapters 2 and 7	Before discharge, treat the aqueous streams resulting from the crude desalting process and combined with produced water and discharge overboard, to a discharge specification of less than 42 mg/L oil-in–water content.
Chapters 2, 7 and 13	Prior to discharge and disposal of bilge water, send bilge water to the bilge water separator unit for oil/water separation, with separated water (meeting the specification of less than 15 ppm oil-in-water content) discharged overboard and separated oil sent to the oily bilge tank. Pump the oil and sludge from the oily bilge tank to an International Maritime Organization (IMO) shore connection, where it can be discharged to a tote tank or to an offshore support vessel for onshore disposal.
Chapters 2, 6, 7 and 13	Discharge treated black water overboard (with a total residual chlorine concentration as low as practical, but not less than 1 ppm). Combine grey water discharges from all sources (except for food waste from the galley macerator) and dose with chlorine automatically via the chlorine dosing system, just before entering the grey water treatment tank, from which the tank contents will be discharged overboard. Monitor residual chlorine concentration of sewage discharges from the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations. Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter [approximately 1-inch-diameter] particle size or less) prior to discharge.
Chapter 2	Separate flushed solids from well de-sanding using a hydrocyclone/accumulator skid and transfer into sand-bagging tanks for later onshore treatment and disposal.
Chapters 2, 6 and 13	Utilize a vapor recovery unit for low-flow process streams from produced water and triethylene glycol regeneration.
Chapter 2	Use a dedicated online oil content analyzer at each Induced Gas Flotation Unit that provides continuous oil content monitoring for the treated produced water stream. The control system will automatically route water to the off-spec tank if an oil content of 42 mg/L is exceeded. From the off-spec tank, return the produced water to the topsides Induced Gas Flotation Unit for further treatment. In the event of unavailability of the off-spec tank, transfer the produced water to slop tanks. If the produced water is routed to the slop tanks, any overboard water discharge from the slop tanks should not exceed 15 ppm oil content.
Chapter 2	Prior to overboard discharge, pass slop water from Slop Tank (SB) through an oil content monitoring (OCM) package for automatic monitoring of oil-in-water content. In the event that the OCM package detects an oil-in-water content above 15 ppm, the overboard discharge line will close and the recirculation line will open automatically; the off-specification slop water will then be recirculated back to Slop Tank (PS) via the hazardous open drain header.
Chapters 2 and 7	Prior to overboard discharge, send the bilge water from the bilge holding tank to the bilge water separator unit for oil/water separation, with separated water (with low oil-in-water content) passing through an OCM package for automatic monitoring of oil-in-water content. In the event that the OCM package detects an oil-in-water content above 15 ppm, the overboard discharge line will close and the recirculation line will open automatically; the off-specification bilge water will then be recirculated to the Bilge Holding Tank.
Chapter 2	In an upset condition, send all sewage overflows from the affected sewage collection points (STP, grey water treatment tank, and/or grease trap/separator) to the oily bilge tank for collection and ultimate transfer to a supply vessel for eventual onshore disposal.

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Chapter 2	In the unlikely event that concentrations of H_2S increase to a level that could represent potential health or safety concerns for the Project's offshore workforce, implement additional management measures as appropriate (e.g., training programs [initial and annual refresher], personal protective equipment (PPE), response planning, and equipment for leak detection and alarms).
Chapters 2, 7, 8 and 9	Advise the Maritime Administration Department (MARAD) of the locations of drill ships during the drilling of development wells and the performance of well workovers in the Project Development Area (PDA), so that mariners can be made aware of these activities. Establish marine safety exclusion zones with a 500-meter (1,640-foot) radius around drill ships during drilling operations and around drill centers during well workovers, as well as around major installation vessels, in accordance with good international oilfield practice.
Chapter 2	Obtain authorizations for major in-water activities from MARAD and notify mariners for all marine vessels, including the FPSO, supply and support vessels, tugs, and those vessels to be used during the installation, hook-up, and commissioning stage.
Chapters 2, 8 and 9	Establish a 2-nautical mile-radius (2.7-kilometer-radius) marine safety exclusion zone centered on the FPSO during offloading activities, where marine support and tanker offloading will occur. No unauthorized vessels will be allowed to enter this approximately 4,310-hectare (10,650-acre) operational marine safety exclusion zone during offloading activities.
Chapters 2 and 10	Optimize and share logistical support among Liza Phase 1, Liza Phase 2, Payara, and Yellowtail, as well as exploration drilling operations.
Chapter 2	Ensure any incinerator employed for use offshore has an IMO-type approval certification consistent with IMO and MARPOL 73/78 requirements for shipboard incinerators.
Chapters 2 and 8	Manage all waste streams for the Project in accordance with a Comprehensive Waste Management Plan (CWMP) used for the management of all EEPGL waste.
Chapter 2	Near the time of decommissioning, develop a more detailed decommissioning plan, in consultation with the appropriate Guyanese regulators.
Chapter 2	As part of the decommissioning planning process, perform comparative assessments of decommissioning options for the various facilities components, as described in Annex A of *Offshore Oil and Gas Decommissioning Guidance Notes* (OPRED 2018).
Chapter 2	During decommissioning, plug and abandon (P&A) development wells permanently.
Chapter 2	During decommissioning, disconnect the FPSO from its mooring system, remove it from the production location, and tow it to a new location for reuse or decommissioning.
Chapter 2	Employ a chemical selection process that includes the following components: • Specify in contracts that offshore chemical supply contractors shall protect the health and safety of people and the environment; • Specify that contractors shall perform services in compliance with applicable laws and EEPGL health and safety policies; and • Work with established chemical suppliers
Chapters 2 and 8	Reuse, recycle, or dispose of unused or used and recovered chemicals in accordance with applicable regulations and good international oilfield practice. Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with the waste management hierarchy.
Chapters 2 and 9	Store all chemicals—either at shorebases, at contractor facilities, or on the drill ships or FPSO—in appropriate storage containers with either secondary containment or appropriate drainage control.

<table>
<tr><th>EIS Chapter</th><th>Commitment</th></tr>
<tr><td>Chapters 2, 7 and 13</td><td>Equip all project vessels to comply with the water pollution control standards required by the International Maritime Organization and International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78). For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with MARPOL 73/78 requirements.</td></tr>
<tr><td>Chapter 2</td><td>For any equipment containing naturally occurring radioactive material (NORM) or radiography sources, ensure the equipment is registered, strictly tracked, controlled, and returned to the vendor at the end of its use or if it must be replaced at any time.</td></tr>
<tr><td>Chapter 2</td><td>Employ a Radiation Management System that addresses NORM.</td></tr>
<tr><td>Chapter 2</td><td>Apply standard industry health controls to manage occupational health risks associated with radiation.</td></tr>
<tr><td>Chapter 2</td><td>Incorporate the following controls to further reduce risk associated with tandem offloading:

<table><tr><th>Parameter</th><th>Yellowtail FPSO</th></tr><tr><td>Number of tugs</td><td>3</td></tr><tr><td>Holdback tug bollard pull capacity (ton)</td><td>120</td></tr><tr><td>Separation distance from FPSO (meters)</td><td>120</td></tr><tr><td>FPSO onboard metocean station</td><td>Yes</td></tr></table></td></tr>
<tr><td>Chapters 2, 6, 7 and 9</td><td>With respect to development well drilling:

1. Use water-based drilling fluids (WBDF) to the extent reasonably practicable (for drilling of initial open-hole well sections);
2. Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings;
3. Prohibit the discharge of cuttings generated using drilling fluids that contain conventional mineral oil, except when the mineral oil is used as a carrier fluid (transporter fluid), lubricity additive, or pill;
4. Prohibit the discharge of drilling fluids that contain used/waste engine oil, cooling oil, gear oil or lubricant, and which have previously been used for purposes other than borehole lubrication;
5. Prohibit use of fluids that contain diesel as the principal component of the drilling mud liquid phase; and
6. For well sections requiring NADF, use only low-toxicity IOGP Group III base fluid and manage in accordance with the associated safety data sheet.
7. Use solids control and cuttings dryer systems to treat cuttings such that end-of-well maximum-weighted mass ratio averaged over all well sections drilled using non-aqueous fluids shall not exceed 6.9 percent wet weight base fluid retained on cuttings.</td></tr>
<tr><td>Chapter 2</td><td>Control fugitive emissions from the injection compressors by implementing a leak detection and repair (LDAR) program that regularly monitors to detect leaks, and repairs any leaks identified within a defined time period.</td></tr>
<tr><td>Chapters 2, 6 and 13</td><td>Use aero-derivative turbines instead of industrial turbines due to the higher efficiency resulting in a reduction in fuel consumption.</td></tr>
</table>

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Chapter 2	Include a spare generator for the FPSO power generation system to improve reliability of the system and reduce upset time.
Chapter 2	Implement an integrated audit program by combining resources with the contractors and participating in their respective audit programs.
Chapters 6 and 13	Develop a flaring minimization plan to document the design measures and operational practices that minimize flaring during Project FPSO operations.
Chapter 6	Use a computerized maintenance management system and a facility integrity management system on the FPSO to schedule efficient use of maintenance time so that the proper equipment inventory is maintained.
Chapter 6	Follow specifically developed procedures for starting up and shutting down equipment to minimize flaring emissions.
Chapter 6	Prior to any major maintenance event, develop a specific plan in advance that includes a review of potential flaring and evaluation of possible mitigations to minimize any flaring.
Chapter 6	Review the annually quantified GHG emissions and establish plans to achieve continuous improvement as part of an annual planning process.
Chapter 6	Provide workers with appropriate personal protective equipment, including ear protection (when engineered controls must be augmented to manage sound exposure).
Chapters 6, 7, and 13	Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible
Chapter 7	Direct lighting on the FPSO and major vessels, where practicable, to required operational areas rather than at the sea surface or skyward. Adhere to maritime safety regulations/standards for lighting on vessels.
Chapter 7	As the Project is located in deeper water, utilize suction piles, a low-noise alternative, instead of impact pile driving.
Chapters 6 and 7	Implement the following controls for underwater sound management: • Gradually increase the intensity of seismic impulses to allow sensitive species to vacate the area before injury occurs (i.e., soft starts), use PSOs during VSP, and implement other measures recommended by the Joint Nature Conservation Committee guidelines (JNCC 2017), as applicable; and • Maintain equipment, marine vessels, and helicopters in good working order and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, to limit sound levels to the extent reasonably practicable.
Chapter 7	Treat permitted discharges of waste streams and effluent discharges to the sea (as needed) in accordance with industry guidelines and good international oilfield practice.
Chapter 7	Use existing shorebase support facilities for onshore infrastructure operations of the Project.
Chapter 7	Use Marine Mammal Observers (MMOs) and soft-start procedures for vertical seismic profiles (VSPs) in accordance with Joint Nature Conservation Committee (JNCC 2017) guidelines and soft starts for any pile driving.
Chapters 7 and 13	Provide screening for seawater intakes to avoid entrainment and impingement of marine flora and fauna.
Chapter 7	Conduct exchanges of the FPSO's ballast water while en route to the PDA to reduce the potential impact of invasive species introduction.

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Chapter 7	Conduct ballast water discharges in accordance with internationally recognized standards and in compliance with IMO requirements[3].
Chapter 8	Implement EEPGL's Operations Integrity Management System to protect the Project workforce from occupational hazards.
Chapter 8	Provide medical facilities and onboard medical professionals on the FPSO and major installation vessels to treat minor medical issues.
Chapter 8	Continue disclosure of Project-related activities, as well as continuous engagement with the fishing community and targeted engagement with certain vulnerable populations including those coastal communities in Region 1.
Chapter 8	Only contractors that are appropriately licensed by the EPA and have been assessed by EEPGL as being of a sufficient standard should be used to treat the Project's wastes.
Chapter 8	Dispose ash from the incineration of waste, residual solid waste from treated hazardous solid wastes, and general non-hazardous wastes to a landfill that has been appropriately licensed by the EPA and assessed by EEPGL as being of a sufficient standard.
Chapter 8	Manage specific wastes that can be recycled locally, such as scrap metal and electronic waste, using approved local recyclers.
Chapter 9	To reduce the possibility and consequence of fuel release, EEPGL or the operators involved in offshore bunkering operations should implement a series of fire prevention controls (design-based and operations) in alignment with good international oilfield practice. Design multiple automated safety features into drill ships and offshore supply vessels to minimize the risk of such releases (e.g., automated shut-off valves, alarms, etc.) as well as train operations and maintenance crews. Additionally, all Project vessels should have robust emergency response plans to direct activities in the event that a leak is detected.
Chapters 9 and 13	Employ a dedicated Mooring Master to supervise offloading activities, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.
Chapter 9	Offloading should only occur when weather and sea conditions allow for safe operations. If the environmental conditions prior to the tanker approaching the FPSO are not suitable, the tanker should stand by at a safe distance until conditions are within acceptable limits. If unexpected adverse weather (e.g., a squall) occurs during offloading, the offloading operations should be stopped and the tanker disconnected and moved away from the FPSO until conditions are within approved, safe limits.
Chapter 9	Implement comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. Provide active oversight over contractors to verify that they are complying with EEPGL's requirements. Contractors should be required to regularly inspect their vessels, which addresses marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability. In addition, vessels operating within the Georgetown Harbour or other coastal areas should be required to adhere to speed restrictions and navigation aids.

[3] This conclusion is based on an assumption that export tankers will comply with applicable IMO requirements; however, EEPGL will have no role in enforcing compliance with these requirements.

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Chapter 9	Utilize Simultaneous Operations procedures to safely manage Project marine vessels performing work in the same vicinity of each other, which will include considerations for avoiding vessel collisions.
Chapter 9	Marine vessels should have industry-proven station-keeping systems (e.g., FPSO mooring system, dynamic position systems on drill ships) to maintain stations in the offshore environment.
Chapter 9	Follow the following measures to prevent hydraulic oil releases: • Use equipment only within the specified weather limitations (required sea states); • Use hoses wrapped in anti-chafe spiral wrap when configurations allow; • Design equipment with monitoring systems with the capability of stopping and isolating a release within minutes; • Conduct pre- and post-dive checks with visual inspections; • Maintain continued focus on any components under pressure during each pre-deployment check to verify the integrity of all hydraulic systems and associated hosing/connections; • Conduct preventive maintenance and proactive replacement of hoses in advance of manufacturer's recommended practices due to the depths and harsh conditions in which such equipment is operated; • Train crews, which includes hazard identification and a focus on spill prevention; and • Use environmentally friendly, highly refined mineral oil–based hydraulic fluids.
Chapter 9	In the event of a spill, prioritize the mobilization of emergency response resources (personnel and equipment) to those areas most sensitive to a spill.
Chapters 6, 7 and 9	Implement the following measures to avoid a spill associated with FPSO offloading: • FPSO and tanker collision avoidance controls (as described in Section 9.1.1.3 of the EIA, Offshore Collision between FPSO and Offloading Tanker); • Use of a certified engineered floating hose system; • Floating hose damage protection controls; • Use of emergency disconnect controls on the floating hose system; • Use of load monitoring systems in the FPSO control room; • Use of leak detection controls including infrared leak detection ; • Flood lighting for night operations; and • Volumetric checks during offloading
Chapter 9	Follow the Spill Impact Mitigation Assessment method to determine whether to use chemical dispersants for spill response. This method is based on the characteristics of the spill, the biological and socioeconomic resources that are at risk from exposure to the oil, and the expected net impact of available response options.
Chapter 9	In the unlikely event of an oil spill causing losses to stakeholders, establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process should be to provide compensation as appropriate for asset losses and the purpose of a livelihood remediation program should be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes should be transparent, fair, and conducted in a timely manner.
Chapters 7, 9 and 13	Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Employ trained Marine Mammal Observers during the conduct of seismic-related activities. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to

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	commencing sound-producing operations in water depths less than 200 meters [656 feet], or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters [656 feet]. Where reasonably practicable, equip sound-making devices or equipment with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.
Chapters 7, 8, 9 and 13	Provide standing instruction to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals, marine turtles, and riverine mammals and to not approach the animals closer than 100 meters (328 feet), when possible, to reduce probability of collisions. EEPGL-contracted vessels should be trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such. Such vessels should reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock. Vessels should also slow to less than 5 knots and should be prohibited from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO when offloading and the 500-meter (1,640-foot) exclusion zone around drill ships and FPSO during all other times. Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.
Chapter 9	Subject the black water treatment system to routine inspection and maintenance, providing the opportunity to identify and correct issues requiring attention prior to an upset scenario occurring.
Chapter 9	Design the black water treatment system to include capacity for storage of 7 days of untreated wastewater in the black water holding tank in the event of an upset to the treatment system, and for additional storage in the oily bilge tank. Additionally, configure the FPSO to allow for the black water stream to be redirected to the IMO flange, where it can be offloaded directly to a supply vessel, for subsequent treatment on shore. These measures will afford time to avoid overboard discharge for a period of time while corrective actions on the treatment system can be implemented, without impacting the ability of the FPSO to continue operating.
Chapter 9	Configure the black water treatment system with multiple closed valves to prevent accidental release of untreated black water to the ocean.
Chapter 9	Implement a series of fire prevention controls (design-based and operations) in alignment with good international oilfield practice to reduce the possibility and consequence of a fire. Design multiple automated safety features into the FPSO and drill ships to minimize the risk of any fire (e.g., fire detection, automated shut-off valves, alarms, deluge system, fire protection) as well as train operations and maintenance crew. Additionally, have a robust emergency response plan to direct activities in the event of such a fire in the FPSO and drill ships.
Chapter 9	Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA.
Chapter 9	In the case of a spill response, deploy air-monitoring equipment to monitor levels of air pollutants and provide appropriate personal protective equipment, as necessary, to those oil spill response workers who have the potential to be exposed.
Chapter 9	Mitigation measures consistent with good international oilfield practices, together with existing embedded controls, should be implemented in the unlikely event of a vessel

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	collision. In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, restitution should be provided in appropriate cases, consistent with governing contracts and applicable laws.
	In the event of a spill that could have transboundary impacts, EEPGL should work with representatives of the respective countries that could be potentially impacted, to perform the following: • Coordinate operations and communications between different command posts; • Create a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues (wastes collected in countries outside of Guyana should be handled according to the regulations required specific to that location); • Identify places of refuge in the impacted region where response vessels could go for repairs and assistance; • Determine how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions; • Determine financial liability and establish claims and/or livelihood remediation processes during a response to a transboundary event; and • Work with local communities within the impacted areas to raise awareness of oil spill planning and preparations.
Chapter 10	Continue to measure and report the Project's GHG contributions to national emissions. Continue to assess measures that can be taken to minimize GHG emissions during each project's production operations stage, and ensure that a Best Available Technology assessment process (i.e., as conducted for the Yellowtail Project) be undertaken to assess the feasible and appropriate embedded controls and mitigation measures that can be implemented to reduce GHG emissions.
Chapter 10	As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions.
Chapters 8 and 10	Continue monitoring of plans for further expansion of the Haags Bosch Landfill (HBL) and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.
Chapters 6 and 13	If well testing[4] is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical; • Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[5] to the sea; • Provide adequate gas sensors that are appropriately located during testing operations so that all sources of gas can be detected;

[4] While well testing is not planned for the Project, there is the potential it could be needed, in which case EEPGL should implement the measures in Table 13-1 of the EIA.
[5] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

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	• Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program; • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test; and • Provide sufficient compressed air to the oil burner for efficient flaring assignment.
Chapters 9 and 13	With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Use controls for mitigating a failure of the Dynamic Positioning (DP) system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – DP proving trials; – System Failure Mode and Effects Analysis; – DP failure consequence analysis; and – Establishment of well-specific operations guidelines.
Chapters 7 and 13	Prior to and post-drilling, a remotely operated vehicle should take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Chapter 13	Install subsea BOP systems consisting of one annular preventer, two shear ram preventers, one of which must be sealing, and two pipe ram preventers, and equip them with choke and kill lines and failsafe choke and kill close valves.
Chapter 13	Utilize a BOP that is able to close on the maximum outside-diameter drill pipe string used for the drilling operations and that contains a safety system to secure the well in the event of a loss-of-control signal and hydraulic supply from the surface to the BOP. At a minimum, subsea BOP systems should allow closure of one set of pipe rams and blind-shearing type rams by remotely operated vehicle intervention if required.
Chapter 13	Facility personnel should conduct bi-weekly well-control drills, or as operations allow, which should be attended by key personnel.
Chapter 13	Prepare contingency plans for well operations that include identification of provisions for well capping in the event of uncontrolled blowout (providing indication of the tools, equipment, and intervention time required) and identification of spill recovery measures.
Chapters 6 and 13	Install waste heat recovery units on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption.
Chapters 6 and 13	Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.
Chapters 6 and 13	Use a gas turbine to drive the export/injection compressors directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor—reducing motor losses and power generation losses.
Chapters 6 and 13	Use large, high-voltage motors, which are more efficient than industry standard machines.

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Chapters 6, 9 and 13	Provide installed spares on compressors for the Flash Gas Compression, Main Gas Compression, and Re-injection Gas Compression systems, such that when one compressor trips, the spare (backup) unit can be started, hence reducing non-routine flaring frequency and volume/duration.
Chapters 6 and 13	Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.
Chapters 6 and 13	Use highly efficient combustion equipment that utilizes heat recovery systems as part of the heat and power production.
Chapters 6, 9 and 13	With respect to non-routine flaring of associated gas, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low nitrogen oxides emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO; • Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.
Chapters 6 and 13	Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Chapters 6 and 13	Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.
Chapters 6 and 13	Adopt measures as far as practicable, in accordance with the Global Gas Flaring and Venting Reduction Partnership when considering venting and flaring options under emergency or upset conditions.
Chapters 6 and 13	Avoid routine venting (excludes tank flashing emissions, standing/ working/breathing losses, secondary seals) except during safety and emergency conditions.
Chapters 6, 7 and 13	Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.

EIS Chapter	Commitment
Chapters 6, 7 and 13	Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Chapters 6, 7 and 13	Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Chapters 9 and 13	Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.
Chapter 13	Adopt risk assessment processes (e.g., hazard and operability study, hazard identifications study, etc.) to assess risks associated with process upset and loss-of-containment events which could impact the environment.
Chapters 9 and 13	Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.
Chapters 9 and 13	Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.
Chapter 13	Use a liquid hydrocarbon checklist before every bulk transfer.
Chapter 9	Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent reasonably practicable.
Chapter 13	Utilize procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.
Chapter 13	Install an Emergency Shutdown System on the FPSO to initiate automatic shutdown actions to bring the offshore facility to a safe condition and which should be activated in case of any significant release.
Chapter 13	Implement a corrosion management system to monitor risks and identify corrective actions in the atmospheric zone, splash zone, submerged zone, and internal zones.
Chapters 9 and 13	Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, in order to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.
Chapter 13	Use low-sulfur (less than 0.5% sulfur content) fuels and/or natural gas on all Project vessels in turbines, reciprocating engines, or boilers used for heat or power generation or to drive machinery such as compressors or pumps.
Chapter 13	Abide with International Maritime Organization guidelines (IMO 2004) including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with the MARPOL 73/78.
Chapter 13	Implement engineering controls, administrative controls, and training to protect offshore workforce from high noise levels in the offshore work environment.
Chapters 7 and 13	Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Chapters 8, 9 and 13	Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.
Chapters 6 and 13	Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Chapters 6, 7 and 13	Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. The chemical

EIS Chapter	Commitment
	selection process should be aligned with applicable Guyanese laws and regulations and include: • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; and • Risk evaluation of residual chemical releases into the environment.
Chapters 7 and 13	Utilize low-toxicity chemicals/materials where practical. Each chemical/material should be managed in accordance with the associated Safety Data Sheet.
Chapters 9 and 13	Regularly (e.g., monthly) check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks and fugitive emissions.
Chapters 8 and 13	For transport of hazardous and nonhazardous wastes offsite for treatment or disposal, confirm the waste is accompanied by a manifest signed by the hazardous waste generator, transporter, and receiving facility.
Chapters 7 and 13	Secure and contain fuel, oils, and chemicals in accordance with their Safety Data Sheet recommendations.
Chapters 8 and 13	Provide for adequate onshore waste-management equipment and facilities for the proper management of waste in accordance with local regulation and good international oilfield practice.
Chapters 8 and 13	For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, properly manifest and transfer such wastes to appropriate onshore facilities for management.
Chapters 8	Document marine waste transfers.
Chapters 8 and 13	Sample and perform analytical testing as needed to properly classify waste.
Chapters 8 and 13	Complete Recoverable Material and Waste Summaries.
Chapters 8 and 13	Periodically audit waste contractors to verify appropriate waste management practices are being used.
Chapters 8 and 13	Record type and quantity of each individual waste stream on board vessels any time a new waste is generated.
Chapters 8 and 13	Inspect on a regular basis waste storage areas and containers; log inspections.
Chapters 6, 7 and 13	Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.
Chapters 8 and 13	Provide health-screening procedures to Project workers to reduce risks of transmitting communicable diseases.
Chapters 8 and 13	Monitor Project workers' occupational exposure to sound.
Chapters 8 and 13	Test for diseases that are communicable through normal medical screening/surveillance.

EIS Chapter	Commitment
Chapters 8 and 13	Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.
Chapters 8 and 13	Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis.
Chapters 8 and 13	Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis.
Chapters 8 and 13	Develop and implement a Stakeholder Engagement Plan.
Chapters 8 and 13	Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities.
Chapters 8 and 13	Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate
Chapters 8 and 13	Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.
Chapters 8, 9 and 13	Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The Road Safety Management Procedure has been implemented as of the writing of the EIA, and the procedure includes the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods
Chapters 8 and 13	Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.
Chapter 13	Use an established Safety, Security, Health, and Environment program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Require all workers and contractors to receive training on implementation of these principles and to adhere to them in the daily execution of their duties.
Chapters 9 and 13	Maintain an OSRP to support an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP. Conduct periodic inspections, training and drills including monthly inspection of oil spill response equipment, quarterly test runs of oil spill response equipment, annual preventive

EIS Chapter	Commitment
	maintenance program execution, and annual exercise and deployment of oil spill response equipment to test readiness and response capability.
Chapter 13	Install volatile organic compound recovery on the FPSO cargo tanks, which results in a reduction in FPSO cargo tank emissions.
Chapters 6 and 13	Optimize gas turbine maintenance so that gas turbines are not overhauled more often than needed, and so that overhauls are completed at the right time, in alignment with other FPSO maintenance activities to reduce the need to flare.
Chapters 6 and 13	Implement trip reduction initiatives for the gas turbines to improve reliability/ availability and thus reduce flaring.
Chapters 8, 9 and 13	Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
Chapters 9 and 13	Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.
Chapters 8 and 13	Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.
Chapter 8	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners.
Chapters 8 and 13	Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.
Chapters 8 and 13	Train Project and contractor personnel with the potential to identify underwater chance finds so that these operators are informed about the identification of chance finds, appropriate use of the Chance Find Procedure, and monitoring and reporting requirements
Chapters 8 and 13	Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.
Chapters 8 and 13	Use a dedicated medical provider to complement the services of the local private medical clinic used by the Project, and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure (ambulance has already been procured as of the writing of the EIA).
Chapters 9 and 13	Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate personal protective equipment by response workers; and • Implementing a Wildlife Oil Response Program, as needed.

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APPENDIX W

Meeting Records—EIA Development

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Meeting Summary

Engagement title: **ALMOND BEACH CDC**

Date: September 20, 2021 **Time:** 9 am **Venue:** By Telephone

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Tourism/Eco Tourism Activities
- Fishing & Hunting Activities
- Marine Activities (Including Piracy)
- Other Livelihood Activities
- Changes to fishing locations as a result of beach erosion
- PAC Turtle Monitoring Program

Documents (minutes, PPT, etc.)

- None

Summary of discussion

The community continues to grapple with the rapid erosion of its beaches, affecting farmlands, turtle nesting, and causing the re-location of buildings. Additionally, changes in rainfall patterns and tide patterns are significantly impacting fishing patterns and yields, agriculture, and turtle nesting.

Key issues raised

- Erosion – affecting life and livelihoods
- Migration of fishes – due to changing water patters caused by changing rainfall patterns
- More frequent and higher high tides causing damage to farms
- Loss of T&T Coconut market due to COVID-19

Action items:	Assigned to:

Next steps:

Notes:

- No changes to tourism plan, however, due to COVID-19 no visitors were allowed by the PAC so tourism is at a standstill.
- There have been changes in the water patterns due to fluctuations in rainfall patterns, causing the fishes to migrate to the Pomeroon mouth and reducing the catch in the village.
- There have been no changes to other marine activities including piracy, with no report of piracy by any local fishermen.
- There may have been instances where pirates on the high seas attacked coast landers; however, there is no major activity in terms of pirates affecting the community.
- Erosion continues to affect the nesting of the turtles on the beach.
- The beach is becoming narrower and shorter due to the rapid erosion. Public buildings have to be re-located due to erosion.
- Entire farms have been lost to erosion; therefore, it is significantly affecting agriculture, and forcing people to move. People are re-locating to Moruka and Mabaruma, with some people awaiting land to be allocated to them in Mabaruma.
- There is no significant livestock rearing in the community.
- Farming is being affected by flooding from more frequent and severe high tides.
- COVID-19 caused the loss of the coconut market in T&T. This was a big setback to the community and remains a big challenge, as they now have no market for the coconuts from the farms not devastated by the erosion.
- The PAC has continued their work under imposed restrictions and guidance. There are currently 3 staff on the ground and locals from other communities outside of Almond Beach Community have been involved.

Meeting Summary

Engagement title: **ARUKA MOUTH CDC**

Date: September 20, 2021 **Time:** 10 am **Venue:** By Telephone

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Tourism/Eco Tourism Activities
- Fishing & Hunting Activities
- Marine Activities (Including Piracy)
- Other Livelihood Activities

Documents (minutes, PPT, etc.)

- None

Summary of discussion

Fishing is a major activity in the community, while tourism, hunting, and livestock are minor. The two main challenges the community is facing are a sharp rise in piracy and decreasing fishing yields due to the increasing frequency and intensity of high tides and floods.

Key issues raised

- Increase in attacks from Venezuelan Pirates
- Decreasing fishing yields due to changing weather and tide conditions

Action items:	Assigned to:

Next steps:

Notes:

- Tourism in the community is almost non-existent.
- Fishing is a major activity in the community and the fisherfolk know the fishing patterns. However, they are not getting the yield that they would normally get at given times. This is due to the frequency and intensity of the high tides and floods from excessive rainfall.
- Not a hunting community and not aware of any changes in hunting patterns.
- Piracy has increased significantly, and this has caused people to curtail their fishing activities, affecting people's ability to earn an income and a livelihood. Most of the pirates come from the Venezuelan border.
- They are having challenges with the chicken they are sourcing from Georgetown being very small, and this is affecting the livestock rearing. There are no other changes in other forms of livelihood.

Meeting Summary

Engagement title: **BARABINA VILLAGE COUNCIL**

Date: September 20, 2021 **Time:** 11 am **Venue:** By Telephone

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:	Documents (minutes, PPT, etc.)
■ Tourism/Eco Tourism Activities ■ Fishing & Hunting Activities ■ Marine Activities (Including Piracy) ■ Other Livelihood Activities	■ None

Summary of discussion

Fishing done in the savannah/swamp areas is a major economic activity of the community. Fishing yields have been decreasing due to increasing water levels, making it harder for the fisherfolks to earn a livelihood. Hunting has also become more challenging as the animals have receded further into the forest.

Key issues raised
■ Decreasing fish yields due to higher water levels ■ Changing hunting patterns as animals recede further into the forest

Action items:	Assigned to:

Next steps:

Notes:

- Not a tourism community.
- Fishing is a major economic activity in the community where fishing is done in the savannah/swamp area. Yield has reduced; however, unclear of the reason why – may be due to climate change. When the water is too high, the yield is less and the water has been excessively high more often than in has the past.
- Hunting patterns have changed as the animals are receding further and further into the forest, and the hunters have to go deeper into the forest. Consequently, their catch is also decreasing.
- No issue with piracy.
- No other marine activity changes.
- No changes to the other livelihood activities such as farming, and livestock rearing.

Meeting Summary

Engagement title: **GIBRALTAR/FYRISH NDC**

Date: September 17, 2021 **Time:** 2 PM **Venue:** By Telephone

Stakeholder representatives:	**Consultants team:**	**EEPGL team (if applicable):**
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Impact of the recent floods on the communities
- Impacts of COVID-19 on the communities commodities prices and cost of living in the communities
- Ecosystem Update

Documents (minutes, PPT, etc.)

- None

Summary of discussion

Almost 80 percent of the NDC–100 or more households–depend on farming, mainly cash crops, and the flooding of both the back dams and the residential areas devastated this. Livestock, also a significant economic activity in the communities, was devastated by the loss of thousands of heads of cattle and poultry. COVID-19 has also severely impacted the community with many small businesses being forced to close, some permanently.

Key issues raised

- The significant impact of the floods on the main economic activities in the communities
- The pandemic caused many businesses in the communities to close, some permanently, equally affecting both men and women
- The floods and COVID, along with increasing commodities prices, food insecurity, and rising unemployment, is frustrating the villagers as their standard of living is decreasing

Action items:	**Assigned to:**

Next steps:

Notes:

Flood Impact

- Entire backdam/cultivation area was flooded as it does not have sufficient drainage, and all of their cash crops were lost, including ground provisions such as plantain and cassava, as well as other cultivations.
- Residential areas also flooded as water build-up from the estate came into the residential areas.
- A farming association controls the farming areas.
- Majority of people cultivate crops and livestock.
- About 80 percent of the NDC (100-plus households) depends on farming, mainly cash crops for their livelihoods.
- Livestock losses were suffered by 50 percent of the community, losing a tremendous amount of goats, pigs, cattle, and sheep, with the average loss per family or household of 100 heads of sheep.
- Poultry loss was also severe in the area, with several big poultry farmers each losing thousands of poultry.
- Food insecurity increased in the communities due to the floods.

COVID-19 Impact

- Many people were unable to work and did not receive any relief from local or national governments.
- Most of the small businesses had to close as a result of both the pandemic and floods; some closed permanently and some closed temporarily.
- About 50 percent of businesses that were forced to close will not be able to re-start operations.
- Pandemic is equally affecting men and women in the communities.
- COVID-19 situation was helped by the first relief grant, but not by the second relief grant.
- People's movement to conduct business and access services outside of the community has been restricted.
- Community is feeling very frustrated.

Ecosystem

- Mangroves
  - Mangroves have decreased in the areas due to coastal erosion.
  - No harvesting of the mangroves by residents is being done.
  - Crabbing by outsiders does occur in the mangroves.
  - People in the community seldom visit the mangrove area.

Commodities Prices

- All commodities in the supermarket increased while people's income has decreased.

Meeting Summary

Engagement title: **KINTRYE NDC Region 6**

Date: September 9, 2021 **Time:** 11 AM **Venue:** By Telephone

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Impact of the recent floods on the communities
- Impact of COVID-19 on the communities
- Commodities Prices and Cost of Living in the Communities
- Fishing and Livestock Activities in the community
- Ecosystem Update
- Coping Mechanisms

Documents (minutes, PPT, etc.)

- None

Summary of discussion

The community is recovering from the recent floods, which resulted in loss of rice farms due to the damaged trails that are used to access farms. This has significantly impacted the livelihood of the villagers. COVID-19 and high food prices has further eroded the standard of living in the village. The already high youth employment has increased, as well as an increase of cost of living for families who are trying to pick up the pieces and move on utilizing the assistance provided by the government and using up their savings.

Key issues raised

- Damage to trails to access cultivation lands, significant loss of cultivation because of the floods
- COVID-19 increased youth unemployment
- Mangrove being lost due to sea erosion
- Household expenditure has increased due to increasing food and commodities prices

Action items:	Assigned to:

Next steps:
Notes:

Flood Impact

- Dams and streets were not affected in the community.
- The trails to farms were destroyed and farmers had to use boats to access and bring produce out from farms.
- Tractors could not access farm.
- Rice farms were destroyed and some farmers lost as much as 50-100 acres, and as little as 5-7 acres.
- Flood did not impact cattle livestock in the area, and this remains the same despite some cattle being lost in the Savannahs.

COVID-19 Impact

- A further increase in the already high youth unemployment.

Livestock and Herding

- This is a cattle-rearing community
- Two months ago has affected cattle; meat birds also affected to varying degrees
- Most are farmers for livestock and losses are not an easy thing to adjust to

Fishing Activities

- Fishermen with boats and seines
  - About 51 boats, most use seine.

Ecosystem

- Mangroves increase, people do not use the mangroves - mangrove loss as a result.
- Mangroves in some areas are devastated by sea erosion.
- Local farmers are going through a difficult time

Commodities Prices

- Food prices increased as well as corresponding items that people use for food has increased.
- Household expenditure has increased.
- Some small shops/community grocery shops have closed permanently as a result.

Coping

- Receiving grants from government and additional assistance.
- Utilizing savings for food and lodging.

Meeting Summary

Engagement title: **LANCASTER/HOGSTY NDC**

Date: September 14, 2021 **Time:** 2 PM **Venue:** By Telephone

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Impact of the recent floods on the communities
- Impacts of COVID-19 on the communities
- Commodities Prices and Cost of Living in the Communities
- Fishing activities in the community
- Project concerns

Documents (minutes, PPT, etc.)

- None

Summary of discussion

The communities in the NDC suffered tremendously from the floods, losing the majority of their cash crops, rice, and livestock. This has plunged these low-income communities further into poverty. Coupled with the COVID-19 challenges, families are finding it hard to meet their basic needs. Additionally, COVID-19 has put a mental strain on families who are confused, misinformed, worried, and unsure about the vaccines. The high and rising commodities prices put further strain on households with out-of-school children having to work to support the struggling parents in these communities.

Key issues raised

- Flood Impacts – Loss of livestock, cash crops and rice; damage to access dams and trenches; loss of investment and income; reduced spending power; shortage of cash crops leading to increased prices
- COVID-19 Issues - Has impacted families psychologically, socially, economically; there is hesitancy to take the vaccine due to misinformation; 3 villages in the district classified as hotspots
- High commodities prices reducing standard of living

Action items:	Assigned to:

■ The need for ExxonMobil to have an oil spill emergency plan that includes compensation for any losses suffered ■ The need to see ExxonMobil giving back at the community level and assisting with their developmental plans		

Next steps:

Notes:

How has the community been impacted by the recent floods?

- Many instances of loss of livestock, rice, and cash crops.
- Severe damage caused to access dams leading to back lands under cultivation requiring machinery to repair, but not getting the co-operation of the Region.
- There was no outbreak of diseases in the district.
- The communities in the district are trying to recover as best as they can from the losses and to rebuild their livelihoods.
- There are discrepancies in the Government Assistance Program and many eligible persons in the community have not benefited.
- The political culture is interfering with and hindering organized efforts to rebuild.
- One Councillor asking for assistance for flood victims from ExxonMobil.

How is COVID-19 impacting the community?

- The Public Health Inspector shared that three communities in the district currently classified as COVID-19 Hotspots.
- There is a reduction in movement and association of people in the district.
- There is a lot of reluctance to take the vaccine in spite of efforts to share information and to educate people; people have their own views, positions, and sources of information.
- People in the district are resistant to the mandatory approach of the vaccination program.
- There is a psychological impact as people are confused and worried, they are exposed and they don't know what to believe, what is fact, what is not; they are concerned about having to send their children out to school with all the risks and these are all affecting them psychologically.
- The economic impact of the pandemic in the district has been great, with farming activities curtailed, shops, restaurants not profitable and people trying to find alternative means of earning a living. Even the NDC is struggling to collect Rates & Taxes.

Any recent increases in prices of commodities?

- Prices for everything have gone sky high and people can't provide for their families.
- Most people in the district work in agriculture and the floods and situation at GUYSUCO has contributed to the economic situation.

- The district is mainly comprised of low-income families that are under severe pressure from rising food and commodities prices.
- People are spending more money to get less stuff.

What changes have occurred to fishing activities and harvests?

- Noticed an increase in dead fishes on the two beaches in the community.
- Doesn't have any information on fishing but will look into this area for future discussions.

Any other concerns the Community Has About the Project?

- Community needs to have a better understanding of whether the long-term removal of oil will create negative environmental issues.
- The district is asking for an Oil Spill Emergency Response Plan to be in place. This is very important given that they are farmers on the coastland.
- Community needs reassurance of compensation in case of losses suffered from any oil spill.
- Community need to see more community level donations from ExxonMobil, and need to see them giving back more to depressed communities and assisting in their developmental efforts.

Meeting Summary

Engagement title: **NAREI – NATIONAL AGRICULTURAL RESEARCH AND EXTENSION INSTITUTE**

Date: September 9, 2021 **Time:** 1:30 PM **Venue:** Virtual Meeting

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Ecosystem Updates
- COVID-19 Impacts

Documents (minutes, PPT, etc.)

- Mangrove extent cover analysis that was done was in 2018
- Preliminary report of the investigation of the erosion at Shell Beach
- Annual Report 2019 & 2020
- 2021 Projects & Future Restoration Plans
- Spatial data on restoration activities

Summary of discussion

Key issues raised

- Current Trends In Mangrove Health
- Shell Beach Erosion
- Restoration and Conservation Activities
- COVID Impact on Community Engagements

Action items:	Assigned to:

Next steps:

Notes:

Ecosystems Update

- Current Trends In Mangrove Health
  - NAREI does not monitor Mangrove Health along the entire coast, however, they would have data for their specific restoration sites. The most recent updated mangrove extent cover analysis that was done was in 2018 and this dataset can be shared.
  - NAREI is working to update this to a 2020 baseline by the end of this year. This is a project with Severe Amazonia. The pilot site to Region 2 has been completed, as well as some ground-truthing exercise for Regions 2 and 3. There are some remote sensing analyses being done for the other regions, which will be followed by ground-truthing exercise for those regions.
- Shell Beach Erosion
  - With respect to Region 1, based on the reports of erosion at Shell Beach, NAREI would have recently started initial investigation on the rate of erosion using remote sensing. The officers are currently working on this, and a preliminary report may be available for sharing.
- Current & Planned Initiatives
  - NAREI'S Annual Reports for 2019 and 2020 will be shared. Projects that are currently being implemented for 2021, as well as future restoration plans, will also be shared.
  - Contract being finalized with a consultancy for a plan that will guide NAREI'S restoration and conservation activities for the next ten years. This consultancy is being supported by Conservation International Guyana and engagements should start by the end of this month.
- Restoration Site Data
  - The restoration activities being conducted are not only mangrove seedling planting. There is spatial data on these sites that can be provided.

COVID-19 Impacts

- BV/LBI Restoration Project was delayed due to limitations in the supply of materials needed. The contractor faced issues with supplies of rocks from the quarry due to the pandemic restrictions.
- The pandemic significantly impacted NAREI's community engagements and public awareness activities, as these are traditionally done face to face. These community level engagements were restricted and social media had to be used as a substitute to disseminate information and engage with the public.
- Mangrove-derived products, specifically bee keeping, were impacted due to the rainy season, resulting in a significant shortfall in honey production and the supply.
- The Mangrove Heritage Trail Tour was suspended last year due to COVID-19. Additionally, the tour will have to be relocated from the Guyana Women's Leadership Institute that is traditionally used, so the tour has not been re-launched as of yet.

Meeting Summary

Engagement title: **NO. 52 / NO. 74 VILLAGES NDC**

Date: September 9, 2021 **Time:** 11 AM **Venue:** By Telephone

Stakeholder representatives:	**Consultants team:**	**EEPGL team (if applicable):**
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Impact of the recent floods on the communities
- Impacts of COVID-19 on the communities
- Commodities Prices and Cost of Living in the Communities
- Fishing activities in the community
- Project Concerns

Documents (minutes, PPT, etc.)

- None

Summary of discussion

The villages in this NDC have seen an increase in fishing activities, with fishing being a major economic activity in the district. There are approximately 400 boats in No. 57 Village and approximately 100 new boats in No. 65 village.

Key issues raised

- Changes to fishing activities in the community

Action items:	**Assigned to:**

Next steps:

Notes:

What changes are there to fishing activities and harvests?

- There has been an increase in fishing activities, with the closure of the sugar estates contributing to this as people seek other means of earning a livelihood.
- There has been a shift to Suriname:
  - There are approximately 400 boats at No. 56 Village and these boats are now docking in Suriname.
- There are approximately 360 boats still in the outfall.
- The number of boats involved in fishing activities with shrimp has increased by 100 boats in the No. 65 Villages.
- No. 63 Village remains the same with seine fishing boats.

Meeting Summary

Engagement title: **PARIKA NDC**

Date: September 9, 2021 **Time:** 11:00am **Venue:** Parika Village Office

Stakeholder representatives:	**Consultants team:**	**EEPGL team (if applicable):**
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:	**Documents (minutes, PPT, etc.)**
■ Impact of the recent floods on the communities ■ Impacts of COVID-19 on the communities ■ Fishing activities in the community ■ Ecosystem Update	■ None

Summary of discussion

Businesses in the community were severely impacted by the pandemic restrictions, and as people were desperately trying to recover, the floods hit, further devastating the business sector and further slowing down the economy. Rice and cash crop frames were significantly affected, as were people's kitchen gardens that they depended on to put food on the table. Both men and women were affected, with the community become heavily indebted, and some people were unable to recover. There is concern for the mangroves that are decreasing due to development, sea defence works, and coastal erosion.

Key issues raised
■ Flooding & COVID – caused a slowdown of business in the community, increased indebted, and forced some people out of business
■ There is concern for the decreasing mangroves in the district
■ Fishing catch has decreased, supply reduced, and price increased in the market

Action items:	**Assigned to:**

Next steps:

Notes:

Flood Impacts

- Rice crops were destroyed by the flooding
- Significant livestock was lost
- The black water in many of the villages was affected by the flooding
- Household and kitchen gardens were affected by the flooding
- The flood, along with the pandemic, has created lots of indebtedness in the district with people defaulting on bank loans, investments, and other financial obligations

COVID-19 Impacts

- The temporary closure of business affected household income and some businesses were unable to re-open
- There was a general slow-down in business in the district and the country
- Villagers were desperately trying to get back on track when they were hit with the flood
- Snackettes, nightspots, and clothing stores were hard hit
- The loss of employment has equally affected men and women
- The pandemic and the flood have impacted the communities both directly and indirectly

What changes are there to fishing activities and harvests?

- There has been a decrease in catch; the fisherfolks are going out but not catching any fish. This has resulted in less fish on the market in the district.

Ecosystem Update

- Councillors concerned about mangroves and the impacts of development on the mangroves.
- Mangroves decreased in the past two years from coastal erosion and sea defence works. In one area, the mangroves were removed to facilitate sea defence works.

Meeting Summary

Engagement title: **Smith Creek CDC**

Date: September 20, 2021 **Time:** 2:00 PM **Venue:** By Telephone

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Tourism/Eco Tourism Activities
- Fishing & Hunting Activities
- Marine Activities (Including Piracy)
- Other Livelihood Activities
- Changes in the Fuel Trade

Documents (minutes, PPT, etc.)

- None

Summary of discussion

There are no changes to tourism, hunting, fishing, or marine activities in the community. However, the community is experiencing high unemployment and continued flooding from the rising river levels. Through a Presidential grant, the community is now involved in fuel trades being imported from Venezuela and traded to Port Kaituma. However, the selling price in Port Kaituma has dropped making business less profitable.

Key issues raised

- Attract and develop ways to increase tourist activity in village
- Unemployment is very high in the community
- Flooding of houses along river
- Fuel trade prices have dropped making it less profitable as a business

Action items:	Assigned to:

Next steps:

Notes:

- There are no changes in tourism activities in the community, with virtually no tourist activities occurring in the community.
- The Chairman would like for this to change and for there to be some developments to attract tourists to the village.
- This is not a hunting community and only a small number of people fish. There have been no changes in these activities.
- There have been no changes in marine activities and no issues with pirates.
- Through a Presidential grant, the community is now involved in the fuel trade. The fuel is imported from Venezuela and traded to Port Kaituma. However, the selling price in Port Kaituma has dropped making the business less profitable. They are seeking a compensating reduction in cost.
- Unemployment is very high in the community.
- The houses are along the river are prone to flooding with every spring tide due to the river levels rising.
- The government is undertaking a project to impolder over 100 acres of land and to build houses in the impoldered area to prevent the flooding. After this, they will be better able to maintain kitchen gardens and cash crops.

Meeting Summary

Engagement title: **Civil Defence Commission**

Date: September 15, 2021 **Time:** 10:00-10:30am **Venue:** Virtual Meeting

Stakeholder representatives:	**Consultants team:**	**EEPGL team (if applicable):**
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Oil Spill Response Plan
- Any questions and concerns related to the proposed Yellowtail Development Project

Documents (minutes, PPT, etc.)

- CDC Guyana National Oil Spill Contingency Plan

Summary of discussion

Stakeholder engagement and consultation has been conducted in Regions 1-6, to ensure both positive and negative feedback is collected and integrated into the EIA. Adjust plans and form new ones in response to feedback and address the concerns of people. In the event of an oil spill, further clarity needs to be provided on the response plan which will be used. Continued communication and engagement is required to ensure the EIA encompasses all concerns from affected stakeholders.

Key issues raised

- Increase stakeholder engagement with Region 1 communities to contribute to EIA process
- EPA needs to conduct their own survey to have an independent EIA completed
- Clarity needs on what plan will be used in the event of an oil spill

Action items:	**Assigned to:**

Next steps:

Notes:

What response is there by EEPGL that is in keeping with our plan?

- These consultations are an avenue for agencies to give their input and share concerns that they wish to have covered in the EIA for the Proposed Yellowtail Project.

There needs to be community level participation, particularly in the Region 1 area, and make communities in Region 1 partners in the EIA process

- The consultants that are conducting the stakeholder consultations for this EIA have engaged dozens of agencies spanning from Regions 1-6. We have met with residents of Region 1, and are scheduled to meet with the community again on Saturday, to ensure that all their concerns, positive and negative feedback, are documented and included in the EIA.

What/whose plan will be used in the event of an oil spill?

- From these consultations, we are able to document positives and negatives, this helps us to have a comprehensive EIA, which will lead to adjustments to plans and formation of new ones to address concerns of the people.

The EPA should have their own survey to have an independent EIA done. This will help the agency to know exactly which species are being affected and which parts of the environment is being directly affected by the oil and gas industry.

- Noted, this will be suggested to them, many agencies lack the resources to carry out these as you mentioned.
- There needs to be a local content with MARAD, etc. in terms of where the trajectory will go.

Meeting Summary

Engagement title: **Conservation International**

Date: September 10, 2021 **Time:** 13:00-14:00 **Venue:** Virtual Meeting

Stakeholder representatives:	**Consultants team:**	**EEPGL team (if applicable):**
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Changes in Guyana's use of, or reliance on, marine or coastal ecosystem services in the last two years
- Any recent research or other initiatives that CI may have participated in within the past two years that could provide information to better characterize coastal or marine resources in the Guyana EEZ

Documents (minutes, PPT, etc.)

- None

Summary of discussion

There is a lack of information on marine and coastal ecosystems and not much has been done to fill these data gaps especially as they relate to oil and gas activities. There have been mass killings of fish in the area and it is unclear as to the source for the incidences, and studies need to be conducted to determine why this is occurring. Additional resources are needed for cleaning up ecosystems and oil spills, as it is not part of CI's mandate or budget. Research and studies are being conducted to look at erosion, mangroves, coastal ecosystems, and soil sediments to better understand the movement of mud banks. Further studies on climate change impacts would be helpful in understanding the changing ecosystems, and continued local community engagements are taking place.

Key issues raised

- Lack of information on marine and coastal ecosystems
- No study on the benefits of mangroves and ecosystems
- Unknown cause of mass killing of fish in the area

Action items:	**Assigned to:**

Next steps:

Notes:

- Lack of information on the marine and coastal ecosystems; not much has been done to fill these data gaps in increased activities around oil and gas development. It is important that the data gaps are filled.
- I am aware that some assessment on some of the key aquatic food species, but no list was provided from that realm.
- No study on the benefits of mangrove and other ecosystems developed.
- Observations made:
  - More patches of brown water that is oxygen depleted
  - Spending longer out at seas to catch fish, and the catches are longer
  - The overall catch is less
  - Some significant focus on the stock assessment, the sea-bob industry
- Recent incidence brought to attention:
  - Mass fish kill along the entire coast of the northwest. We are not sure of the cause, but those kinds of events emphasize the need for us to have a better understanding of the marine activities in the coastal realm and to fill the data gaps. If the gaps aren't filled we won't be able to expand activities within the marine realm.
  - There was also dead fish washing up along the Kingston foreshore. We are not sure if this is due to the drilling offshore, but studies need to be conducted to determine why this is happening.
- We are run by donor funds, so cleaning up of ecosystems, and oil spill response is not in our mandate and we lack resources to do this.

Any recent research or other initiatives that CI may have participated in within the past two years that could provide information to better characterize coastal or marine resources in the Guyana EEZ?

- We are working with a company to look at the erosion, mangroves and coastal ecosystems/growth of land and capture of soil sediments washed from the Amazon River in order to try and better understand the movement of mud banks. We also conducted studies on mangroves, and the results are available online, in order to understand marine and a coastal space. We also have a study on mangroves that we are wrapping up and would be available by October 2021.
- Studies on climate impacts, in terms of direct immersions, any impacts on the ability of ecosystems to carry out the function of removal of carbon from the atmosphere, and ecosystems to help people to adapt to climate and rising sea levels would be useful.
- Meaningful Local Community Engagements:
  - Water quality testing around FPSO and wider ecosystem
  - Flaring volumes
  - Extensive marine mammal surveys
  - Documents on the mangrove and conservation projects can be found here: https://nbslmegef.wordpress.com/

Meeting Summary

Engagement title: **Gender Affairs Bureau – Ministry of Human Services and Social Security (MoHSSS)**

Date: September 17, 2021 **Time:** 10:30-11:30 **Venue:** Virtual Meeting

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:	Documents (minutes, PPT, etc.)
■ COVID-19 related impacts on women ■ Women's experiences with offshore developments to date ■ Perceived challenges and opportunities in the oil and gas sector ■ Any questions and concerns related to the proposed Yellowtail Development Project	■ None

Summary of discussion

COVID-19 specifically impacted women's health, reproductive health, mental health, economic growth, caregiving requirements, and safety.

Women are experiencing gender inequality, discrimination and harassment while working jobs in the extractives sectors. Additional protection through policies and training is needed to protect women. However, economic opportunities can be brought forward for women in spin-off roles from new developments in the extractives sector, such as hospitality and catering services.

Key issues raised
■ Negative impact of COVID-19 specifically on women (health, income, violence)
■ Gender equality and protection for women needed in the extractives sector
■ Policies and training needed to be implemented to protect women

Action items:	Assigned to:

Next steps:

Notes:

COVID-19 related impacts on women

- Majority of front-line workers are women, so their COVID-19 exposure is high
- Women's reproductive health suffered due to COVID-19 as pregnant mothers found it challenging to get the care they needed. They could not access healthcare facilities because of the risk of becoming infected with COVID-19, as well as not having any access in some areas (significantly in Region 1 and 2 – in this context) to pre-natal services.
- Healthcare providers are focusing on COVID-19, so women's healthcare was seen as burdensome.
- Women burdened with childcare, due to the closure of schools (unpaid care work) and many women gave up employment in order to stay at home to care for children or elderly parents.
- There is a reduction in economic activity for women as women's income is centered around/on Trading and Vending.
- Venezuelan/migrant women have trouble with travelling and access to healthcare (especially since many are undocumented). Therefore, many are refused healthcare.
- Stigma and discrimination of women.
- COVID-19 was a contributing factor to un-reported violence and abuse experience by isolation of women.
- Economic circumstances creating mental health issues and suicide.

Women's experiences with offshore developments to date

- This sector is a "Man's World."
- How are women protected from abuse in the sector? Is there a gender policy? Anti-sexual Harassment Policy? Anti-Discrimination Policy?
- What is the level of jobs they do, and are they receiving representation in these sectors?
- What is the Corporate Social Responsibility of the Companies to provide gender equal jobs (how many women are at senior levels)? Is there a pay gap (equal work for equal pay)?
- Protection is needed for women against trafficking and anti-prostitution. There is a link between the sex trafficking industry and the large extractive industry, mining, and oil and gas industry; therefore, there must be systems in place to protect women against this.

Perceived challenges and opportunities in the oil and gas sector

- It will create economic opportunities for women – with jobs in spin off areas, women can play a great role in providing services to the sector e.g. hospitality management, catering, etc.
- A few women still complain about the sexism that exists in this sector where men believe it is not a place for women
- Provide training on diversity and inclusivity specifically targeted at men in the workplace

Any questions and concerns related to the proposed Yellowtail Development Project

- No

Meeting Summary

Engagement title: **Ministry of Health – Chief Medical Officer**

Date: September 30, 2021 **Time:** 13:00-13:30 **Venue:** Virtual Meeting

Stakeholder representatives:	**Consultants team:**	**EEPGL team (if applicable):**
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:	**Documents (minutes, PPT, etc.)**
■ Updated information on disease incidences ■ Updated health statistics ■ Update on healthcare resources ■ Impact of COVID-19 ■ Any questions and concerns related to the proposed Yellowtail Development Project	■ None

Summary of discussion
Information as noted below was provided subsequent to the meeting.

Key issues raised

Action items:	**Assigned to:**

Next steps:

Notes:

COVID-19- Overview of the situation in Guyana

The present Guyana COVID-19 situation as of 10th Oct 2021:

- Total number of COVID-19 cases: 33, 696 (Males: 15,947, Females: 17,749)
- Number of COVID-19 cases in ICU: 27
- Number of Deaths: 840
- Number of Recovered cases: 28,992
- Total number of COVID-19 Tests to date: 332,400

COVID-19 Vaccines

Guyana first received 24,000 COVID-19 vaccine doses in January 2021 through the COVAX Facility, a partnership between the Coalition for Epidemic Preparedness Innovations (CEPI), GAVI, the Vaccine Alliance, the Pan American Health Organization/World Health Organization (PAHO/WHO) and the United Nations Children's Fund (UNICEF). In May, another consignment of 38,400 vaccines arrived through the same arrangement. Guyana has also received vaccines through the CARICOM/ African Union agreement, USA, Barbados and CARPHA.

Guyana has approved the following vaccines for use AxtraZeneca, Sputnik V, Pfizer, Sinopharm, Sinovac, Moderna and Johnson and Johnson.

Adults

As of October 7th a total of 367,645 first dose (49.2% of total population; 71.7% of adults 18 and older) and 223,148 (31.2% of total population; 43.5% adults 18 and older) second doses have been administered.

Children and Pfizer vaccines (as of Oct 7th)

A total of 25,787 (35.4% of 12 – 17 years population coverage) 1st dose Pfizer have been administered and 15,196 (20.8% - 12 – 17 years population coverage) 2nd dose Pfizer.

New infectious disease hospital and its capacity

The Infectious Disease Hospital commissioned in July 2020 was established as a result of a burdened health system especially on the part of the tertiary hospital Georgetown Public Hospital Corporation (GPHC), receiving its first patient on September 1, 2020. The facility has a capacity for 190 beds and also caters for laboratories, a pharmacy, an ICU, an operating theatre, a mortuary and administrative offices.

The facility falls under the management of the GPHC. The hospital has a 120-regular bed capacity, 39-ICU bed capacity, which is more than the ICU at GPHC. It has 25 functional ventilator machines. It is manned by 50 doctors and 89 nursing staff. It also has a maternity section to manage COVID-19-positive pregnant women at the Centre for Disease Control and Prevention at Liliendaal.

Number of Physicians and Nurses per capita

Density of select health professionals shows that there are 11.2 doctors and 24.37 nurses per 10,000 population, as of 2020; indicating a marginal increase density from the previous year.

The table below shows the records available for number of doctors and nurses distributed in regions 1-6 for both public and private facilities.

Item	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6

Number of nurses (total)	46	74	124	1088	109	445
Number of physicians (total)	14	25	102	474	29	134

Health Status

The top causes of total number of deaths in 2019 across all ages combined are due to communicable, maternal, neonatal, nutritional diseases, non-communicable diseases and injuries. The same result in the most death and disability combined. Risk factors that drive the most death and disability combined are metabolic risks, environmental/occupational risks and behavioral risks. Of concern among environmental factors is air pollution, which is the ninth of the top ten risk factors.

Public Health and Environment	
Population using improved drinking water sources (%) Total	98.3 (2015)
Population using improved sanitation facilities (%) Total	83.7 (2015)

The Universal Health Coverage (UHC) effective coverage index represents service coverage across population health needs and how much these services could contribute to improved health. As of 2019, Guyana scored 40.6 for this index.

Updated Health Status – Mental Health

There has been a policy shift in the provision of mental health services in keeping with the World Health Organization's (WHO) recommendation of strengthen community mental health to reach the community to better provide necessary and essential mental health services. The Ministry of Health has since embarked on training a number of health personnel from different cadres across the county to be better equipped with skills to deal with mental health conditions of concern. The table below shows that number of facilities providing community mental health services across the six regions of interest.

Region	Hospitals	Health Centre	Health Post	Other Institution	Total
1	3	1	1	1	6
2	3	4	1	2	20
3	3	6	-	-	9
4	4	24	1	11	40
5	2	8	1	4	15
6	4	7	-	1	12

The table below shows the specific facilities with staff in mhGAP which is to aimed at closing the gap by scaling up care for mental health and substance use disorders.

Region	Hospital	Health Centre	Health Post	Other Institutions
1	Mabaruma Regional Hospital, Pakera District Hospital, Port Kaituma Hospital	Arakaka Health Center	Baramita Health Post	Ministry of Social Protection
2	Charity Hospital, Oscar Joseph District Hospital, Suddie Hospital	Guyana Sunrise Centre, Huist Dieren Health Centre, Windsor Castle Health Centre, Dartmouth Health Centre	Suddie Health Centre,	Blosson Inc, Ministry of Social Protection
3	West Demerara Regional Hospital, Wakenaam Cottage Hospital, Lenora Cottage Hospital	Versailles Health Centre, Canal #1 Health Center, La Grange Health Centre, Parfaithe Harmony Health Centre, Parika Health Centre, Vreeden-Hoop Health Centre		
4	Georgetown Public Hospital Corporation, Saint Joseph Mercy Hospital, CC Nicholson Hospital, Diamond Hospital	Albouystown Health Centre, Campbellville Health Centre, Dorthy Bailey Health Centre, Enmore Polyclinic, Grove Health Centre, Industry Health Centre, Kitty Health Centre, La Bonne Intention Primary Health Centre, Long Creek Health Centre, Melanie Health Centre, Buxton Health Centre, Mocha Health Centre, East La Penitance Health Centre, Mon Repos Health Centre, Soesdyke Health Centre, Plaisance Health Centre, Unity Health Centre, Nickona Health Centre, North East La Penitence Health Centre, Ogle Diagnostic Centre, Sophia Health Centre, Supply Health Centre, Timehri Health Centre, Victoria Health Centre,	Yarrowkabra Health Post	Guyana Prison Service, Guysuco, Mental Health Unit, Ministry of Education, Ministry of Health, Ministry of Social Protection, National Care & Treatment Centre, PAHO/WHO, Public Health Nurse Training, Positively United to Support Humanity, Suicide Prevention Helpline
5	Fort Wellington Hospital, Mahaicony District Hospital	Bush Lot Health Centre, Belladrum Health Centre, #28 Health Centre, Experiment Health Centre, Cotton Tree Health Centre, Rosignol Health Centre, Dundee Health Centre, Ithaca Health Centre	Rosignol Care Treatment Site	Regional Democratic Council, Bushlot Secondary School, Mangrove Organization Hugo Chavez Centre
6	New Amsterdam Regional Hospital, National Psychiatric Hospital, Port Mourant Hospital, Skeldon Hospital, Mibicuri Hospital	Rose Hall Health Centre, Angoy Avenue Health Centre, Bohemia Health Centre, Sand Vort Health Centre, Cumberland Health Centre, Lan-Liv-Man Health Centre, Whim Health Centre,		Regional Health Service

A total of 460 personnel have been trained including doctors, nurses, social workers, psychiatrists, psychologists, counselors, community health worker and others.

Meeting Summary

Engagement title: Ministry of Human Services and Social Security (Ministry of Social Protection)

Date: September 21, 2021 **Time:** N/A **Venue:** Emailed Response

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:	Documents (minutes, PPT, etc.)
■ Any data on the socio-economic impact of the Oil and Gas industry to selected groups in Guyana. ■ Any new data on Socio-economic impact analysis for: o Venezuelan migrant population o Other migrants living in Guyana ■ Perceived challenges and opportunities in the Oil and Gas sector	■

Summary of discussion

The Ministry of Human Services and Social Security currently provides humanitarian support interventions to vulnerable migrants from Venezuela and other migrants living in Guyana. The vulnerabilities that qualify a beneficiary to access interventions are not specific to the socio-economic impacts relative to the Oil and Gas Sector, rather the humanitarian interventions are developed in keeping with social safety standards and are provided on a needs responsive basis to qualifying beneficiaries. As such, the Ministry is unable to provide evidence-based data to support any socio-economic impacts on the migrant population in Guyana correlating to the Oil and Gas Sector.

Though there are several opportunities that can materialize from this sector, there are also many challenges. These relate particularly to the access of these opportunities for the vulnerable population who may have small business ventures without the adequate quality controls required to do business in this sector. As such, there needs to be training so that persons can be aware of the requirements, and receive the necessary assistance to capture these opportunities, whether it is via employment by firms who provide services, or by providing these said services from their small businesses.

Key issues raised
■ Access to opportunities in Oil and Gas for vulnerable populations

Action items:	Assigned to:

Next steps:
Notes:

Meeting Summary

Engagement title: **Ministry of Tourism, Industry and Commerce**

Date: September 20, 2021 **Time:** 13:30-14:30 **Venue:** Virtual Meeting

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Economic data on business performance and outlook
- Any questions and concerns related to the proposed Yellowtail Development Project

Documents (minutes, PPT, etc.)

- Guyana Tourism Authority data

Summary of discussion

The Ministry of Tourism, Industry and Commerce does not collect its own data on business performance. They rely on the GDP data classified by sector, which is produced by the Bureau of Statistics available at this website: https://statisticsguyana.gov.gy/data/data-tables/. GO-INVEST has data that are more current on the Oil and Gas industry.

Key issues raised

- See questions and concerns in Notes section provided by email subsequent to the meeting

Action items:	Assigned to:

Next steps:

Notes:

Questions and Concerns from the Ministry of Tourism Industry and Commerce

- Possible Positive Externalities on Economic Sectors
  - Will the project influence infrastructure and institutional developments that would otherwise not be developed?
  - Will the project cause an emergence of new industries or the development of new value-added products?
  - Will the project attract investments into the non-oil sectors?
  - Will the project absorb excess supply of labour?
- Possible Negative Externalities on Economic Sectors
  - Does the emergence of the new project cause increase demand for locally supplied good and services resulting in shortages or limited availability to non-oil buyers?
  - Does the demand for goods and services induced by the project affect (increase) prices?
  - Does prioritization of oil relation imports/exports produce cause delays in the trade relating to non-oil sectors?
  - Does employment in the new oil and gas project affect the supply of skilled labour and its availability to the non-oil sectors?

Meeting Summary

Engagement title: **Protected Areas Commission**

Date: September 30, 2021 **Time:** 15:00-15:30 **Venue:** Virtual Meeting

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:

- Concerns about Oil Spill Response Plan
- Concerns about marine turtles
- Changes noticed in your community in the last year
- Changes noticed in marine fishing/harvests, fishing areas, or vessel travel routes
- Questions or concerns about the activities occurring offshore (i.e., ongoing development of Liza 1 and 2, Payara, or planned future activities)

Documents (minutes, PPT, etc.)

- None

Summary of discussion

There were concerns around the oil spill response plan and marine turtles at Shell Beach. Shell Beach is a protected area, and therefore covered under the Protected Area Commission. There have been demonstration exercises carried out at Waini Point that EEPGL has participated in. In 2018 and 2019, marine turtle activity was studied and reported on in previous Environmental Impact Assessments which the Protected Area Commission participated in.

The community has felt the negative impacts of COVID-19 on ecotourism and is working to reengage members of the communities and commence work. The area experienced challenges related to illegal operations such as poaching and resource extraction for timber in the mining areas.

Outside the Protected Areas, Guyana is doing a lot of work through the Ministry of Home Affairs on conservation beyond national jurisdiction.

Key issues raised

- Concerns about oil spills and marine turtles at Shell Beach
- Low tourism and engagement due to COVID-19

Action items:	Assigned to:

■ Experiencing illegal operations in the mining areas		

Next steps:

Notes:

- Concerns about oil spill response plan and marine turtles
  - Shell Beach is a Protected Area
  - CDC has an oil spill and contingency plan that is used
  - Protected Areas Commission fall under that National framework
  - Demonstration exercise at Waini Point that EEPGL participated in
- Participated in prior marine turtle studies that are in Environmental Impact Assessments.
  - ERM conducted the activity and has the data collected from the 2018 and 2019 turtle season studies

What changes have you noticed in your community in the last year?

- There were no engagements in the community during COVID-19, especially in Shell Beach. There is usually engagement on the beach from March to August and September to December. However, the villages had a no entrance policy to outsiders.
- There is currently an exercise in progress to reengage the communities and to recommence work.
- Across Guyana, eco-tourism was affected due to COVID-19.
- Other areas that PAC covers saw struggles and experienced challenges related to illegal operations in the mining areas, such as poaching and resource extraction for timber.

Do you have any questions or concerns about the activities occurring offshore? (i.e. ongoing development of Liza 1 and 2, Payara, or planned future activities)

- Outside of Protected Areas, we are moving forward as a country and having a conversation in terms of the EEZ such as what will we be doing, where we would be fishing etc.
- Guyana is doing a lot of work through the Ministry of Home Affairs on how we will conserve beyond national jurisdiction, whether it is at the Guyana level or international/regional level.

Meeting Summary

Engagement title: **Rosignol Fishermen's Cooperative Society Limited**

Date: September 30, 2021 **Time:** 11:00-12:30 **Venue:** Virtual Meeting

Stakeholder representatives:	Consultants team:	EEPGL team (if applicable):
[Withheld for privacy]	[Withheld for privacy]	[Withheld for privacy]

Agenda, objectives and/or planned content:	Documents (minutes, PPT, etc.)
■ Changes to Fishing Activities and Harvest ■ Update/Confirmation of data from last EIA (2019) ■ Cross-border migration, and change from prior years ■ Impact of COVID-19 on the community, including population (rural, coastal), economic growth, livelihoods, cost of living, transportation, housing, healthcare	■ None

Summary of discussion

The 2019 EIA data regarding Rosignal was confirmed and updated, as well as the cross-border migration and change from prior years. COVID-19 significantly impacted the community's economic growth, livelihoods, cost of living, transportation, housing, and healthcare. There is concern regarding coastal fishing in the area as pen catching is practiced at the mouth of the river and the deep water harbour will impact this. There is also increased congestion in the area and concerns around new port facilities opening close to existing fishing port facility.

Key issues raised
■ Impact of COVID-19 on the community including population (rural, coastal), economic growth, livelihoods, cost of living, transportation, housing, and healthcare ■ Coastal fishing being impacted from CGX Deep Water Harbour ■ Coastal fishing being impacted from flooding and water levels rising

Action items:	Assigned to:

■ Congestion and safety near new and existing port facilities		

Next steps:

Notes:

Rosignal Wharf

- Confirm from 2019 EIA: 90 boats using the Rosignol wharf for commercial fishing. Catch includes queriman, bangamary, butterfish, and some shrimp
  - Confirmed at 90 – some amount of snapper and cat fish and common cat fish/ Karass Fish
- Confirm from 2019 EIA: Significant livestock grazing
  - Confirmed that there is not very much
- Confirm from 2019 EIA: River transportation wharf was used by over 1,000 persons daily for river launch crossing in 2019.
  - Yes, data remains the same
- Confirm from 2019 EIA: Berbice River Bridge was used by thousands of persons daily in 2019
  - Yes, data remains the same
- In 2019, Berbice River launch transported almost 1000 schoolchildren and Government workers on weekdays between Rosignol and New Amsterdam. The bridge cost has been reduced and the river crossing has been completed. Therefore, everyone is using the bridge as the main mode of transport.
- Patterns of cross-border migration, and change from prior years
  - Yes, there are around 50 Venezuelans that came to work and live in the Rosignol Area

Impact of COVID-19 on the community, including population (rural, coastal), economic growth, livelihoods, cost of living, transportation, housing, and healthcare

- Vaccination was facilitated through vaccine drives to the area.
- The communities depended largely on the sugar industry, so when banks were closed half day that affected them and their spending. They didn't have free access to withdraw money.
- Region 5 is a hub for commerce; two banks (RBL and NBS) are there.
- Decline in spending in the beginning; however, there is an increase now.
- Early closure of clothing and grocery businesses because of the curfew.
- Many people moved back to Rosignol because their University classes were online (they are also job seekers now). This was because they couldn't afford their rent in Region 4.
- Cost of Living has increased and the $2040 ($255 x 8hrs) is the daily minimum wage.
- The grocery prices have increased.

- Transportation cost has increased for buses from $280 to $400 (per passenger fare) because of the restricted COVID Guidelines for Public Transportation.
- Healthcare received complaints from healthcare workers about PPE.

Additional Questions and Comments

- Would there be destruction of the pens if they were to do a CGX deep water harbour at Berbice River Mouth?
- What role would the CGX Deep Water Harbour play this in the Yellowtail Project?
- The catch was altered because of the fish not coming to that area as per normal. This is because of the flooding due to the inland water being high (gravity flow) and there is vast amount of sweet water. Hence, the salt-water fish wouldn't come and remained further out.
- Coastal fishing will be affected because Pen Catching is practiced at the mouth of the river.
- The deep water harbour at the Berbice River mouth will cause the eradication of this fishing practice.
- How will these people be compensated because they will be out of a job if the industry dies.
- If there are port facilities opening close to the existing fishing port facility, what systems would be put in place for small commuters using the river?
- Multiple commuters using the same route can cause congestion in the area and cause accidents because of the method of fishing used – the use of Seine to catch fish and Pen Catching are done close to the mouth of the Berbice River.
- The fishermen also practice little to no health and safety.
- Some fisherfolk have moved to Mahaicony River. They dock there and fish, then move the catch via canter trucks to sell in Rosignol. This is done because it is cheaper.