INSTITUTE OF MARINE AFFAIRS

TRINIDAD & TOBAGO STATE OF THE MARINE ENVIRONMENT REPORT - 2018

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Trinidad & Tobago, W.I.

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Foreword

The Institute of Marine Affairs (IMA) is the only multi-disciplinary coastal, marine and environmental research organization in the CARICOM States established to conduct inter-disciplinary studies. The IMA was established and incorporated in accordance with the provisions of an Act of Parliament, No. 15 of 1976, now Chapter 37:01 in the Revised Laws of the Republic of Trinidad and Tobago, and became operational in 1978. During its 40 years of operation, the IMA has pioneered and participated in numerous programmes locally and regionally. IMA's mission is to conduct and foster research and to provide advice for the sustainable management of the coastal and marine areas and resources of Trinidad and Tobago.

The IMA uses widely accepted and published scientific methodologies to conduct its research and monitoring programme. This State of the Marine Environment Report attempts to convert sound scientific data into pertinent information that can be used by decision-makers, policy makers and the wider public to inform development planning. The IMA thereby plays an important role in promoting an understanding and awareness of the interaction between human activity and the sea, and reconciling this with national development process. This is recognition of the fact that Trinidad and Tobago's marine and coastal environment is extremely important for the country's development and in sustaining the blue economy. IMA is willing to partner with sister agencies, local and regional academic institutions and community-based organisations to foster science-based management, and to support the science-policy nexus.

Dr. Ahmad Khan
Director

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Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
BRDs	Bycatch Reductions Devices
BRMP	Buccoo Reef Marine Park
CARICOM	Caribbean Community
CARICOMP	Caribbean Coastal Marine Productivity Programme
CC4FISH	Climate Change Adaptation of the Fisheries Sector in the Eastern Caribbean
CCME	Canadian Environmental Quality Guidelines
CFU	Colony Forming Units
CLME	Caribbean Large Marine Ecosystem
COP 21	Conference of the Parties
CPCe	Coral Point Count with Excel extensions programme
CPU	Coastal Protection Unit, Ministry of Works and Transport
CROSQ	CARICOM Regional Organisation for Standards and Quality
DCRS	Draft CARICOM Regional Standard Guidelines for Recreational Water Quality
DDPH	Dissolved Dispersed Petroleum Hydrocarbon
DEM	Digital Elevation Model
DFMB	Draft Fisheries Management Bill 2018
DO	Dissolved Oxygen
DST	Defined Substrate Technology
EAF	Ecosystem Approach to Fisheries
EEZ	Exclusive Economic Zone
EMA	Environmental Management Authority
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIS	Geographic Information System
GoP	Gulf of Paria
GORTT	Government of the Republic of Trinidad and Tobago
ICZM	Integrated Coastal Zone Management
IFPAMTT	Improving Forest and Protected Area Management in Trinidad and Tobago
IMA	Institute of Marine Affairs
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IUU Fishing	Illegal, Unreported and Unregulated Fishing
LABIDCO	La Brea Industrial Estate
LiDAR	National Light Detection and Ranging Survey
LoC	Levels Of Concern
LSD	Lands and Surveys Division
MARPOL	International Convention for the Prevention of the Pollution from Ships
MBL	Marine Biological Laboratory
MOWT	Ministry of Works and Transport
MPA	Marine Protected Area
N/A	Not applicable
NCRI	National Coral Reef Institute
NDA	No data available
NDCs	Nationally Determined Contributions
NEP	Draft National Environmental Policy
NTU	Nephelometric Turbidity Unit
PA	Protected Area
PAHs	Polycyclic Aromatic Hydrocarbons
ppb	parts per billion
ppt	parts per thousand
PRECIS	Providing Regional Climates for Impacts Studies
RCP	Representation Concentration Pathway
REBYC-II LAC	Sustainable Management of Bycatch in Latin America and Caribbean Trawl Fisheries project
SDG	Sustainable Development Goals
SIDS	Small Island Developing States
SOME	State of the Marine Environment
TSS	Total Suspended Solids
UNFCCC	United Nations Framework Convention on Climate Change
US FDA	U.S. Food and Drug Administration
USD	United States Dollars
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
WHO	World Health Organization

Executive Summary

The State of the Marine Environment Report 2018 (SOME, 2018) is a scientifically grounded, non-technical document which provides in depth insight into conditions existing within Trinidad and Tobago's coastal and marine space. The health of the environmental resources and ecosystems found here are analysed and their statuses tied to the natural and anthropogenic influences to which they are subject. The SOME, 2018 also seeks to highlight current and proposed measures aimed at alleviating coastal and marine degradation, encouraging sustainability in resources use and boosting human and ecological resilience in the face of global environmental change.

Pollution of the marine and coastal waters around Trinidad and Tobago continues to be a critical problem as the levels of pollutants reported were similar to those in the SOME, 2016. The pollution issue manifests itself through high nutrient, heavy metal, suspended solids, hydrocarbon and microbial levels in many areas, particularly in the Gulf of Paria (GoP). Land-based activities are mostly responsible for pollution of Trinidad and Tobago's marine environment with chronic inputs leading to some of the elevated parameter levels that are detailed in this Report.

Marine and coastal pollution can have very real negative effects economically, socially and culturally. For instance, poor bathing beach water quality as a result of pollution can affect recreational opportunities, tourism revenue and have human health impacts. In this Report, poor bathing beach quality, reflected in high microbial levels, was recorded at different times of the year in parts of Cedros, Guapo Bay, Cocos Bay, Mayaro Bay and southwest Tobago including Bon Accord Lagoon, Kilgwyn and La Guira.

The many oil spills that Trinidad has experienced have also affected beachgoers at other locations. Additional impacts of oil spills have been felt by fisherfolk who suffered loss of potentially productive fishing hours as well as aversion to consumption of their products. Interestingly however, this SOME, 2018 highlights that recent studies performed on fish and shrimp samples collected in the GoP have indicated that the levels of Polycyclic Aromatic Hydrocarbons (PAHs) measured in these seafood samples do not appear to pose a health risk for consumers based on the risk assessment criteria established by U.S. Food and Drug Administration (US FDA) for the Deepwater Horizon oil spill response (US FDA, 2010).

Trinidad and Tobago's fisheries continue to be in decline however, with many commercial stocks either near full exploitation, fully exploited or over-fished. Legislative and policy reform is now imperative as well as protection of critical fish nursery habitat. One such habitat, seagrass beds, are not faring well country-wide. Seagrass beds in the northwest peninsula have been decimated by siltation and land reclamation and there have been no signs of recovery. In Tobago's La Guira and Kilwgyn, the beds have not recovered from *Sargassum* inundation which took place in 2015. The only extensive climax seagrass community in Trinidad and Tobago is now found in the Buccoo Reef Marine Park (BRMP).

Seagrasses are not the only coastal ecosystems that are threatened. Tobago's coral reefs, which were severely negatively impacted by bleaching in 2010, have had coral cover extent stabilize in recent years. However, 2019 is forecasted to be an El Niño year. In El Niño years the chances of coral bleaching are heightened so the island's reefs may again be subject to detrimental impacts from thermally induced bleaching and coral disease.

The SOME, 2018 has also documented losses in the aerial extent of mangroves in both Trinidad and Tobago between 2007 and 2014. These ecosystems are critical for the many services they provide. The Caroni Swamp, for instance, provides, among other things, coastal protection, critical habitat for sensitive species and a source of livelihood for surrounding communities. This report demonstrates the value of the Caroni Swamp in removing pollutants from the water flows making its way to our already stressed coastal waters of the GoP.

SOME, 2018 devotes much attention to documenting the impacts and potential impacts of climate change on Trinidad and Tobago. It reveals the extent of inundation forecasted for specific coastal areas around the country. The forecasts show that areas earmarked for possible development, for example Bon Accord/Pigeon Point, or in close proximity to critical infrastructure for instance Point Lisas, may be under water by 2100. Although full inundation may be decades away, the SOME, 2018 also details shoreline changes (accretion and erosion) that has already happened in these areas within the last decade. These analyses confirm erosion has been taking place at Columbus Bay and Pigeon Point and accretion in the central GoP.

Coastal erosion in other areas, such as parts of Cocos Bay and Los Iros Bay in Trinidad and Barbados Bay and Grange Bay in Tobago, have also been documented in the SOME, 2018 through long term beach profile monitoring work.

Recognising that climate change impacts will have tangible and considerable effects on Trinidad and Tobago economically, socially, culturally and environmentally, this country is making strides to both lower levels of greenhouse gas emissions and adapt to climate change impacts. Being undertaken are mitigation analyses, to develop and implement emission reduction measures, and vulnerability and adaptation assessments to chart a climate resilient future. Expanding the nationwide protected area network is also expected to bring mitigation and adaptation benefits, in addition to safeguarding some of the most sensitive species and ecosystems found in the country. The Improving Forest and Protected Area Management in Trinidad and Tobago (IFPAMTT) Project is creating management plans for six pilot areas around the country including the Caroni Swamp, Nariva Swamp, Matura Forest and coastal zone and North East Tobago Marine Protected Area (MPA).

Progress is also being made towards implementation of an Integrated Coastal Zone Management (ICZM) Framework for Trinidad and Tobago. The draft policy was identified as a crucial avenue through which negative impacts on the coastal and ocean environment can be addressed. This includes emerging issues such as debris, plastics and microplastics in marine areas. An action plan for implementing the draft ICZM Policy Framework has been developed and is being executed with the aim of, among other things, reducing conflict and encouraging intra- and inter-sectoral collaboration in ocean and coastal management, across time and space.

Macqueripe Bay, Chaguaramas

Preface

Trinidad and Tobago has always relied on its coastal and ocean resources for economic prosperity primarily from oil and gas exploration, tourism and fisheries. It is estimated that almost 80% of all socio-economic activities and 70% of Trinidad and Tobago's population are located along the coast. Approximately 8% of all public and private infrastructure by value is located immediately on the coastline, while 89% of the total value of physical assets lie within the broader coastal zone inclusive of the Exclusive Economic Zone (EEZ) (CH2M Hill Halcrow, 2016). The country collectively has 704 km of coastline and about 15 times more sea than land; which indicates the importance of the ocean sphere. Our economic policies, aimed at diversifying the economy, has focused on investments in the tourism, agriculture, aquaculture and the maritime sectors, all of which require healthy oceans.

According to an analysis of the contribution of Trinidad and Tobago's coastal zone to the national economy, undertaken as part of the feasibility studies for a climate resilient coastal zone management programme, the estimate of Gross Domestic Product (GDP) (2015) immediately on the coastline was US$2.14 billion and within the broader coastal zone (up to the EEZ) was US$22.5 billion; 81% of the country's total GDP (CH2M Hill Halcrow, 2016). It is important to recognize that coastal ecosystems contribute to this value, especially by providing coastal protection, and supporting tourism and fisheries. In addition, they provide services, where the value to people is not reflected by exchanges in the market.

In 2015, the government of Trinidad and Tobago committed to the 17 Global Sustainable Development Goals (SDG) to achieve three extraordinary things in the next 15 years - end extreme poverty, fight inequality and injustice and fix climate change. Goal # 14 in particular addresses life below waters and speaks to the conservation and sustainable use of oceans, seas and marine resources for sustainable development. This goal has ten targets one of which speaks to sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts. This can be done by strengthening resilience, and taking restoration action in order to achieve healthy and productive oceans by 2020. In April 2017, the Ministry of Planning and Development, with assistance from the United Nations (UN), prepared a Roadmap for SDG Implementation in Trinidad and Tobago. The Roadmap aims to serve as a bridge between the implementation of the nationally defined development priorities and the SDGs, by aligning the national and international agendas. Among other things, it covered acceleration, financing, data requirements, advocacy and institutional coordination. To place environment at the centre of development (Theme V of Trinidad and Tobago's National 2030 Vision), the Roadmap proposes developing an integrated land and coastal management system by enhancing the protected areas system, enhancing the land development system, strengthening regulatory enforcement and promoting sustainable land use practices.

Despite ratifying a number of multi-lateral environmental agreements and signalling its intention to conserve and sustainably use the oceans and their resources, Trinidad and Tobago still faces challenges in the management and sustainable use of its coastal and ocean spaces and resources. In 2016, the IMA produced the first SOME Report. The report provided a scientifically grounded understanding of the condition of Trinidad and Tobago's coastal and marine ecosystems, habitats and species, all of which are extremely important for the country's development and sustainability. It also detailed how the status of these resources have been, and are being affected by the range of natural and human pressures to which they are subjected such as land-based pollution and impacts from climate change. Through the SOME, 2016, the IMA translated data collected using standardized and widely accepted scientific methods into pertinent information (knowledge products).

This second SOME Report continues in a similar vein by again being a vital knowledge product targeted towards a range of stakeholders, including the general public. The information contained herein is essential in strengthening a national awareness of the role played by the oceans and coasts in maintaining and enhancing our regional, national and personal wellbeing. The SOME, 2018 can be used by decision-makers and civil society when developing policies to manage the marine environment. Perhaps more importantly, the SOME, 2018 seeks to empower the population through education, and encourage advocacy towards holistic sustainable management of our ocean and coastal spaces.

Approach

The datasets provided in this report were collected under IMA's on-going monitoring programmes and research projects from 2016 to 2018 using standardized scientific methods. The nutrients in the water were determined following Grasshoff *et al*. (1983) and Strickland and Parson (1972). Analyses for heavy metals were performed using the Perkin-Elmer AAnalyst 100 Atomic Absorption Spectrometer with deuterium background correction. Petroleum hydrocarbons were measured using chrysene standard and UV/ fluorescence spectrometric analysis (IOC, 1984). Microbiological analyses were done using rapid methods (Colilert-18, Colilert and Enterolert) and Standard Methods ISO 9308 (membrane filtration) in accordance with the United States Environmental Protection Agency (USEPA). Beach profiles were conducted using standard survey leveling techniques. Coral reefs were surveyed using both video and photo transect methods and the National Coral Reef Institute (NCRI)/Nova South-eastern University Oceanographic Centre's Coral Point Count with Excel extensions programme (CPCe) Analysis. Seagrass sampling was done using methodology provided by CARICOMP (2000) while mangroves were mapped using GIS software (ArcGIS 9.0), topographic maps and aerial photography. In situations where the IMA does not have primary data, information from reference sources was used.

IMA researchers sampling benthic organisms

Oil spill sample collection exercise, Sea Lots (2016)

Coastal and Marine Water Quality

Coastal and Marine Water Quality

Physical parameters and nutrients

In SOME, 2016, it was stated that pollution of coastal waters was an ongoing, pervasive problem and in parts of the GoP the problem is particularly acute. However, country-wide, areas with elevated levels of total suspended solids, hydrocarbons, nutrients and heavy metals have been identified. This pollution problem has been found to be mainly land-based; where runoff and effluent from terrestrial sources and activities have negatively impacted coastal water and sediment quality. Coastal water pollution has partially influenced the observed decline of important ecosystems such as coral reefs and seagrass beds. These pollution trends have continued for locations within the GoP inclusive of Pt Lisas, Caroni, Port of Spain and off the north west peninsula. (Table 1).

Temperatures recorded at the marine stations were within the USEPA (1995) water quality criteria for the protection of aquatic life (< 32.2 °C) with the exception at Point Lisas-Yara Trinidad Ltd. This station had an elevated temperature of 36.3°C when sampled on 25th July 2017. Elevated temperature can hinder the growth and development of aquatic organisms and can lead to their ultimate death (USEPA, 1995).

Average Dissolved Oxygen (DO) levels found at marine stations in the GoP were generally above the USEPA limit of 5.0 mg/L for the protection of aquatic life (USEPA, 1995) for both wet and dry seasons (Figure 1). However, poor water quality (< 3 mg/L) was recorded at inland stations (Figure 1), likely due to land-based sources of pollution from agricultural, domestic and industrial sources. Persistently low DO can lead to reduced species diversity and abundance, as well as fish kills.

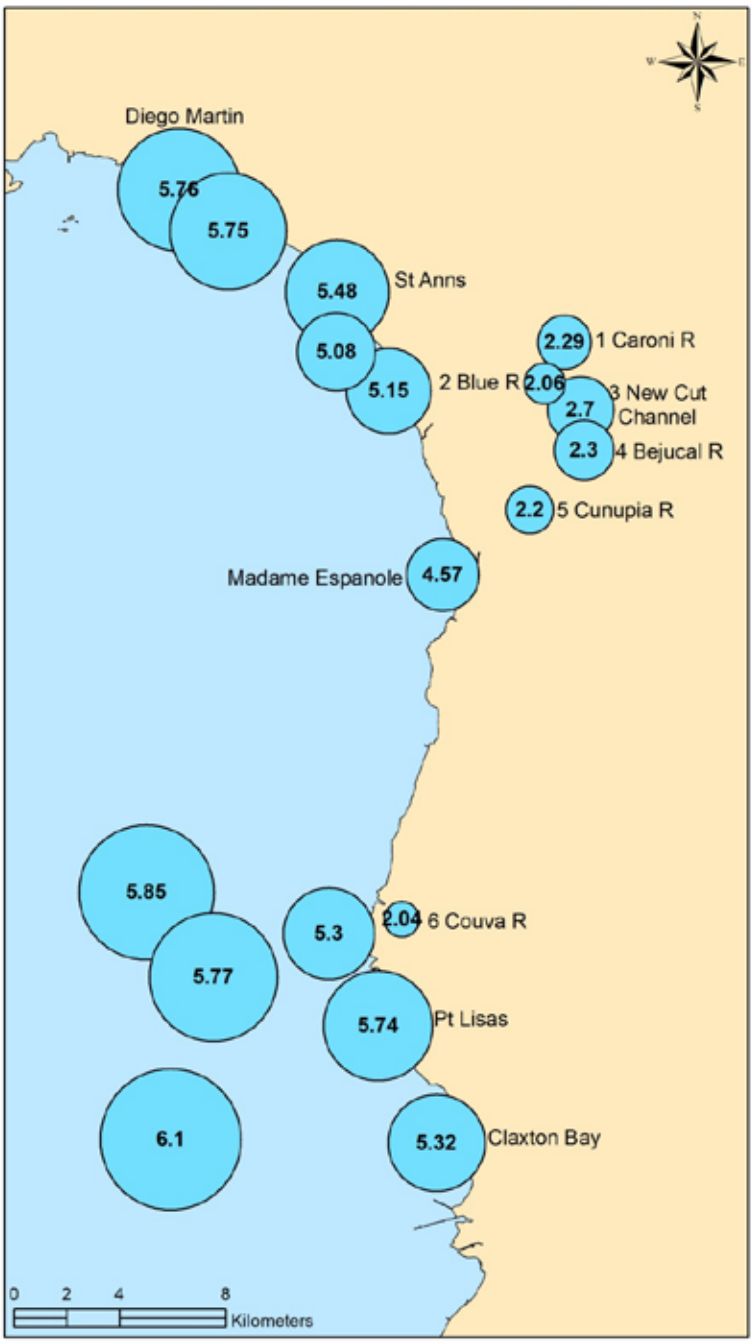


Figure1:
Dissolved oxygen (DO) levels in the marine and inland stations. Poor water quality is noted at sites with DO less than 5.0 mg/L

Table 1:
Summary statistics for physico-chemical parameters sampled at marine stations in the GoP during March 2016 to September 2017

Parameter	Season	no. of stations sampled (n)	Mean	Std. Dev.	Minimum	Maximum	Guideline limit or criteria
pH	Dry	30	8.00	0.14	7.58	8.18	6.0 – 8.5[α]
	Wet	36	8.11	0.18	7.84	8.37	
DO (mg/L)	Dry	30	5.41	0.84	2.93	6.50	5.0 (1 day minimum for early aquatic life stages).[α]
	Wet	36	5.65	0.88	3.47	6.91	
Temperature °C	Dry	30	27.20	0.42	26.30	28.20	Not to increase above 32.2 characteristic of a sub-tropical region[α]
	Wet	36	28.90	1.41	27.80	36.30	
Salinity (ppt)	Dry	30	34.43	0.93	33.21	36.20	N/A
	Wet	36	23.61	3.36	17.38	29.31	
Ammonium (µM)	Dry	30	0.92	1.03	0.30	4.97	1.07[β] (total ammonial nitrogen)
	Wet	36	3.00	5.20	0.31	23.33	
Nitrites (µM)	Dry	30	0.28	0.28	0.03	1.47	N/A
	Wet	36	0.44	0.68	0.02	3.41	
Nitrates (µM)	Dry	30	1.05	1.16	0.01	6.01	N/A
	Wet	36	1.45	2.85	0.02	15.43	
Reactive Phosphates (µM)	Dry	30	0.47	0.26	0.14	1.10	1.61[β]
	Wet	36	0.99	1.33	0.10	6.26	
Total Phosphates (µM)	Dry	30	1.15	0.31	0.71	1.81	0.65[β]
	Wet	36	1.35	1.75	0.04	10.64	
Dissolved and Dispersed Petroleum Hydrocarbons (µg/L)	Dry	30	0.27	0.38	0.07	0.96	N/A
	Wet	36	0.55	0.26	0.22	2.23	
Total suspended solids (mg/L)	Dry	30	79.0	74.3	14.4	348.2	No increase > 5mg /L from background levels for any long-term exposure (inputs lasting between 24 h and 30 d).[γ] Background levels can be approximated to the minimum values for each season.
	Wet	36	36.5	33.9	8.6	148.8	
Turbidity (NTU)	Dry	30	1.7	1.8	0.3	8.5	1-20[β]
	Wet	36	3.3	3.6	0.3	72.9	
Chlorophyll "a" (µg/L)	Dry	30	0.54	1.71	0.02	9.30	0.5 – 0.9[β]
	Wet	36	0.36	0.35	<0.01	1.44	

N/A – Not applicable α – US EPA 1995 β – ANZECC (2000) γ –CCME (2007)

Values in red indicate parameter exceeding guideline values.

Plate 1: Sediment laden waters off the Caroni Swamp

As expected, salinity in the GoP was higher in the dry season compared to the wet season, a difference of 10.82 ppt due to natural seasonal changes. However, in the wet season, the nearshore stations from Claxton Bay/Pt Lisas/ Couva to Madame Espagnole River had higher surface salinities compared to the offshore stations at Claxton Bay/Pt Lisas/Couva. The salinity difference between the nearshore to offshore locations suggests salinity build up from land-based discharges.

Levels of Total Suspended Solids (TSS) found in the GoP were representative of ambient conditions at some locations, and were elevated at other locations. The mouth of the Caroni River (Plate 1), Blue River and Madame Espagnole River had the highest levels of TSS compared to other stations sampled in the dry season.

TSS is due to land-based runoff from land clearing for development on hillsides, quarrying activities, and from land reclamation which takes place especially along the northwest peninsula of Trinidad. High TSS levels in marine waters adversely affect photosynthetic organisms by reducing the sunlight available for primary productivity. This is particularly noted in Williams Bay, along the northwest peninsula of Trinidad, where *Thalassia* (turtlegrass) dominated seagrass beds have disappeared since 2015 (SOME, 2016).

Sediment laden waters can affect the growth of photosynthetic organisms and cause disruption to habitat such seagrass beds, and other nursery areas for fish and shrimp.

Dissolved ammonia is the toxic form of nitrogen and is harmful to aquatic life. Excessive ammonia levels which exceeded the ANZECC (2000) guidelines were found off Caroni River, Blue River, Madame Espagnole River, Couva River, Point Lisas-Yara Trinidad Ltd and Claxton Bay. This information indicates that the nearshore marine waters of the GoP remain subjected to nutrient pollution which has the potential to harm sensitive aquatic species. Compared to an ambient ammonium level of 0.30 µM obtained in the GoP, areas at Pt Lisas, Couva River and Caroni River had an average elevation of 24, 16 and 12 times higher ammonium levels respectively, which suggest continual inputs at these locations. Industrial sources of ammonia, which includes ammonia and methanol production at the Point Lisas Industrial Estate, have been identified in past studies (Banjoo, 2016; Banjoo, 2010; IMA 1995; IMA 1997; IMA 1998; IMA, 1982).

In addition, average levels of total phosphates exceeded the Australian/New Zealand guideline of 0.65 µM for both wet and dry season at all stations except one (off Pt Lisas, offshore). Like ammonia, levels of phosphates found in the GoP suggest nutrient inputs which require management interventions to lower pollutant levels in the environment. Phosphate-based detergents are one of the major sources of phosphates in the marine environment, apart from agricultural, domestic and industrial sources. Trinidad and Tobago should consider banning the use of and switching to non-phosphate-based detergents.

Chlorophyll "a" (chl "a") is a common measure of total phytoplanktonic biomass. Phytoplankton is the base of most marine food webs, and supports fisheries. The magnitude of chl "a" values can indicate the state of a water body as being nutrient poor or oligotrophic, moderately nutrient rich or mesotrophic, and nutrient-rich or eutrophic. Although the average values of chl "a" for the entire GoP suggests an oligotrophic system, eutrophic areas were found off Point Lisas and mesotrophic areas at Couva River and Claxton Bay.

Nutrient source identification and absorption in Caroni Swamp

The Caroni Swamp sits at the hydrological end point of the Caroni River Basin and therefore receives all the upstream effluent from the most densely populated area of Trinidad (the east west corridor) and from extensive agricultural lands. There are a number of different sources of nutrient pollution. These include discharges from wastewater treatment plants, non-functional wastewater treatment plants, agricultural runoff, grey water from houses, and industrial effluent. The IMA partnered with the Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts, USA, in 2016 to determine the major sources of the nitrogen entering the Swamp using stable isotopic analyses, and to quantify the amount of nutrients that the Swamp absorbed. The results indicate that for the New Guayamare and Cunupia watersheds which flow into the Caroni Swamp, the primary source of nitrogen is fertilizers from agricultural runoff. In contrast, for the Caroni River the primary source of nitrogen was likely due to wastewater discharges. Ammonium trends are illustrated in Figure 2.

The nearshore marine waters of GoP remain subjected to nutrient pollution which has the potential to harm sensitive aquatic species.

The ammonium concentrations at the inflow stations were larger than those measured in many other mangrove estuaries across the world. The values were only exceeded by concentrations in a few mangroves in India with heavily populated watersheds. The median ammonium concentrations in Caroni Swamp were approximately six times larger than those in mangroves elsewhere. As illustrated in Figure 2, the levels of ammonium declined from the inflow to mid-estuary to the river mouth. Some of this decline is due to the mixing with the marine waters, however analysis by MBL indicated that a significant amount of this ammonium, as well as other nitrogen species (nitrates and nitrites) are absorbed and sequestered by the Caroni Swamp.

The Caroni Swamp therefore performs a key role in reducing nutrient pollution before it reaches the GoP. With the primary sources of nutrient pollution identified, and the need to address the very high levels of nutrients entering the swamp, the IMA collaborated with a number of other government and academic agencies to develop an ecosystem based management project under the Caribbean Large Marine Ecosystem (CLME) initiative. This project is targeting the Cunupia and New Guayamare watersheds to work with farmers to reduce fertilizer usage (and hence reduce nutrient pollution runoff) while maintaining agricultural productivity.

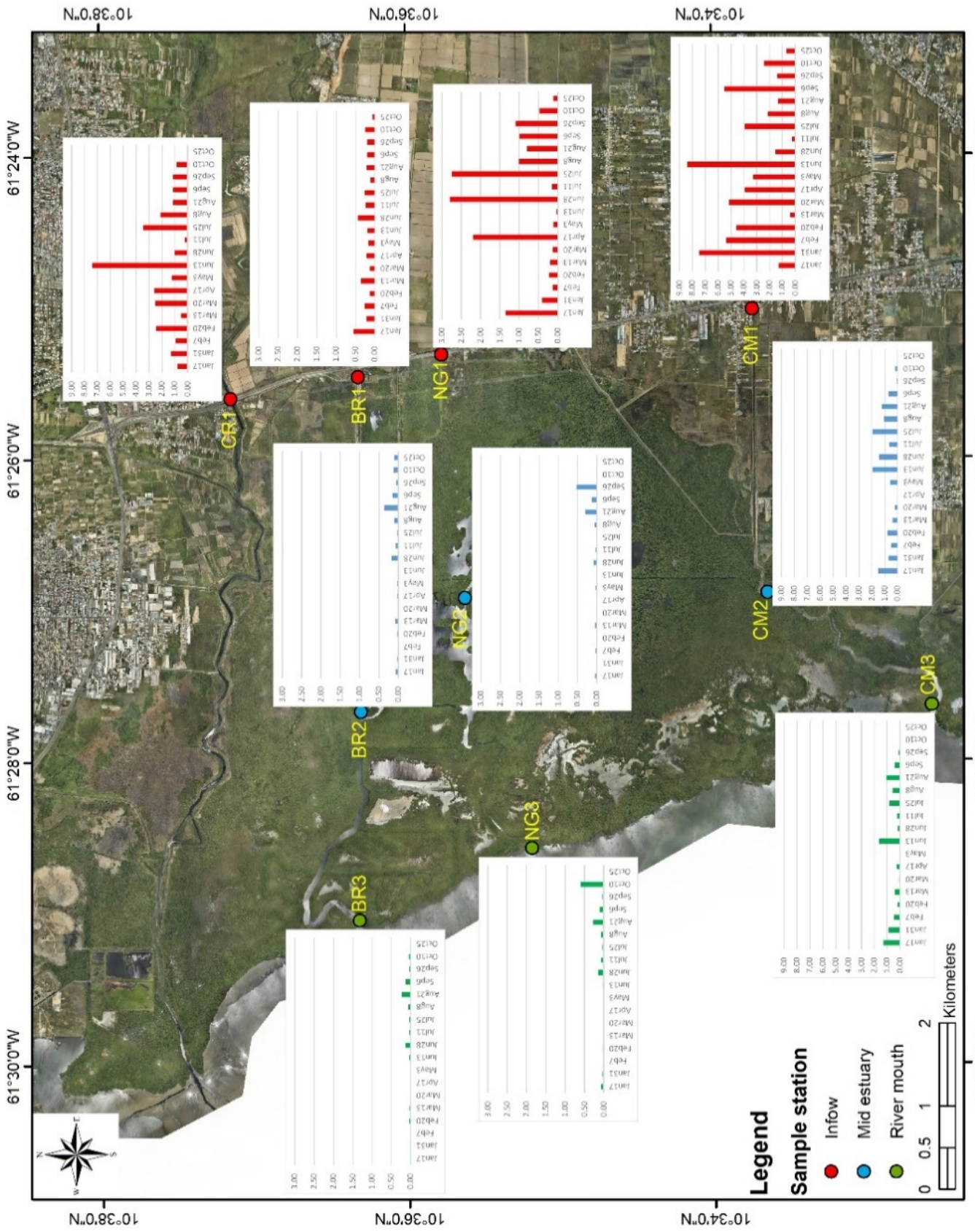


Figure 2: Ammonium levels (mg/l) along water system transects at swamp inflow station (red), mid-estuary stations (blue) and river mouth (green).

Oil Pollution

Trinidad and Tobago experiences several oil spills annually (Table 2). Severity ranges from trace quantities as "oil sheens" to thick black oil covering many kilometres of water. The oil spills in Trinidad and Tobago are related to explorations, refining, transport, shipping, storage and accidental spills. Abandoned derelict vessels have become a source of oil spills that require management interventions. The major impacted areas of the oil spills have been the north-western and south-western peninsulas of Trinidad. From oil fingerprinting analyses, the main source of spilled oil identified in the GoP is marine fuel oils; the source being ship-based or bunkered fuel oil. Oil spills impact our coasts and cause discomfort to beachgoers, fisherfolks and the general public as well as economic losses.

Generally, Dissolved Dispersed Petroleum Hydrocarbon (DDPH) concentrations above 10.0 parts per billion (ppb) are found close to oil and gas operations on the west coast whereas concentrations less than 1.0 ppb (µg/L) are considered ambient, and found in other areas away from petroleum sources. DDPH levels found at the marine stations from Claxton Bay to Diego Martin ranged 0.07 -2.23 µg/L with averages of 0.27 and 0.55 µg/ L for the dry and wet seasons respectively (Table 1). Higher levels of DDPH (>100.0 µg/L) were recorded in the south-western peninsula of Trinidad in 2016 and 2017 after oil spill incidents associated with oil-based activities or sunken vessels (Table 3), or due to circulation patterns in the southern GoP.

Table 2: Oil Spill reports for Trinidad and Tobago submitted to the Environmental Management Authority (EMA)

	2015	2016	2017	Jan to Sept 2018
Number of oil spills and releases	103	95	104	36

Hydrocarbons in Biota

A study of hydrocarbon levels in fish and shrimp samples collected in the GoP were conducted by the Ministry of Planning and Development in September 2016. Test results for 59 fish consisting of five (5) species (red fish, carite, cro cro, salmon, catfish) and one crustacean species (white/ cork shrimp) showed low level contamination by PAHs. PAHs are the toxic hydrocarbons found in refined and crude petroleum and are cancer causing agents (carcinogens). PAHs can bio-accumulate in seafood, and can present a risk to human health when contaminated foods are consumed. Test results for the fish and shrimp sampled in the GoP were below the limits of quantitation, and when detected, levels were found at least two orders of magnitude lower than the corresponding levels of concern (LOC). The LOC values are a "trigger level" and if exceeded suggest contamination and food being unfit for consumption. The results therefore indicated that the levels of PAHs measured in the seafood samples do not appear to pose a health risk for consumers based on the risk assessment criteria established by U.S. Food and Drug Administration for the Deepwater Horizon oil spill response (US FDA, 2010).

Five fish species (blinch, cavalli, white mullet, catfish and puffer fish) were analysed by the IMA in response to a fish kill in La Brea in July 2018. The samples were analysed for the USEPA's 16 priority PAHs which are used worldwide for the testing of toxic hydrocarbons (naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene), benzo[k]fluoranthene), benzo[a]pyrene, benzo[g,h,i]perylene, indeno[1,2,3-c,d] pyrene, and dibenz[a,h]anthracene). The PAHs tested in the fish samples were below detection limits of 0.08- 2.4 parts per billion (µg/kg) of the analytical test. Systematic testing of biota samples is required to determine risk to human health, and for providing fish advisories.

Oil spills impact our coasts and cause discomfort to beachgoers, fisherfolks and the general public as well as economic losses.

Table 3: Summary of DDPH levels recorded in the southwestern peninsula of the GoP after oil spills

Sample location	Sample Date	DDPH Analysis (µg/L)/ ppb	Remarks	References
1- off LABIDCO Industrial Estate, close to sunken vessel on southern side	14/03/2016	0.19	Investigated sunken Barge LABIDCO Industrial Estate	IMA (2016a)
2- off LABIDCO Industrial Estate, close to sunken vessel on northern side		0.19		
3-Control station, marine area off LABIDCO Industrial Estate		0.94		
1-Carat Shed Beach, La Brea	26/09/2016	5.82	Investigated oil like substance at Carat shed Beach	IMA (2016b)
2-Carat Shed Beach, La Brea		33.55		
1- Coffee Beach	12/09/2016	496.17		
2- Carat shed Beach		280.87		
3-Pt Sable		158.07		
4-Station Beach		73.34		
1- San Fernando Wharf	24/04/2017	3.14	Oil spill investigation 1 day after spill at Petrotrin, Pointe-a-Pierre involving 130, 000 barrels of fuel oil	IMA (2017)
2- Vessigny Beach		578.54		
3- Station Beach		372.11		
4-Coffee Beach		25.47		
5-Carat Shed Beach		100.56		
6-Pt. Sable Beach		100.64		
7-Otaheite		8.34		
1- Guapo Beach	25/04/2017	48.34	Oil spill investigation 2 days after spill at Petrotrin, Pointe-a-Pierre involving 130, 000 barrels of fuel oil	IMA (2017)
2- Clifton Hill Beach		11.93		
3- Icacos Pt		10.11		
4-Columbus Bay		4.39		
5- Fullerton Beach		6.90		
6-Bonnasse Beach		4.33		
7-Granville		95.02		

Heavy Metals

Heavy metals have been identified as major pollutants since human health disasters in the late 1970s were attributed to the release of mercury and cadmium effluent into the environment. Heavy metals are usually defined as elements with densities greater than 5.0 g/cm^3. This definition encompasses a range of elements, for example, chromium, nickel, manganese and iron, as well as the more toxic mercury, cadmium and lead. They occur naturally in the environment, but anthropogenic activities increase the bioavailable metal pool. While some of these metals for example copper, zinc, selenium are essential elements, that is required for important biochemical functions in an organism, all metals can have toxic effects in an organism when present in excess. Heavy metals are persistent in the environment and can bio-accumulate in aquatic organisms, posing a threat to consumers, including man. Adverse effects on human health may include neurological, systemic, carcinogenic effects and birth defects, depending on the metal involved.

Industrial activity in Trinidad and Tobago has increased significantly over the past two decades so that there are greater quantities of contaminants entering coastal areas through rivers, surface runoff and land-based point sources (Mohammed *et al*., 2012). In addition to contaminants from industrial activities, the coastal environment receives contaminants from agricultural activities, sewage and domestic waste, and urban runoff. Coastal sediments are considered important reservoirs for heavy metals, as metals tend to become adsorbed onto suspended particles and are scavenged from the water column into bottom sediments (Daskalakis and O'Connor, 1995; Karickhoff, 1984), but may become re-suspended due to storm events, activities such as dredging and burrowing by benthic organisms. Sediments also provide a time-averaged indication of metal contamination (Schropp *et al*., 1990).

The SOME, 2016 Report was based on the most recent island-wide assessment of heavy metals in coastal sediments available at that time, which was conducted in 2011. That assessment showed that sediment quality was poorest in the GoP, off the west coast of Trinidad. This was attributed to:

1. Anthropogenic activities that occur on this coast and in its associated watersheds including manufacturing; light and heavy industries such as plants producing iron and steel, iron carbide, power, gas, ammonia fertiliser, urea and methanol, liquid natural gas, cement; petroleum refining; oil and gas exploration and production as well as shipyard and yachting activities and intensive agriculture (IMA/UNEP, 2008);
2. The main urban areas, residential/housing areas, commercial areas, employment centres and the two main seaports in Trinidad, which are located on this coast;
3. The Total organic carbon /organic matter content of the sediments; and
4. The semi-enclosed/sheltered nature of the water body.

The main focus for 2016-2018 period was the GoP, which was the area of greatest concern based on the last assessment. Water and sediment samples were collected from 14 stations throughout the GoP in the dry and wet seasons of 2017 (Figure 3). Target analytes included cadmium, chromium, copper, iron, lead, nickel and zinc. Results are available for samples collected in the dry season of 2017. Ranges for metal concentrations in water and sediment are shown in Table 4.

Table 4: Metal concentration ranges in water and sediment from the GoP

Metal	Concentration Range		USEPA Criteria- Short Term (µg/ml)	CCME ISQG (µg/g)
	Water (µg/ml)	Sediment (µg/g)		
Cadmium	< 0.05	< 0.02	0.033	0.7
Chromium	< 0.10	4.2- 56.3	1.100	52.3
Copper	< 0.05	2.0- 18.4	0.005	18.7
Iron	< 0.10	13.5- 54.9[1]	na	na
Lead	< 0.10- 0.25	3.2- 16.6	0.210	30.2
Nickel	< 0.05	3.1- 21.9	0.074	20.9[2]
Zinc	< 0.05- 0.28	46.5- 63.3	0.090	124

[1] *Iron concentration- mg/g*
[2] *Effects range low (Long et al., 1995)*
na none available

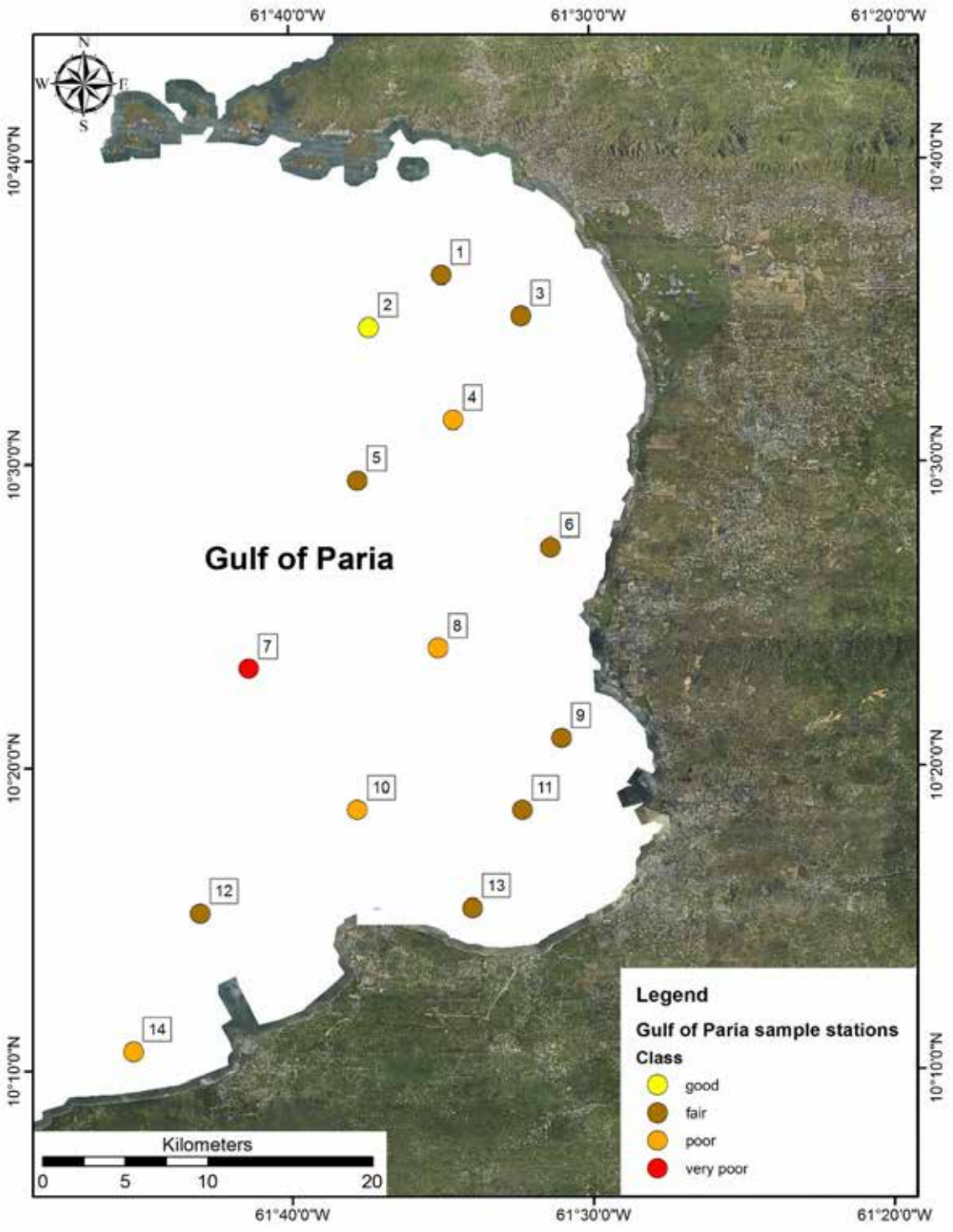


Figure 3:
Heavy Metal sampling at stations in the GoP

Classifications of “very good”, “good”, “fair” or “poor” were used for this report. Table 5 shows the definitions of the various classification terms used.

Table 5 Definitions of Classification Term

Term	Definition
Very good	All metal concentrations acceptable based on available guidelines; concentrations comparable with background data for the Gulf of Paria.
Good	All metal concentrations acceptable based on available guidelines; concentrations of some metals higher than background data for the Gulf of Paria.
Fair	One or more metal concentrations close to available guidelines; concentrations of some metals considerably higher than background data for the Gulf of Paria.
Poor	At least one water or sediment quality guideline exceeded (*i.e.* metal concentration is unacceptable).
Very poor	Both water and sediment quality guidelines exceeded.

Most stations in the GoP were classed as fair; only one station was classed as good (Figure 3). This station was located in the northern part of the GoP. Chromium, iron and lead were most elevated in the northern part of the Gulf; elevated concentrations of copper and nickel were also recorded in this area. One station in the northern part of the Gulf was classed as poor due to elevated concentrations of chromium in sediment; three stations in the central/southern part of the Gulf were classed as poor due to elevated concentrations of lead and zinc in water. These were the only two metals detected in water and concentrations tended to be more elevated in this part of the Gulf perhaps due to industrial activity. The only station that was classed as very poor was located further offshore in the central part of the GoP. This was due to elevated concentrations of nickel in sediment and of zinc in water. Results of the assessment suggest, as was noted in the previous report, that heavy metals at some locations within the GoP have the potential to adversely affect aquatic life.

Heavy Metals in Shellfish

Samples of the blue land crab, *Cardisoma guanhumi*, were collected from 12 stations in the Caroni Swamp during the wet season of 2017 and the dry season of 2018 (Figure 4). Target analytes included arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc. Although methylmercury is the more toxic fraction of mercury, because it is more costly to analyse than total mercury, the USEPA recommends that total mercury be determined and the assumption be made that all mercury is present as methylmercury, as this would be most protective of human health (USEPA, 2000). The USEPA recommends re-sampling for methylmercury if high concentrations of total mercury are detected (USEPA, 2000). Results are available for total mercury in samples collected in 2017.

Total mercury concentrations in the crabs sampled ranged from 0.02-0.34 µg/g wet weight (the corresponding methylmercury concentrations would therefore be lower). Highest concentrations were recorded along the Blue River (at the river mouth, at the north-south drain intersection, near the Visitor’s Centre and east of the highway). All concentrations, however, were acceptable based on the local maximum permissible level for methylmercury in non-predatory fish of 0.5 µg g^{-1} wet weight (GORTT, 1998), as well as the FAO/WHO Codex Alimentarius methylmercury guideline for non-predatory fish of 0.5 µg g^{-1} wet weight. Concentrations were also below the United States Food and Drug Administration/ Environmental Protection Agency Action Level of 1.0 µg g^{-1} wet weight.

Heavy metals concentrations in water and sediment at some locations within the GoP are likely to be unsuitable for the protection of aquatic life. All samples of the blue land crab, *Cardisoma guanhumi*, collected from the Caroni Swamp, contained mercury concentrations that are safe for human consumption, based on local and international guidelines.

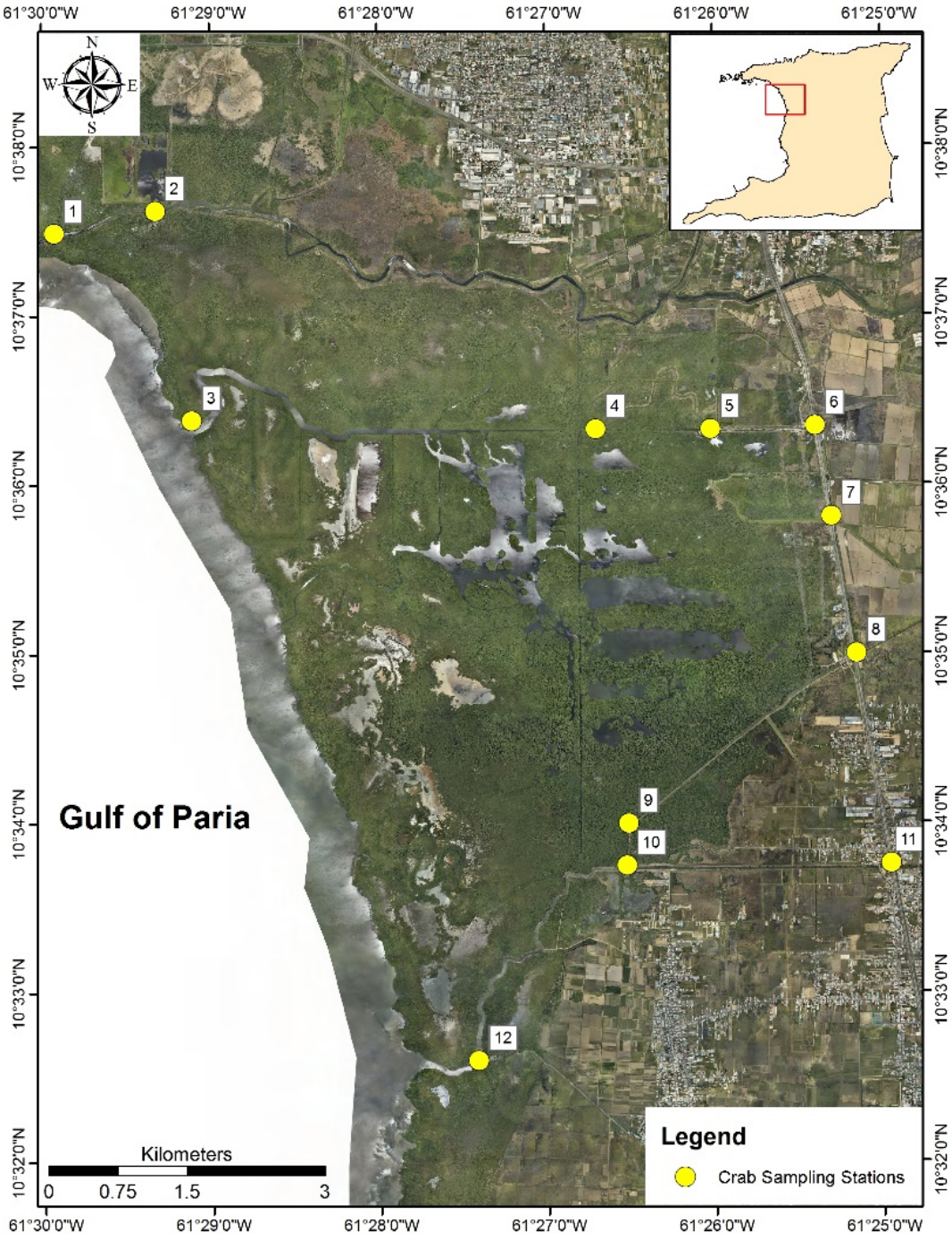


Figure 4:
Sampling stations for the blue land crab *(Cardisoma guanhumi)* in the Caroni Swamp

Bathing Beach Water Quality

In Trinidad and Tobago, beaches are used for recreational activities such as swimming, sporting activities, fishing and "the good old-fashioned lime." Here, beaches are also regarded as places of healing and joy. Beachgoers benefit from reduced stress, improved alertness, concentration, and immune system functioning, faster healing of skin wounds and some skin conditions, as well as enhanced skin cell regeneration. These benefits accrue at the seaside due to the sound of waves and from exposure to sea air and seawater (Ryman, 2013; Suval, 2014).

Beaches can also be risky places where beachgoers are exposed to microbiological hazards. One such microbiological hazard is the infection risk associated with swimming in sewage-contaminated water. Viruses are believed to be the major cause of swimming-associated illnesses such as gastroenteritis, hepatitis, respiratory illness and ear, nose and throat ailments. At beaches, swimmers with full body water contact and others, such as waders and fisherfolk with partial body water contact, can be exposed to waterborne pathogens. However, children, the elderly and those with weakened immune systems are more susceptible to becoming ill.

Bacteriological water quality data can indicate whether there would be potential health risks for persons participating in water contact activities at a beach or bay. Faecal coliforms, *Escherichia coli* and Enterococci bacteria were used as indicators of possible contamination from sewage during the conduct of bacteriological water quality surveys at beaches.

There are popular beaches in Trinidad and Tobago for which bathing water quality is non-existent. The IMA is currently conducting baseline surveys as part of a data gap filling process of a project designed to implement bacteriological water quality monitoring at popular beaches in Trinidad and Tobago, given the health risks associated with swimming in sewage contaminated water. Data of this type is available for some of the beaches and bays along the north, west and east coasts of Trinidad and for southwest Tobago. Findings of bacteriological water quality surveys conducted at Maracas Beach and at Las Cuevas Bay on the north coast of Trinidad, as well as at Williams Bay, Chagville Beach, Welcome Bay and along the San Fernando Coastline (from the cemetery on Lady Hailes Avenue to the Marabella River) on the west coast of Trinidad, were presented in the SOME, 2016. This SOME, 2018 report presents findings of surveys conducted at other beaches and bays along the east and west coasts of Trinidad and at southwest Tobago.

The IMA assessed bathing water quality by determining compliance with several international and regional bathing beach standards in the absence of local standards. These were the USEPA Quality Criteria for Water (1976), the USEPA Ambient Water Quality Criteria for Bacteria (1986), the CARICOM Regional Organization for Standards and Quality (CROSQ) Draft CARICOM Regional Standard (DCRS) Guidelines for Recreational Water Quality ((2010) and the Caribbean Blue Flag Water Quality Criteria (2003).

Las Cuevas Bay, North Coast

West Coast of Trinidad
Coastline from Bonasse Beach to Fullerton Beach at Cedros Bay (Figure 5)
(Dry Season Survey)

- Bathing water quality at Bonasse Beach in the dry season progressively deteriorates from the eastern section to the western section, off the main settlement at Bonasse Village, with the poorest water quality in the vicinity of the jetty at the extreme western end of Bonasse Beach.

- Eastern Bonasse Beach safe for bathing in the dry season (Stations 1 – 4). A river and drain are two potential sources of pollution, more so in the wet than in the dry season.

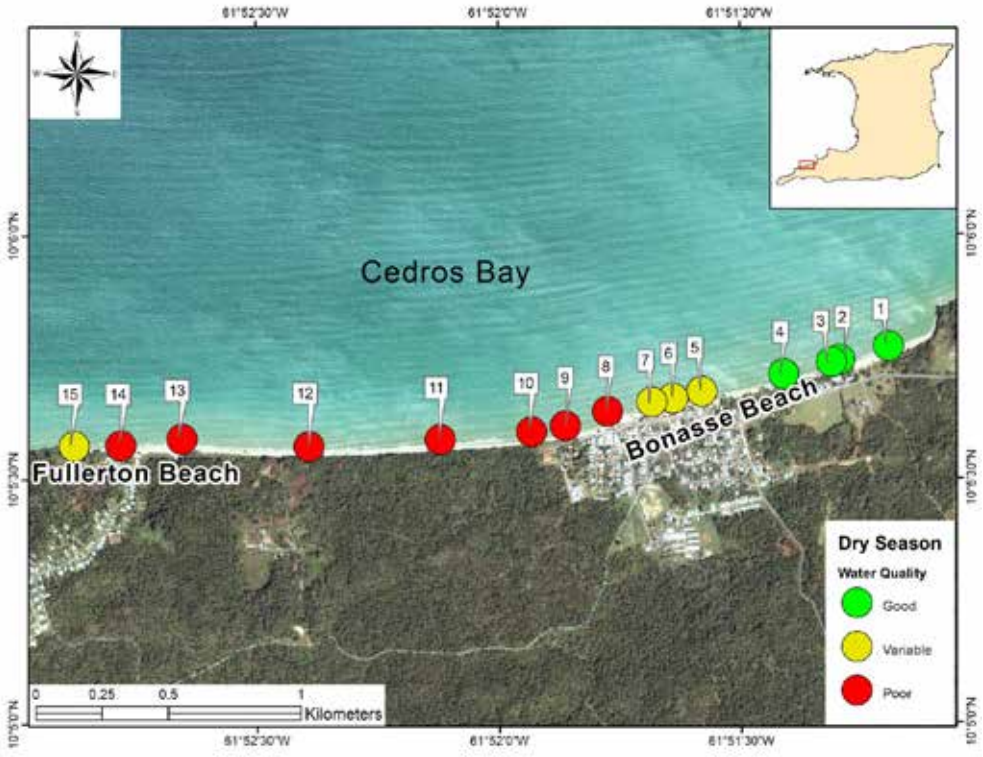


Figure 5:
Bacteriological water quality from Bonasse Beach to Fullerton, Cedros, West Coast of Trinidad

- Water quality varies at eastern section, off the main settlement at Bonasse Village. Unsafe for bathing after heavy rainfall (Stations 5 – 7). Two drains here are sources of pollution.

- Western section, off the main settlement at Bonasse Village, unsafe for bathing with potential health risks in the dry season (Stations 8 – 10). Two drains and a stream are sources of pollution for western Bonasse Beach.

- Along the coastline between Bonasse Village and Fullerton Village, unsafe for bathing due to poor water quality and potential health risks in the dry season (Stations 11 – 13). A source of pollution is a river at the eastern end of Fullerton Beach.

- Nearshore bathing water quality at Fullerton Beach progressively improves from off the end of the main road at Fullerton Village towards the headland at the western end.

- Bathing water quality along Fullerton Beach was mostly poor, with potential health risks for those with water contact in the dry season (Stations 13 – 15). A drain which channels wastewater from houses and businesses along the main road to Fullerton Beach is a source of pollution.

Coastline from Guapo Beach to Clifton Hill Beach at Western Guapo Bay (Figure 6)
(Dry and Wet Season Surveys)

- There is seasonal variation in bathing water quality at Guapo Beach.

- At Guapo Beach, from off the end of the road just west of the Guapo River, until the No Fishing sign just west of Clifton Hill Beach Resort compound, safe for bathing in the dry season (Stations 1 – 8).

- In the wet season, due to poor nearshore water quality, Guapo Beach is unsafe for bathing with potential health risks (Stations 1 – 8). Guapo River and a drain are sources of pollution for nearshore Guapo Beach.

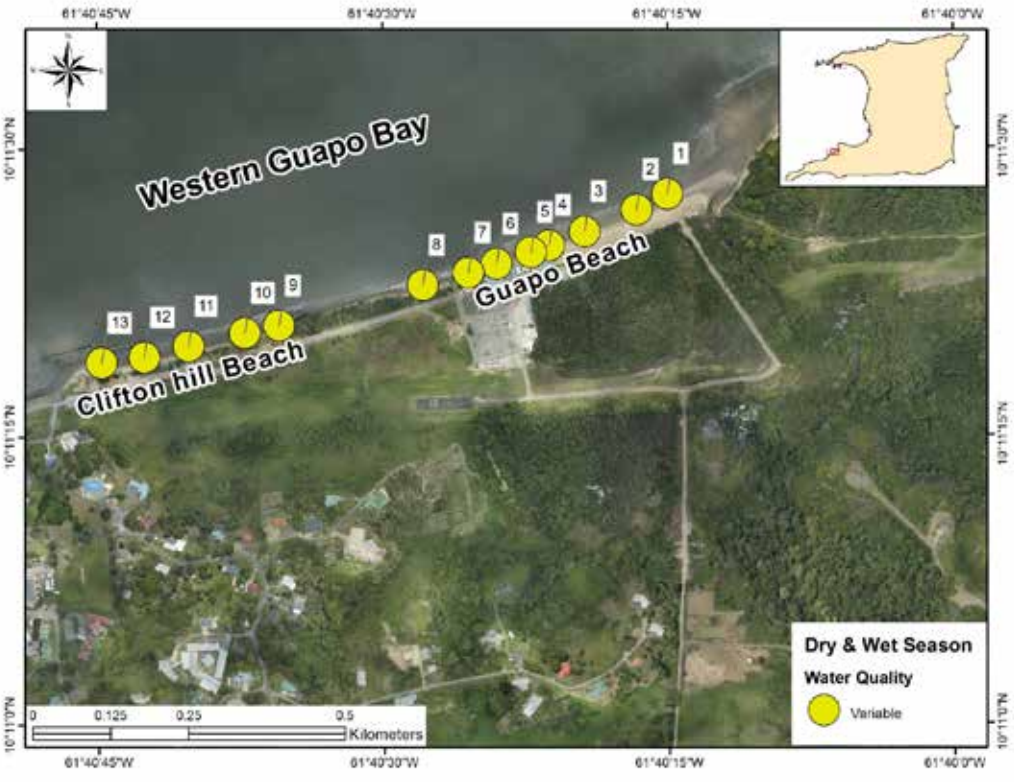


Figure 6:
Bacteriological water quality from Guapo Beach to Clifton Hill, Point Fortin

- Rainfall and turbidity may be useful indicators when assessing potential bathing water quality at Guapo Beach. Periods of heavy rainfall and very brown turbid nearshore waters are often associated with higher bacteria levels and hence potential health risks for beachgoers.

- Extreme eastern Clifton Hill Beach, safe for bathing in the dry season (Stations 9).

- However, at extreme eastern Clifton Hill Beach in the wet season, nearshore bathing water quality is poor, with potential health risks (Station 9). Flow from Guapo River is a potential source of pollution for extreme eastern Clifton Hill Beach.

- Nearshore water quality sometimes varies during the dry season and in the wet season at some locations along Clifton Hill Beach (Stations 10, 11, 12 and 13).

- Nearshore water quality from eastern to western Clifton Hill Beach is usually safe for bathing in the dry season (Stations 10 – 13). Occasionally during the dry season however, nearshore water quality deteriorates and is unsafe for bathing at some locations along Clifton Hill Beach, for example, at stations 10, 12 and 13.

- In the wet season nearshore water quality at Clifton Hill Beach is mostly unsafe for bathing (Stations 10 – 13). However, there are instances during the wet season when bathing water quality is good at some locations along Clifton Hill Beach, for example, at stations 11 and 13.

- Potential sources of pollution for Clifton Hill Beach are Guapo River and a small stream at western Clifton Hill Beach.

- Rainfall and turbidity may be useful indicators when assessing potential bathing water quality at Clifton Hill Beach. Periods of heavy rainfall and very brown turbid nearshore waters are often associated with higher bacteria levels and hence potential health risks for beachgoers.

East Coast of Trinidad

Coastline from L'Ebranche River to Ortoire River at Cocos Bay, Manzanilla (Figure 7)

(Wet Season Survey)

- Just south of the mouth of the L' Ebranche River, nearshore water quality in the wet season is unsafe for bathing with potential health risks (Station 1). A potential source of pollution here is the L'Ebranche River.

- Nearshore bathing water quality at Manzanilla Beach Facility in the wet season progressively improves from the northern end towards the southern end of the facility.

- In the wet season, nearshore water quality is mostly poor at the northern end of the Manzanilla Beach Facility (Station 2) with potential health risks for bathers, improves at the middle section of the facility with occasional poor water quality and resultant health risks (Station 3) and is safe for bathing at the southern end of the facility (Station 4).

- Two potential sources of pollution for nearshore Manzanilla Beach Facility are a stream at the northern end of this facility and flow from the L'Ebranche River.

- Water quality at Breakway, further south for a distance of at least 7km which is a section of coastline at Cocos Bay accessed via tracks from the Manzanilla Mayaro Road, and Bellpiece at the spit are safe for bathing in the wet season (Stations 5, 6, 7, 8, 9).

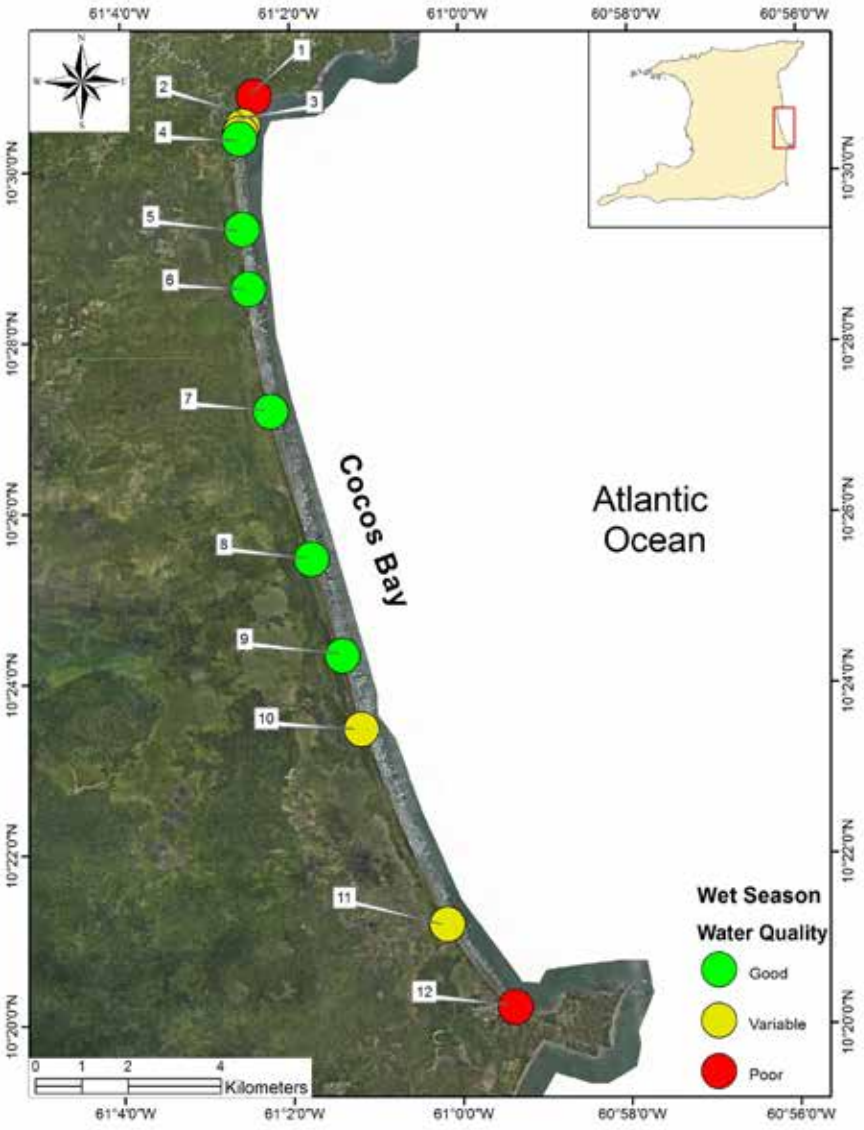


Figure 7:
Bacteriological Water Quality in Cocos Bay East Coast of Trinidad

- Just downstream of the mouth of the Nariva River, off the retaining wall, nearshore bathing water quality deteriorates and is often unsafe for bathing in the wet season (Station 10). Further south along the coastline, between Kernahan and Cascadoo Trace, at the end of the Rip Rap, nearshore bathing water quality improves and is mostly good and only occasionally poor (Station 11). Potential sources of pollution for this section of Cocos Bay include two rivers and a canal.

- Nearshore bathing water quality after the mouth of the Ortoire River, just before the headland at Pt. Radix is unsafe for bathing in the wet season (Station 12). A potential source of pollution here is the Ortoire River.

Coastline from St. Joseph Village to Indian Bay at Mayaro Bay (Figure 8)
(Wet Season Survey)

- Nearshore bathing water quality is safe in the wet season along the coastline at the northern section of Mayaro Bay: at St. Joseph Village, off the Travelling Officers Quarters and at Rabita Avenue (Stations 1, 2, 3). A drain and a river are potential sources of pollution for this northern section of Mayaro Bay.

- Further south along the coastline at Granado, there is some deterioration in nearshore bathing water quality (Station 4). In the wet season, water quality at Granado is sometimes safe for bathing. However, there are instances when nearshore water quality is poor with potential health risks for bathers. Two rivers are potential sources of pollution for Granado.

- At D'eeroze, nearshore water quality in the wet season is often poor, with bathers exposed to potential health risks (Station 5). Flow from a sewage contaminated drain is a source of pollution for nearshore D'eeroze.

- Further south along the coastline at Plaisance, nearshore bathing water quality improves. There is often good nearshore bathing water quality in the wet season (Station 6). However, there are occasions when water quality is poor with resultant potential health risks for bathers, as well as others with partial body water contact such as fisherfolk.

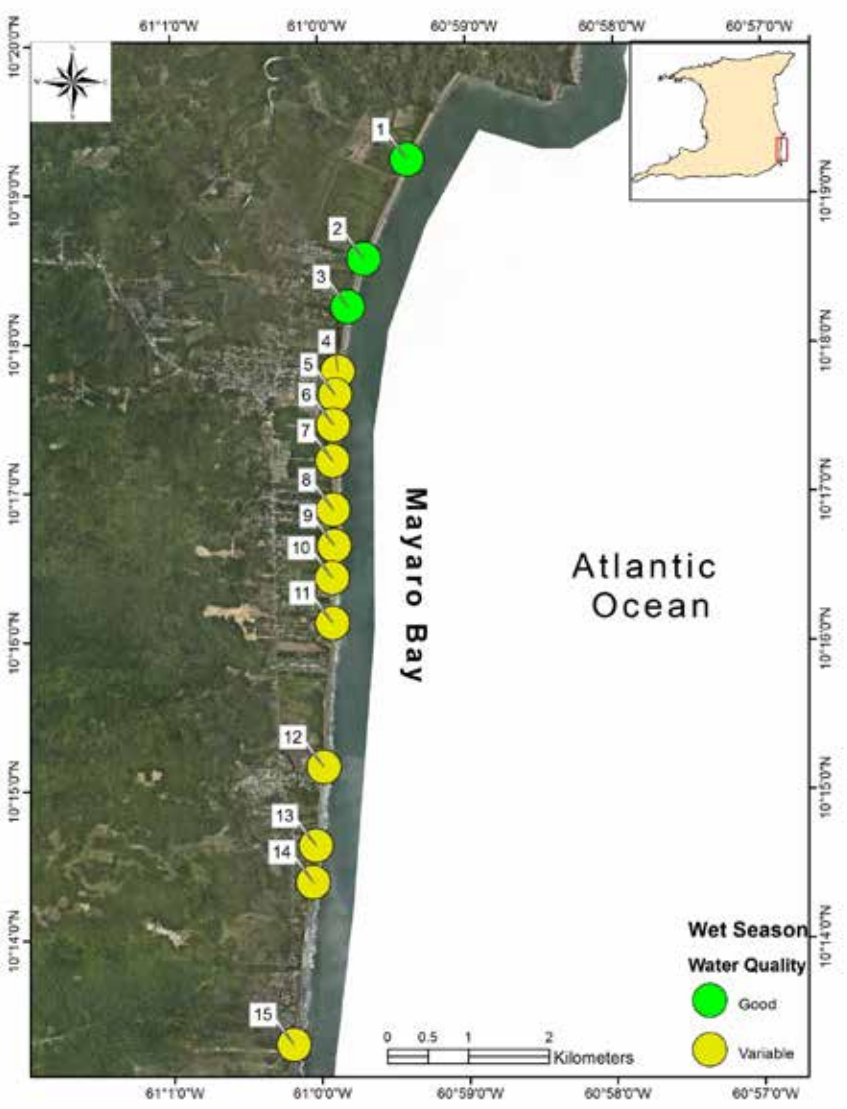


Figure 8
Bacteriological water quality in Mayaro Bay North Coast of Trinidad

- At Beaumont, nearshore bathing water quality deteriorates. Water quality at Beaumont is mostly unsafe for bathing in the wet season, with bathers exposed to potential health risks (Station 7). However, there are some instances in the wet season when nearshore bathing water quality is good. A river is a potential source of pollution for Beaumont.

- Further south along the coastline, nearshore water quality off St. Ann's Road is often good in the wet season (Station 8). However, on occasion, water quality is unsafe with potential health risks for bathers. A potential source of pollution here is the St. Ann's River.

- Nearshore bathing water quality off Church Street is mostly good in the wet season (Station 9). There are instances however when water quality is unsafe and bathers are exposed to potential health risks in the wet season. Two rivers are potential sources of pollution for this section of Mayaro Bay.

- Further south along the coastline at Radix, nearshore bathing water quality is often good in the wet season (Station 10). However, occasionally water quality is poor with potential health risks for bathers. A river is a potential source of pollution here.

- At Bonespoire, nearshore bathing water quality is mostly good in the wet season (Station 11). On occasion however, water quality is poor with resultant potential health risks for bathers. A river is a potential source of pollution for nearshore waters at Bonespoire.

- Further south along the coastline, wet season nearshore bathing water quality is often good at Grand Lagoon (Station 12). However, there are instances when water quality is poor and bathers are exposed to potential health risks in the wet season. A river is a potential source of pollution for nearshore Grand Lagoon.

- Off Maloney Road, wet season nearshore water quality improves and is usually safe for bathing (Station 13). However, on occasion, water quality is poor and there are potential health risks for bathers in the wet season. A stream is a potential source of pollution for this section of the coastline.

- Further south along the coastline off Harry's Guest House, nearshore water quality is usually safe for bathing in the wet season (Station 14). Occasionally however, nearshore water quality is poor in the wet season and unsafe for bathers who are exposed to potential health risks. A river is a potential source of pollution here.

- Nearshore bathing water quality at popular Indian Bay is usually good in the wet season (Station 15). On occasion however, nearshore water quality is poor in the wet season and there are potential health risks for bathers. A river is the potential source of pollution here.

Las Cuevas Beach

The SOME, 2016 highlighted areas with good and poor bathing water quality at Las Cuevas Beach.

- From off the Tourist Facilities to extreme western Las Cuevas Beach, a section of which was in the second season of Blue Flag Certification, had good bathing water quality.

- East of the Tourist Facilities to extreme eastern Las Cuevas Beach had poor water quality and was unsafe for bathing.

- The main source of pollution for eastern Las Cuevas Beach was a river contaminated with effluent from a sewage treatment plant as well as waste from a fishing depot, which discharged into the nearshore waters of this beach.

It is noteworthy that Las Cuevas Beach is no longer Blue Flag certified. The Blue Flag Programme was a tool which facilitated management in a holistic manner, as well as an improvement in environmental quality, at Las Cuevas Beach. With the flag flying, beachgoers were assured that bathing water quality at the Blue Flag section of Las Cuevas Beach was good, surroundings were clean and recycling of waste materials was encouraged. Lifeguards were on duty daily with available first aid and lifesaving equipment. There was zoning at the beach to prevent accidents and conflicts. For disabled persons, there was a bathroom facility, a winch for beach access and an amphibian wheel chair for access to the sea. There were also environmental education activities and codes of conduct on the beach.

There must be the recognition that recreation which is well planned and managed can be an impetus for bringing sustainable tourism as a vehicle of development to local communities. Blue Flag certification of Las Cuevas Beach and other popular bathing beaches in Trinidad and Tobago is important as sustainability is one of the core values required to drive the tourism industry forward. Central to this process is the adoption of voluntary initiatives such as certification schemes, among others, that encourage commitment to change on the road to sustainable tourism in Trinidad and Tobago.

Maracas Beach

In the SOME, 2016, microbial analysis conducted at Maracas Beach highlighted areas with good, variable and poor water quality.

- The eastern side of the Maracas River had good water quality and was safe for bathers during both wet and dry seasons.

- The western side of the Maracas River had variable water quality and was safe for bathers during the dry season or days without heavy rainfall.

- The Maracas River had poor water quality and was unsafe for bathers during both seasons.

In 2018, routine monitoring was not performed, however, a sampling exercise was conducted in response to reports of sewage pollution at the beach. Investigations revealed that the new sewage treatment plant was still under construction and the old plant was not properly maintained in the interim. The Ministry of Tourism has been working with relevant stakeholders to have the situation rectified. The IMA continues to recommend that bathing at or in close proximity to the Maracas River should be avoided, due to high levels of faecal coliform bacteria present on occasion.

Bacteriological Water Quality in Southwest Tobago

In Southwest Tobago, water quality monitoring is done in conjunction with coral reef and seagrass monitoring. Bacteriological monitoring was added to the existing programme in 2015 to determine if sewage pollution was prevalent at the various locations. The microbial indicator used was Enterococci which is the best indicator for sewage pollution in marine waters. The method employed a rapid technique (Defined Substrate Technology (DST)) which detected Enterococci using the enterolert test. This test, manufactured by IDEXX, facilitated the work to be done in Tobago without requiring laboratory facilities.

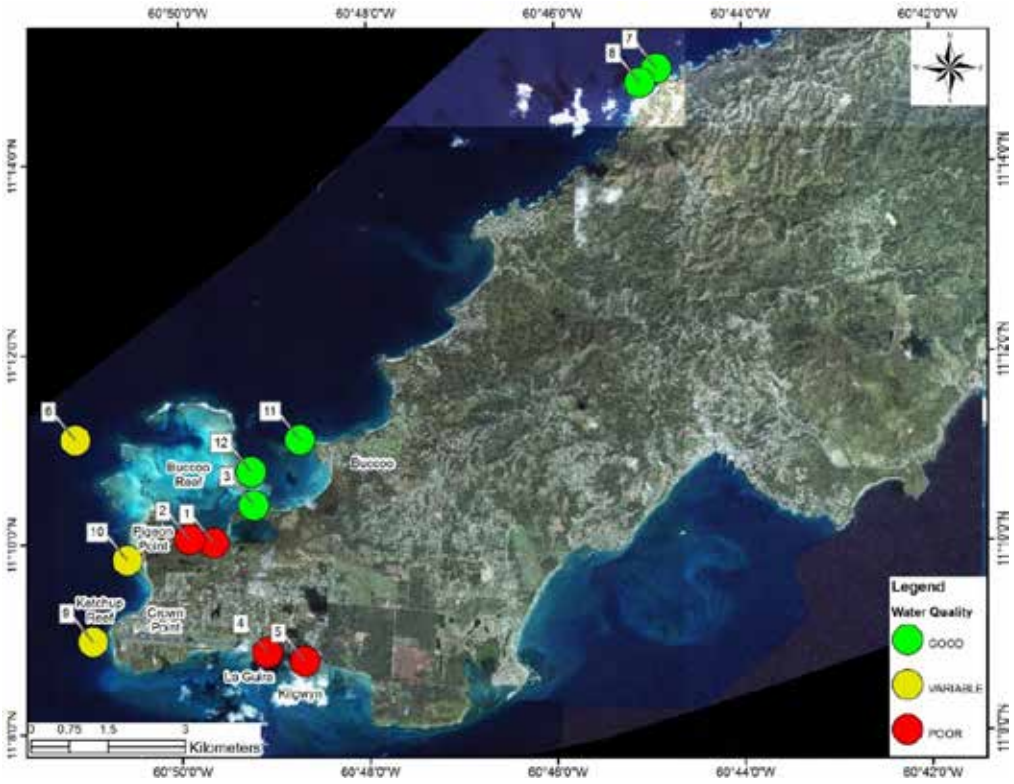


Figure 9:
Bacteriological water quality in southwest Tobago

For the indicator organism, Enterococci, the USEPA (1986) Daily limit is 126 Colony Forming Units (CFU) /100ml. The results from daily sampling and ratings were established for each site in Tobago, based upon whether or not samples collected exceeded water quality guidelines (poor). The bacteriological water quality at the 12 stations are presented in Figure 9.

- Buccoo Bay, North Sheerbird's Point, Culloden Bay – Good water quality (green)
- Bon Accord Lagoon, Kilgwyn Bay and La Guira Bay – Poor water quality (red)
- Bon Accord Lagoon water quality was poor possibly due to effluent emanating from the Bon Accord Sewage Treatment Plant
- Kilgwyn Bay and La Guira Bay was poor possibly due to outflows from nearby residential development
- Crown Point and Pigeon Point water quality was good in the dry and the wet season but it should be noted that the results were near BORDERLINE in the wet season possibly due to increased land-based runoff.

Potential health risks exist for beachgoers from poor bathing beach water quality, reflected in high microbial levels, recorded at different times of the year in parts of Cedros, Guapo Bay, Cocos Bay, Mayaro Bay, and southwest Tobago including Bon Accord Lagoon, Kilgwyn and La Guira.

Coastal protection measure at Cocos bay

Coastal Dynamics

Coastal Dynamics

The IMA has been monitoring the dynamic nature (erosion and accretion rates, coastal processes) of selected beaches and bays throughout Trinidad and Tobago since 1988 under its Coastal Conservation Project. Currently, 30 bays in Trinidad (76 benchmarks) and 30 bays in Tobago (61 benchmarks) are monitored. Beaches are dynamic coastal features which respond to the coastal processes (waves, winds, currents and tides) dependent on their geology. Where the coastal geology is resistant to wave attack, erosion may occur at a reduced rate (Cambers, 2009) and where it is more susceptible, it may erode at a faster rate (Van Rijn, 1998). In Trinidad, the north coast is mainly rocky cliff, while the west coast is rocky at the northern end, consists of wetlands and mudflats at its central region and alluvium material toward the southern end. The south coast is comprised of sandstone cliff, and the east coast is varied with rocky cliffs at the northern end, wetlands and sandstone cliff at the central and southern areas. In Tobago, the coastline consists mainly of rocky cliff to the central and northeast of the island with coral limestone in the southwest.

When there is no net loss of sediment during an annual cycle of accretion and erosion, a beach is classified as being in dynamic equilibrium. Beaches accrete (become wider) when there is a net gain of sediment and erode (become narrower) when there is a net loss of sediment. The coastline can be protected using hard and soft techniques that may arrest coastal erosion. The techniques employed need to be properly informed by oceanographic data (waves, currents, tides) and topographic data (land surveys such as beach profiles). The technique chosen is based on several factors inclusive of cost and type of material used. The following maps, photographs and graphs illustrate the dynamic nature of selected beaches around Trinidad and Tobago's coastlines for the period 2016 – 2018, highlighting erosion and coastal protection in some instances.

San Souci Bay, North Coast Trinidad

The IMA monitors two benchmarks at San Souci Bay (Figure 10). At Benchmark 2, the sand levels fluctuated during the period January 2016 to January 2018 with the lowest elevation in January 2018 (Figure 11). San Souci beach (Benchmark 2) before and after wave events in 2018 is provided in Figures 12 and 13.

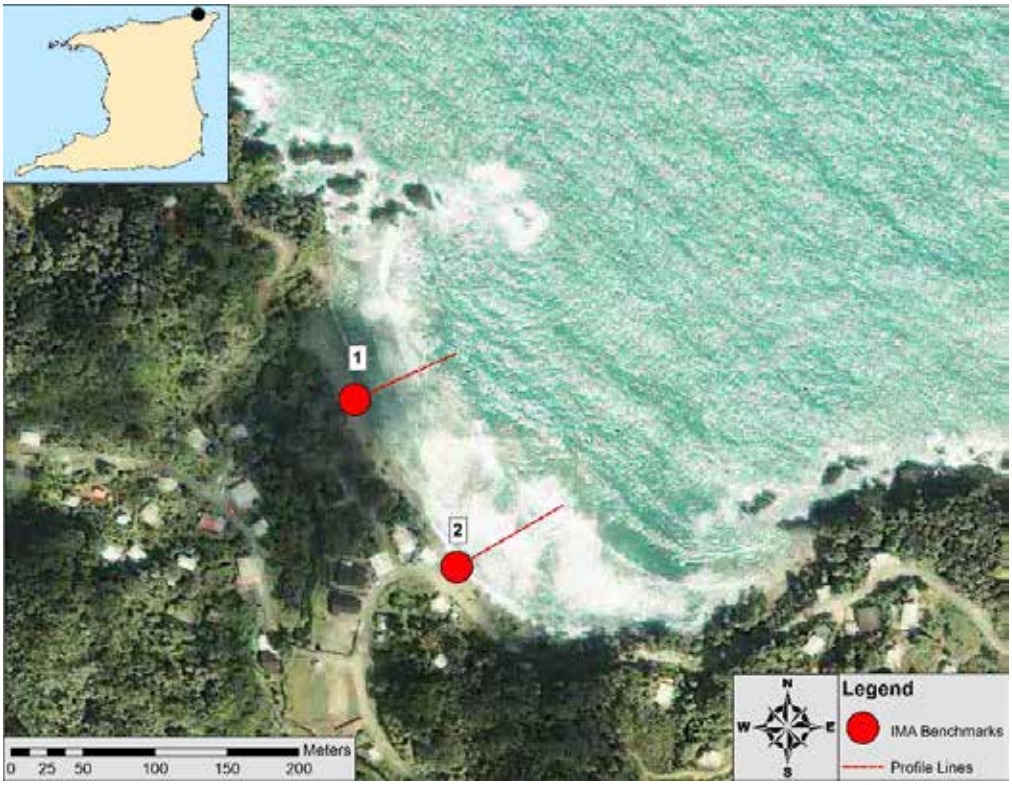


Figure 10:
Map of IMA monitoring benchmarks at San Souci Beach

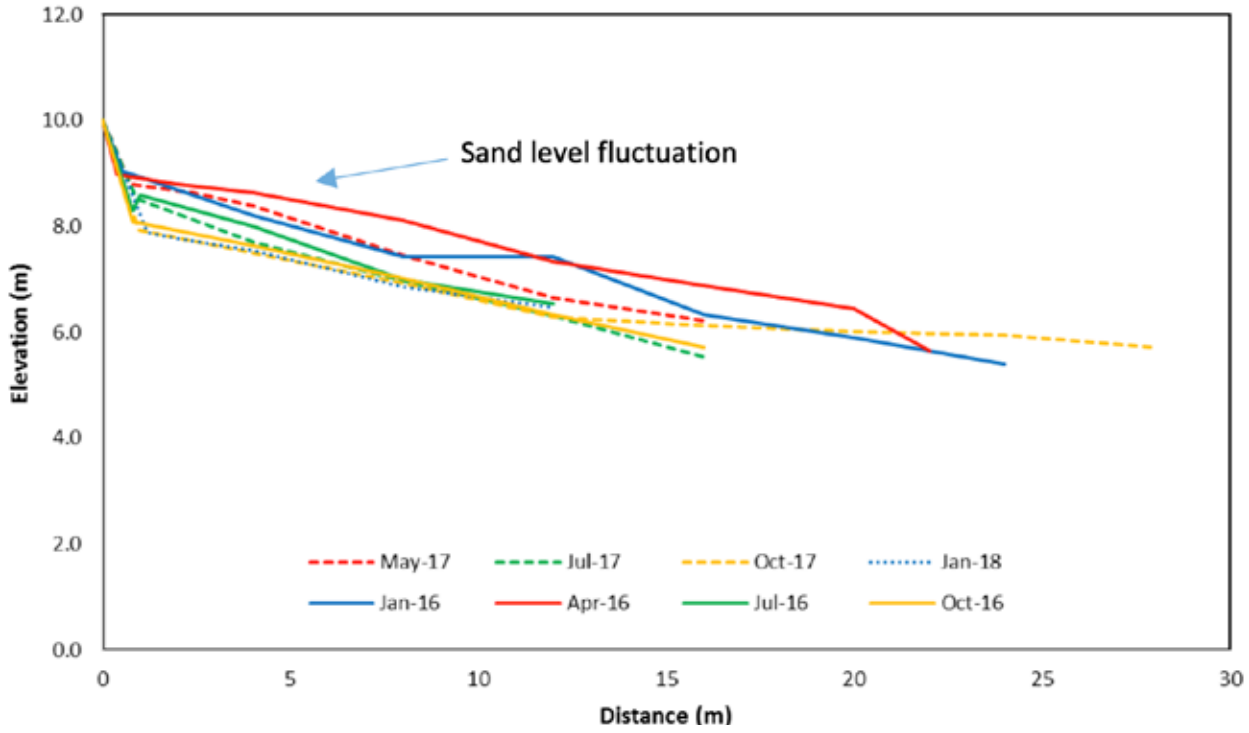


Figure 11:
Beach profiles at benchmark 2, San Souci Bay, Trinidad, showing sand level fluctuations (2016-2018).

Figure 12:
Before swells (2017)

Figure 13:
After swells (2018)

The seawall (Figure 12) which protected the Paria Road and shoreline at San Souci Bay in 2017 was destroyed (Figure 13) by large swells during early 2018. Rubble revetment is currently being utilized for protection of this coastal infrastructure.

Cocos Bay, East Coast, Trinidad

The IMA monitors six benchmarks on Cocos Bay (Figure 14). A southerly view of Cocos Bay (benchmark 1B) from the adjacent beach facility (2017), illustrating residential structures within the active beach zone which are susceptible to spring tides and storm surge is shown in Figure 15. Beach profiles taken at this benchmark during 2016 to 2018 are illustrated in Figure 16.

The beach profiles indicate a steepening beach face during November 2016 to January 2018. This morphological change is indicative of erosion at this section of the beach. The erosion rate is estimated at 0.07 m/yr for this period.

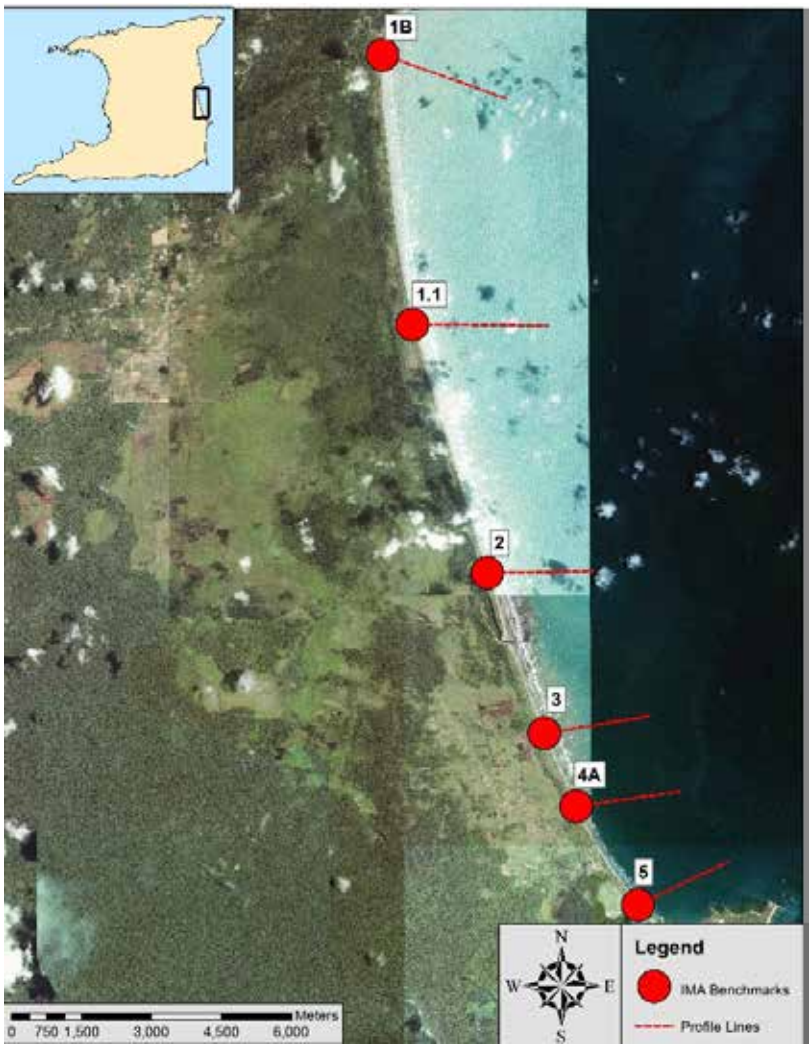


Figure 14:
Location of IMA monitoring benchmarks on Cocos Bay

Views of Cocos Beach Facility before and after protection works were implemented are shown in Figures 17 and 18. The seawall at the Manzanilla Beach Facility was compromised and the action of the waves with overtopping removed the supporting material behind it (Figure 17). Restoration works were completed on the seawall in 2017 (Figure 18). An aerial view of the Manzanilla Beach Facility Seawall Stabilization Works is provided in Plate 2.

Figure 15:
Southerly view of benchmark 1B on Cocos Bay (2017)

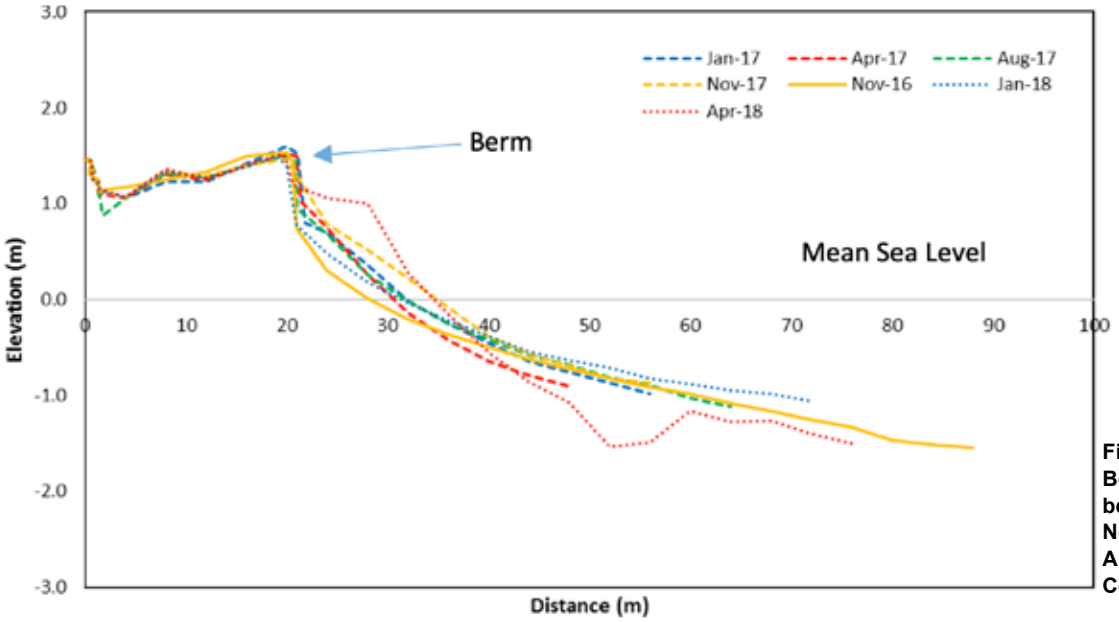


Figure 16:
Beach profiles at benchmark 1B from November 2016 to April 2018 at Cocos bay, Trinidad

Figure 17:
Before protection works, southerly view (2015)

Figure 18:
After protection works, northerly view (2017)

Plate 2:
Aerial view of the Manzanilla Beach Facility Seawall Stabilization Works
(Source: Coastal Protection Unit, Ministry Of Works and Transport)

Los Iros Bay, South Coast, Trinidad

The IMA monitors 2 benchmarks at Los Iros Bay (Figure 19). Beach profiles for the two stations in Los Iros Bay for the period 2016 to 2018 are illustrated in Figures 20 and 21. A high distinct berm is observed at Benchmark 2 (Figure 20) while a narrow low beach was observed at Benchmark 1 (Figure 21).

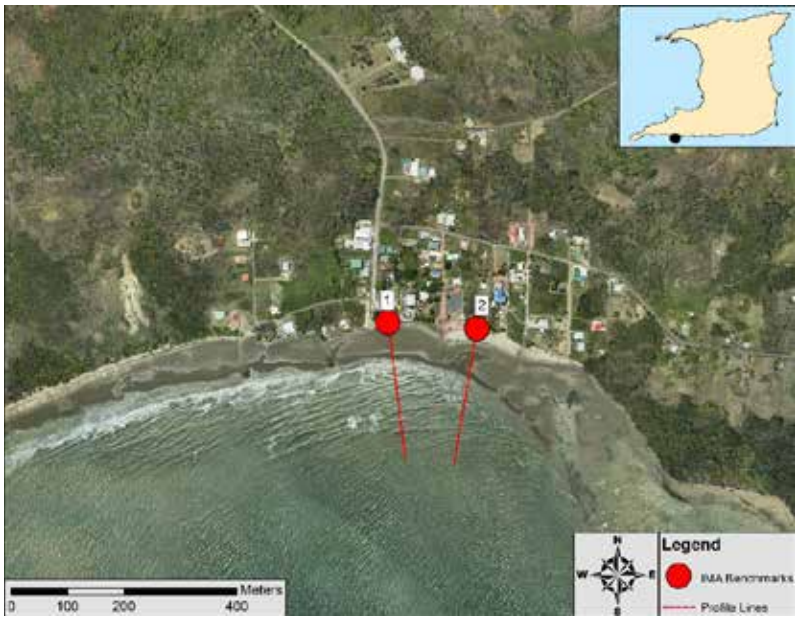


Figure 19:
Map of IMA's monitoring benchmark at Los Iros Bay (2015)

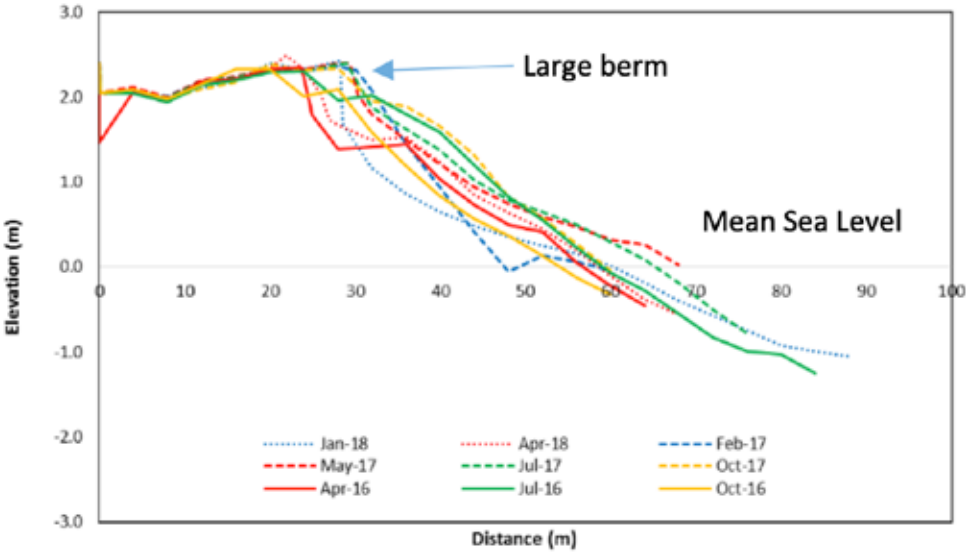


Figure 20:
Beach profiles at benchmark 2 Los Iros, Trinidad (2016) illustrating sediment accumulation

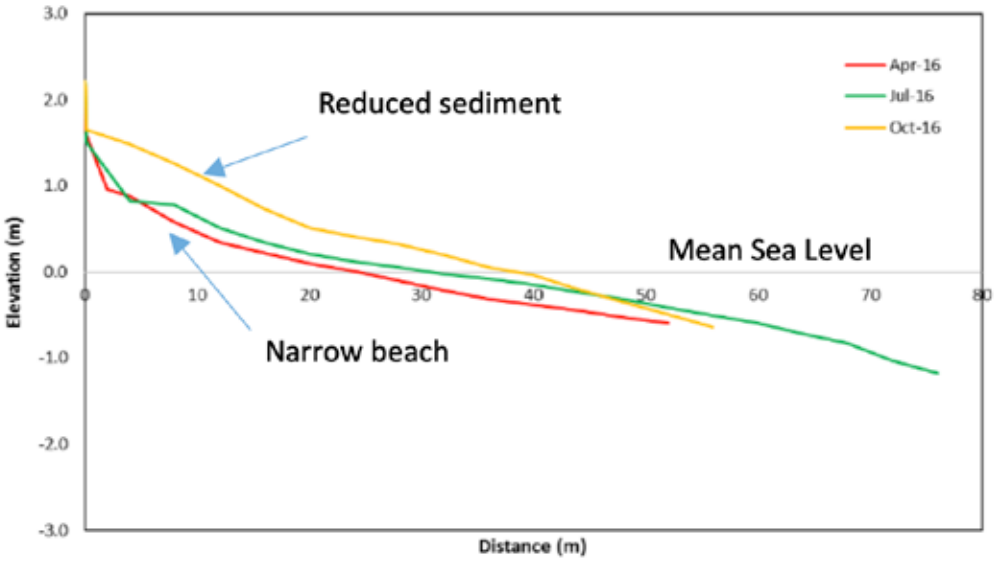


Figure 21:
Profiles at benchmark 1 Los Iros, Trinidad (2016) illustrating a sediment starved beach

The groyne to the west (Figure 22) prevented sediment from flowing along the rest of the bay and starved that region of sediment (Figure 23), which resulted in erosion of the beach and reduced sediment illustrated by the profiles at benchmark 1.

Figure 22:
West view of berm at benchmark 2, Los Iros Bay, Trinidad (2015)

Figure 23:
West view of sediment starved beach at benchmark 1 Los Iros Bay, Trinidad (2017)

Tobago

The sites selected around Tobago are situated in close proximity to critical infrastructure (such as roads and coastal protection structures) around the island.

Barbados Bay, Windward Coast

The IMA monitors 3 benchmarks on Barbados Bay (Figure 24).

Benchmark 3 indicates erosion of the cliff at a rate of 0.67 m/yr (Figure 25). The erosion rate of the easily weathered cliff has increased marginally from previous years, however, this erosion is progressing so much so that the Windward Road will be impacted by the Atlantic Ocean in less than a decade if no intervention occurs.

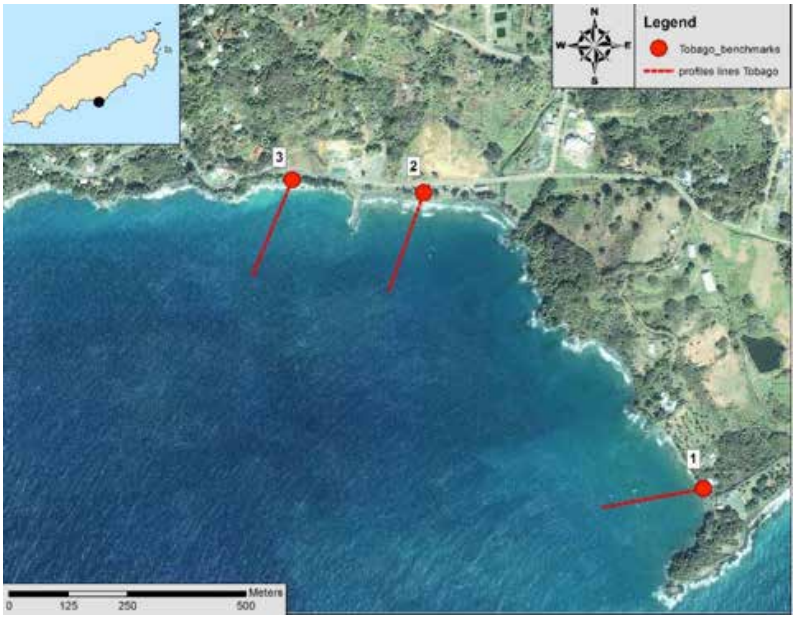
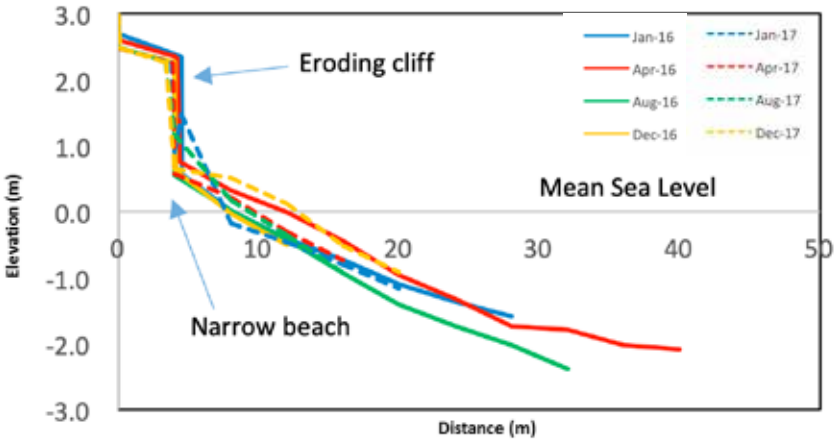


Figure 24:
Location of IMA monitoring benchmarks at Barbados Bay



The Windward Road which is approximately 5m away from the cliff edge has approximately 7 years before the Atlantic Ocean compromises it. Figure 26 and 27 illustrate a very narrow beach at Benchmark 3.

Figure 25:
Beach profiles at benchmark 3, Barbados Bay, Tobago (2016-2017)

Figure 26:
Seaward view (2016)

Figure 27:
Landward view (2016)

Mt Irvine Bay, Leeward Coast

The locations of IMA monitoring benchmarks adjacent to the Leeward Road at Mount Irvine Bay are shown in Figure 28.

The beach profiles at the western region of Mount Irvine Bay highlights the seasonal variation (Figure 29) in the sediment which shows periods of accretion and erosion. Profile 2B is located at the centre of the Grange Bay seawall (Figure 28).

The seawall in Figure 30 was constructed to protect the Windward Road but both the seawall and road have been compromised and are in need of repair.

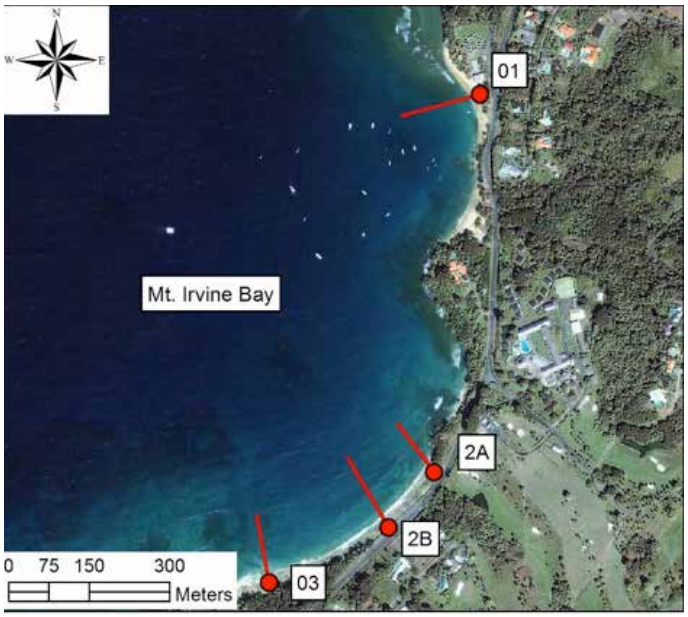


Figure 28: Location of IMA's monitoring benchmarks on Mt Irvine Bay

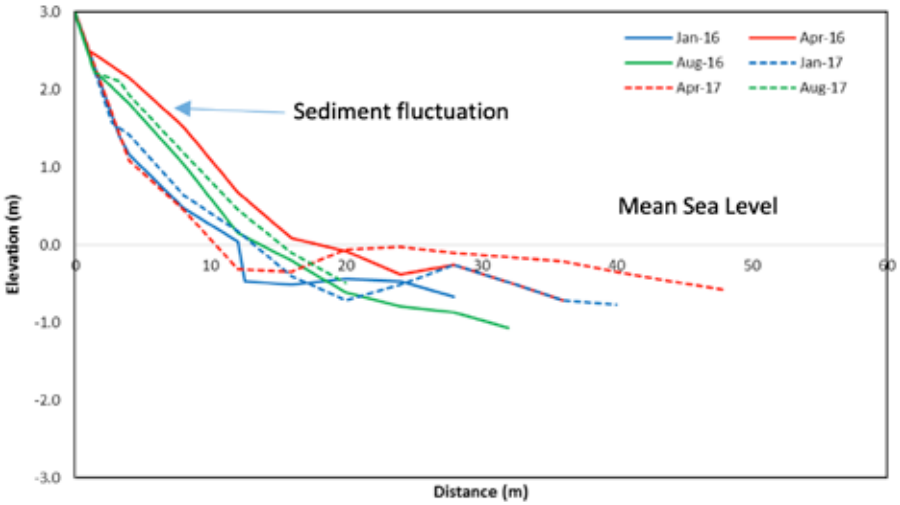


Figure 29: Beach profiles at benchmark 2B, Mount Irvine Bay - Grange (2016-2017) showing seasonal sediment fluctuation

Figure 30: View of large cracks along sections of seawall at benchmark 2B, Mount Irvine Bay - Grange (2016)

Many of our beaches and bays are subjected to coastal erosion and this is expected to intensify with the impacts of climate change, particularly sea level rise and increases in storm surge.

Coastal Protection in Trinidad and Tobago

The Coastal Protection Unit (CPU) was established in 2014 to implement the mandate of the Ministry of Works and Transport (MOWT) through the Critical Coastal Protection Programme. The Critical Coastal Protection Programme is designed to address and provide improved understanding of coastal hazard susceptibility relating to sea level rise, extreme weather events and riverine flooding. The CPU executes the MOWT coastal protection mandate as follows:

- Deliver prioritized coastal stabilization solutions;
- Continuously monitor the coastline to identify issues that affect its stability;
- Assist in the development and implementation of Government's policies regarding coastal zone management, climate change and shoreline management; and
- Recommend a lasting course of action for the sustained delivery of the MOWT's coastal protection mandate.

The Critical Coastal Protection Programme executed by CPU is a multiphase strategy or roadmap for addressing the impacts of coastal erosion and flooding in Trinidad. It is comprised of a combination of projects and components which collectively will realize the inherent benefit, to raise the standard of living and quality of lives of citizens. The Programme provides short, medium and long-term solutions to address coastal erosion and coastal inundation (flooding) at critical areas along Trinidad's shoreline, with a focus on shoreline management using a combination of hard engineering structure and nature-based solutions. Table 6 provides a list of coastal protection interventions made by the CPU since 2015.

Coastal protection structures (hard and soft structures) are designed to reinforce the shoreline against the impact of coastal processes, climate change and sea level rise – if constructed with the coastal processes considered. Additionally, continuous monitoring and evaluation of these structures are needed to ensure that the structures implemented are functioning effectively and are not compromised.

While the CPU, MOWT is the government authority with responsibility for coastal protection in Trinidad, in Tobago this responsibility falls under the Coastal Zone Unit, Department of Infrastructure Quarries and Environment, Tobago House of Assembly (THA). Some projects to be executed under this Unit to arrest erosion include the Lambeau Shoreline Stabilization Work, the Pigeon Point Coastal Vulnerability Study and the Pinfold Bay Shoreline Stabilization Work.

Table 6: Coastal Protection Unit projects around Trinidad 2015 - present

Project name	Comments
Manzanilla Beach Facility Seawall Stabilization Works	Completed in 2015
North Cocos Bay Shoreline Stabilization Works	Completed in 2015
Shore Of Peace Coastal Cliff Stabilization Works	Completed in 2016
Sans Souci Shoreline Stabilization Works	In progress
Quinam Coastal Protection Works	In progress
Cocos/South Cocos Bay Shoreline Stabilization Works	In progress
Matelot Shoreline Stabilization Works Phase 2	In progress
Cap De Ville Shoreline Stabilization Works	Future project

Shoreline Change Analysis

Shoreline Change Analysis

The coastline is the interface between the sea and the land, and is a dynamic area that is influenced by coastal processes. Along the coastlines of both Trinidad and Tobago are extensive infrastructure, industry, settlements, important natural ecosystems, and beaches upon which much of the tourism industry is based. The coastline is impacted by storms, storm surges, sea level rise, and human interventions which alter the natural dynamics leaving it vulnerable to erosion.

Monitoring the change in the shoreline over time is important in enabling proactive action to be taken to protect lives, property, infrastructure and ecosystems. Continuing work undertaken by the IMA (Jehu and Ramsawak, 2012) in which the stable vegetation line was mapped using 1994 aerial photography and 2007 Ikonos satellite imagery, the vegetation line from the 2014 aerial photography was mapped and the changes in the coastline for selected areas of interest are displayed below.

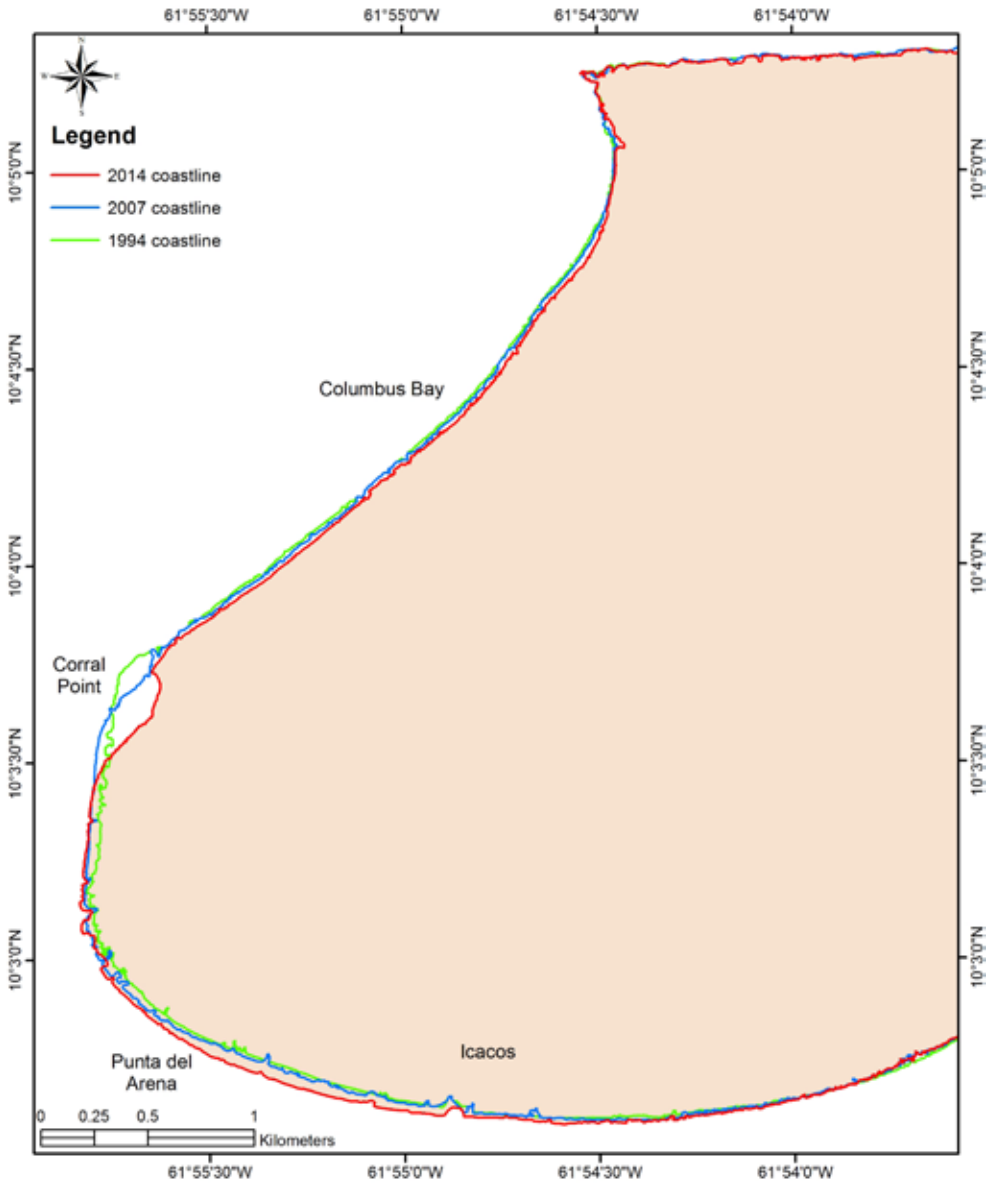


Figure 31:
Change in the shoreline at the Columbus and Icacos Bays, South Trinidad from 1994 to 2014

Columbus Bay, located on the tip of the southwestern peninsula, has been experiencing erosion over decades. Observation of the coastline of Columbus Bay indicates that there is recession along the entire length of the Bay (Figure 31). The erosion is so severe at the southern end of Columbus Bay that the area known as Corral Point is no longer a point, but a bay.

The coastline at Corral Point receded by a maximum of 71 m from 1994 to 2007 and then by a maximum of 156m from 2007 to 2014.

This has resulted in the loss of parts of the coconut plantation as well as plantation buildings and roads. In contrast to the severe erosion occurring along Columbus Bay, further south at Punta del Arenal and west towards Icacos there is a significant amount of accretion occurring and the coastline in this area is expanding (Figure 31). The coastline at Punta del Arenal accreted by a maximum of 16m from 1994 to 2007 and then by a maximum of 55m from 2007 to 2014.

Much of the Pt Lisas Industrial Estate was built on former mangrove swamp and sugar plantation which resulted in a significant modification of the coastline (Figure 32). Hard structures were installed to armour and stabilize the coastline and protect the heavy industry located in close proximity. As a result, in these areas there has been no significant changes on the coastline. However, just north of Pt Lisas where the mouth of the Couva River flows, there has been a large, human driven expansion in land area. The coastline at the mouth of the Couva River accreted by a maximum of 1,036 m from 1994 to 2007 and then by a maximum of 368 m from 2007 to 2014.

In the construction of the Estate about 5 km^2 of mangrove was removed and in an effort to promote the natural replacement of mangrove, the dredge spoil from the shipping channel was dumped to the north of Pt Lisas and south of the Couva River. This resulted in the accumulation of the sediments outside the mouth of the river, and facilitated the expansion of the mangroves which colonized the area, expanding the coastline outwards. The area just to the south of Cascajal Point has also been experiencing significant expansion of land area. This is due to the natural deposition of sediments and expansion of mangroves (Figure 32).

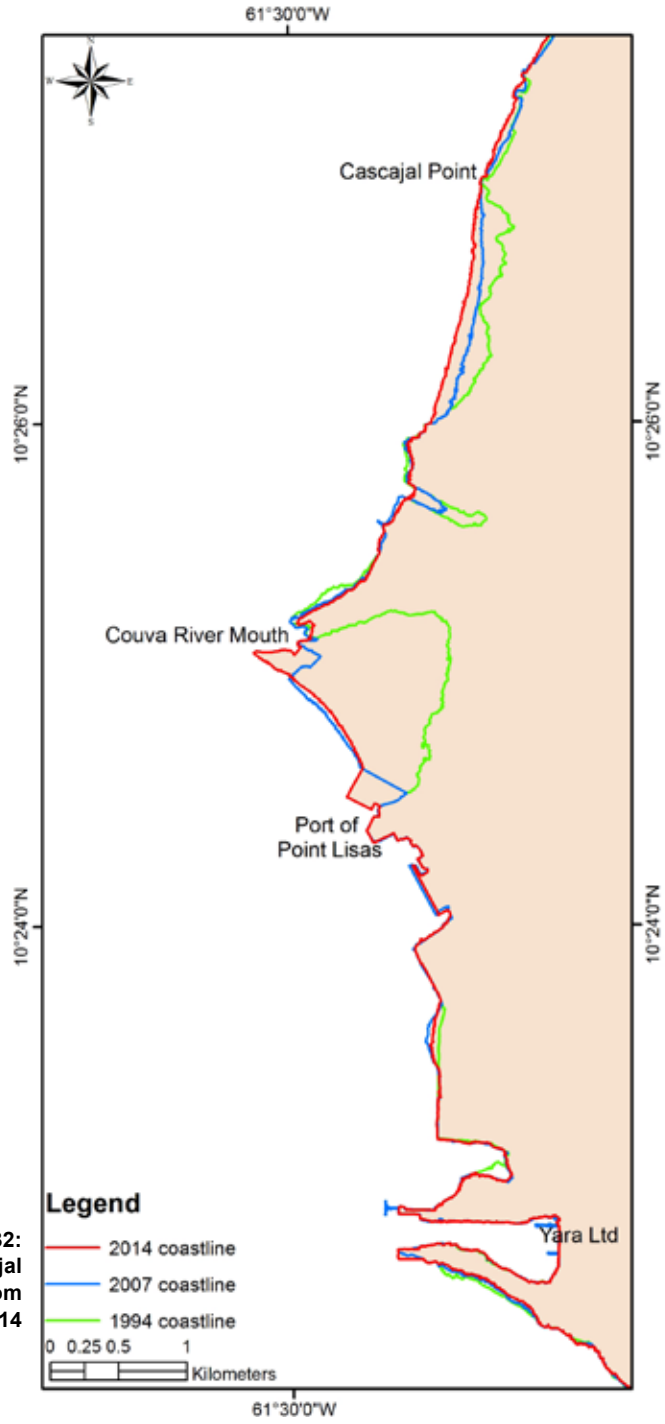


Figure 32:
Change in the shoreline in the Central GoP from Cascajal Point to Claxton Bay (Point Lisas Industrial Estates) from 1994 to 2014

Pigeon Point and Bon Accord Lagoon inclusive of Sheerbird's Point (No Man's Land) is renowned for its beaches, ecotourism and water sports activities. The western side of Pigeon Point is experiencing some erosion, but the eastern side is experiencing a very high level of accretion of greater than 2m per year, and as high as 4.29m per year in some locations (ERM, 2018) with mangroves expanding to stabilize the sand, and further enhancing accretion (Figure 33). The western side of Sheerbird's Point is experiencing very high levels of erosion with greater than 2m per year of coastline recession, and as high as 3.52m per year in some locations (ERM, 2018).

Coastline change is spatially dynamic with some areas experiencing accretion and others erosion depending upon site specific processes.

The net spatial extent (difference between accretion and erosion) from 2007 to 2014 was positive, meaning that the land area increased. However, the types of land that were gained were mostly in swamp areas, while the land lost was mostly agricultural land.

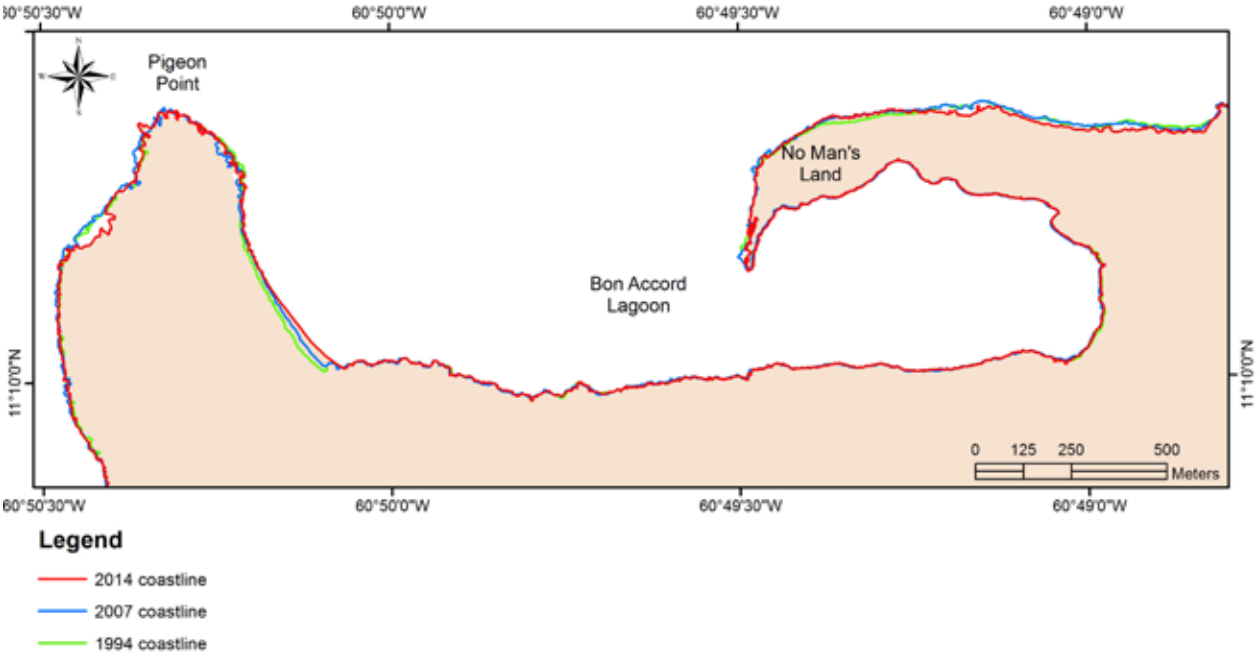


Figure 33:
Changes in the shoreline in Bon Accord Lagoon inclusive of Sheerbird's Point (No Man's Land) and Pigeon Point, Tobago

Projected Impacts from Sea level rise

Projected Impacts from Sea level rise

Sea level is rising due to human induced climate change. The average temperature of the atmosphere of the earth is increasing due to anthropogenic greenhouse gas emissions. This results in the thermal expansion of the oceans (as they absorb heat) and the melting of land ice (such as glaciers and icecaps), resulting in increasing sea levels. The rate of sea level rise at Port of Spain, from the Lands and Surveys Division (LSD) tide gauge (1984 to 1992), was calculated to be 1mm per year (Miller *et al*., 2005). Further analysis for the period 2009 to 2014 indicated that the rate had increased to 2.41mm per year (Nanlal, 2018, unpublished thesis). This suggests that the rate of sea level rise for Trinidad and Tobago is increasing. At the United Nations Framework Convention on Climate Change (UNFCCC) 21st Conference of the Parties (COP 21), hereafter referred to as the Paris Agreement, the world agreed to aim to limit the increase in global average temperatures to less than 2°C, and keep temperatures ideally below 1.5°C by 2100.

This is roughly in line with a Representation Concentration Pathway (RCP) - *a scenario that projects how climate will change in the future* - RCP 2.6. However, a number of studies have all demonstrated that when the Intended Nationally Determined Contributions (INDCs) of carbon reductions proposed by countries are evaluated, the global average temperature increase by 2100 will be between 2.7°C to 3.7°C. This is roughly in line with the RCP 6.0 scenario. Locally modelled sea level rise for RCPs 2.6 and 6.0 estimates increases to be 0.74 m and 1.08 m respectively by 2100 (UNEP, 2015).

The Government of the Republic of Trinidad and Tobago conducted a National Light Detection and Ranging (LiDAR) survey in 2014. This provided very accurate and detailed elevation data that was used to create a 1m resolution Digital Elevation Model (DEM). Using the values of sea level rise for the RCP 2.6 and 6.0, the land areas inundated in these scenarios was modelled. The images illustrate the land area expected to be inundated by sea level rise in RCP 2.6 (in pink) and the land area further inundated in the RCP 6.0 (in red) (Figures 34 and 35). The areas inundated are modelled assuming that no human intervention is undertaken to protect the land area from the impact of sea level rise.

For the tip of southwest Trinidad, most of the wetlands would be inundated in the RCP 2.6 scenario (Figure 34). In the RCP 6.0 scenario the inundation is more extreme with some of the residential areas of the Icacos village, and significant amounts of the coconut plantation under water (Figure 34). In addition, the village would become cut off since the only road access to Icacos, through the wetland, would be permanently inundated.

Columbus Bay, South Trinidad

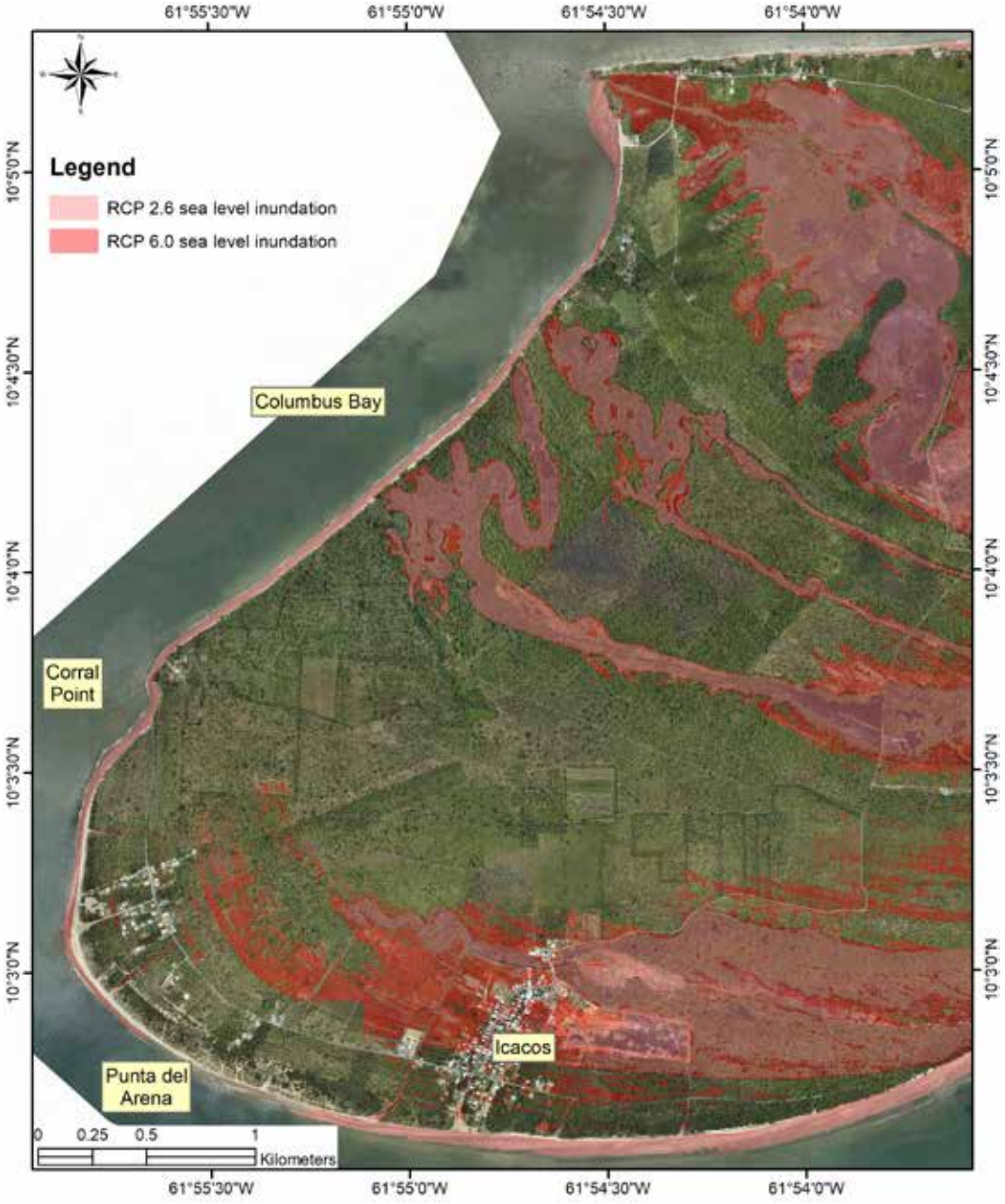


Figure 34:
Projected inundation due to sea level rise along the southwestern tip of Trinidad

In the Pt Lisas area most of the mangrove areas which had been gained through accretion and coastline expansion would be permanently inundated in the RCP 2.6 scenario (Figure 35). However, these areas may be able to stay above water if the sediment supply from the Couva River is sufficient to increase the land elevation and keep up with the rate of sea level rise. The industrial infrastructure would not be impacted by sea level rise under either scenario. However, due to the very close proximity to what would become the new coastline, and the likely loss of the mangrove in the permanently inundated areas, the industrial infrastructure would be more vulnerable to impact from storm surges.

For the Pigeon Point/No Man's Land/Buccoo Bay area, all the mangrove areas would be permanently inundated in the RCP 2.6 scenario (Figure 36). In the RCP 6.0 scenario some residential areas would be impacted and land area as far as Golden Grove Road would be inundated. It is unlikely that the mangrove swamps of this area could stay above water through topographic elevation increases since these areas are not supplied by riverine sediments and therefore are unlikely to be able to keep up with the rate of sea level rise. The mangrove forests may be able to migrate landward, once not hindered by built development. Any proposed development in the Pigeon Point/No Man's Land/Buccoo Bay area would need to seriously consider the challenges, feasibility and costs associated with mitigating against the impact of rising sea levels.

Figure 35:
Projected inundation due to sea level rise along the Central GoP-Point Lisas

Figure 36:
Projected inundation due to sea level rise in Bon Accord Lagoon, Buccoo Bay and Pigeon Point, Tobago

Plovers *(Charadrius spp.),* Icacos Swamp

Mangrove Swamp

Mangrove Swamp

Healthy mangroves help us cope with extreme weather events, and are an important defence against sea level rise. Typically wave height is reduced 13-66% per 100m of mangrove (Massel *et al*., 1999). Loss of mangrove forest will increase threat to human safety and increase damage to shorelines from coastal hazards such as erosion, flooding, storm waves and surges. Its loss will decrease coastal water quality, reduce biodiversity, eliminate fish and crustacean nursery habitat, adversely affect adjacent coastal habitats, and eliminate a major resource for human communities that traditionally rely on mangroves for numerous products and services. Furthermore, mangrove destruction can release large quantities of stored carbon and exacerbate global warming trends.

Much of the mangrove forests in Trinidad and Tobago have been impacted by human activities, and now they are projected to be negatively affected by sea-level rise especially where they are starved of sediment and/or constrained on the landward side by built development – a process known as coastal squeeze. In 2018, the IMA remapped the mangrove forests in Trinidad and Tobago using high resolution aerial photography taken in 2014 (Figures 37 and 38).

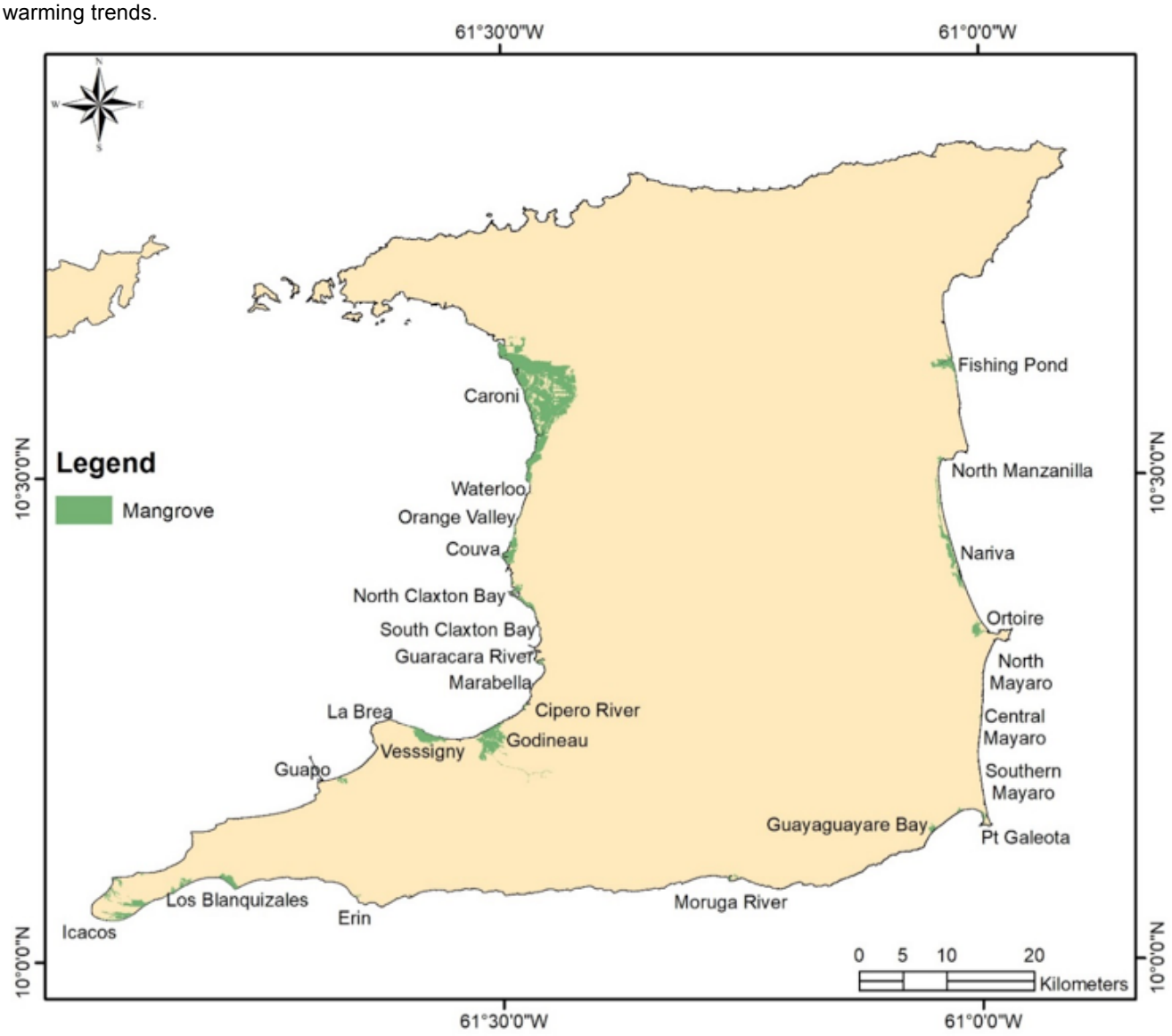


Figure 37:
Mangrove coverage in Trinidad based on 2014 aerial photography

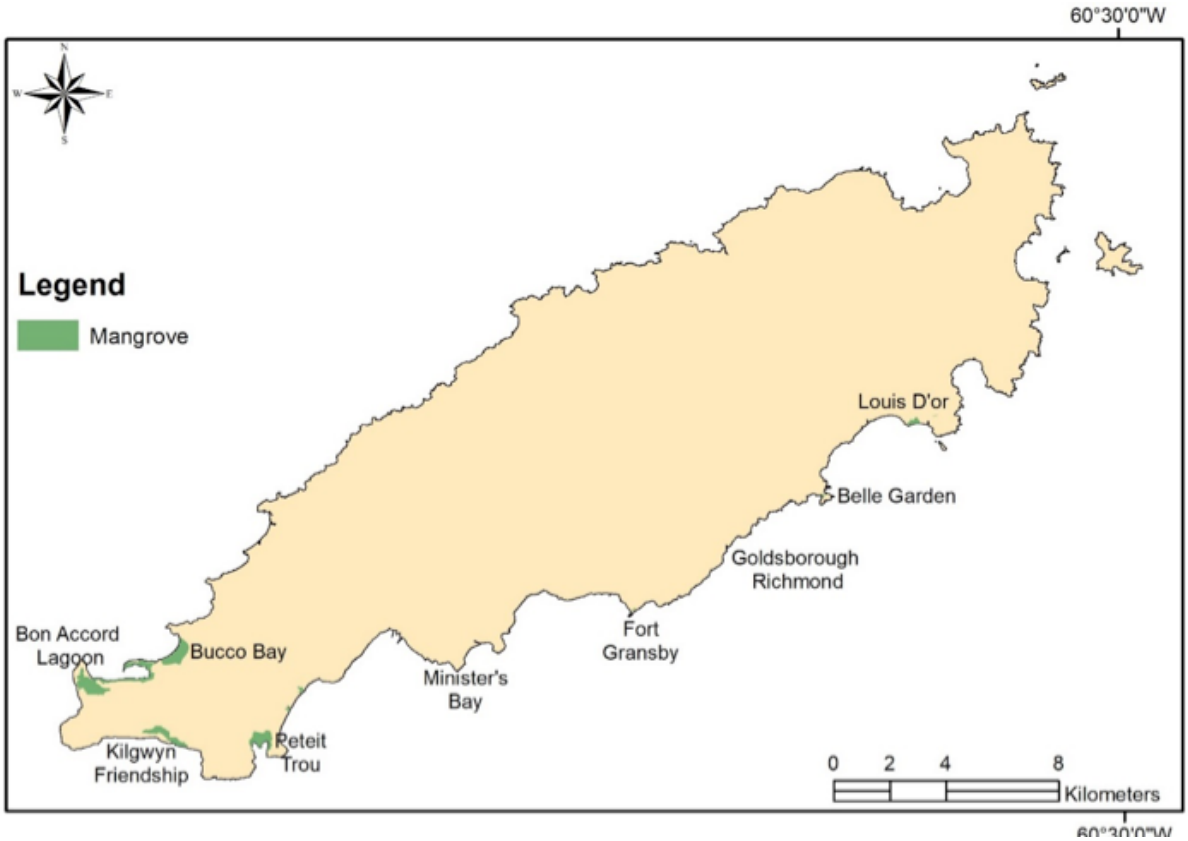


Figure 38:
Mangrove coverage in Tobago based on 2014 aerial photography.

Overall, mangrove coverage declined in Trinidad by 252.4 ha (3.3%) from 7686.6 ha in 2007 to 7434.2 ha in 2014. Changes in mangrove extent at selected areas are provided in Table 7. Declines were recorded in Caroni Swamp and this was primarily due to erosion on the seaward side, and large areas of mangrove die-off north of Blue River; Godineau Swamp - as mangroves were cleared to facilitate a highway; and at Cuesa River in Chaguaramas, Guaracara River, Marabella and North Claxton Bay due to development. In Waterloo, mangrove loss has resulted because of severe coastal erosion. Increase in mangrove extent was observed in Couva River and Orange Valley as mangroves have colonised extensive mudflats fronting these areas; and in Icacos, the mangrove forest has extended into freshwater marsh area due to salt water intrusion.

In Tobago, mangrove coverage declined by 16.6 ha (7.8 %) from 212.7 ha in 2007 to 196.1 ha in 2014. Notable decline was observed in Buccoo Bay - from 41.5 ha in 2007 to 23.4 ha in 2014, while minor declines were recorded in Little Rockly Bay, Louis D'or, Minister's Bay and Petit Trou Lagoon. Mangrove coverage in the Bon Accord Lagoon increased from 90.8 ha in 2007 to 100.6 ha in 2014. This increase was observed on the western end of the Lagoon, where accretion is occurring (Figure 33). A small increase in mangrove extent (1.1 ha) was recorded in the Kilgwyn/ Friendship area.

Table 7: Mangrove coverages at selected sites in Trinidad in 2007 and 2014

Wetland area	Mangrove coverage (ha) 2007	Mangrove coverage (ha) 2014	Type of Change Decrease - Increase +
Caroni Swamp	4506.4	4276.68	-
Couva River	243.6	267.7	+
Cuesa River	2.2	1.0	-
Erin	10.5	7.98	-
Fishing Pond	259.62	238.77	-
Godineau Swamp	700.16	691.61	-
Guaracara River	39.2	29.8	-
Icacos	374.1	409.0	+
Marabella	2.3	0.5	-
Nariva Swamp	408.4	401.2	-
North Claxton Bay	169.9	160.2	-
Orange Valley	1.5	15.5	+
Waterloo	7.6	3.8	-

Nationally, mangrove coverage declined between 2007 and 2014. Loss of mangrove forests can translate into loss of ecosystem services such as coastal protection, carbon sink, water quality maintenance, and fish and crustacean nursery habitats.

Mangrove Restoration Initiatives

The mangrove forests that exist continue to be impacted by encroachment for development and by land-based sources of pollution. To sensitize both primary school students and citizens about the importance of mangrove forest, two mangrove planting exercises were conducted by the IMA in conjunction with the Ministry of Planning and Development. In May 2018, a mangrove planting event with primary school students was conducted in the Caroni Swamp, north of the Blue River. Mangrove was planted to stabilise a channel bank that was exhibiting erosion (Plate 3). In July 2018, about 100 volunteers participated in a mangrove planting exercise in the Brickfield/Waterloo area to help protect the coastline from further erosion (Plate 4).

Plate 3: Primary school children planting mangrove in the Caroni Swamp to stabilise the channel bank (May 2018)

Plate 4: Volunteers replanting mangrove seedling on mudflats in Brickfield to help arrest coastal erosion (July 2018)

Sargassum seaweed surrounding Mangrove roots and blocking sunlight to seagrasses beneath, Bon Accord Lagoon, Tobago (2018)

Seagrass Beds

Seagrass Beds

Seagrasses are flowering plants that grow on the seafloor in shallow coastal habitats. They function as semi-permeable filters that stabilize bottom sediments, slow current flow, prevent erosion and filter suspended solids and nutrients from coastal waters. Seagrasses form highly productive, faunally rich and ecologically important marine ecosystems as they provide habitat, shelter, and food for many invertebrates and fish species, and can serve as bio-indicators for assessing changes in the coastal environment. Dredge and fill activities, construction on the shoreline, damage associated with commercial exploitation of coastal resources, and recreational boating have led to reduced seagrass cover worldwide.

In Trinidad, the most productive seagrass site was found at Williams Bay in Chaguaramas. This area was home to a diversity of species including fish such as seahorses, grunts and snappers; invertebrates such as starfish, conch and urchins; and the endangered green turtle. However, since 2012, a decline in seagrass biomass and productivity was recorded. This coincided with the development taking place on the peninsula. The *Thalassia* (turtlegrass) dominated community was decimated in Williams Bay by 2015, and has not recovered. Seagrasses once found on the eastern side of St Peter's Bay were no longer present by 2010 while the community on the western side of the Bay had disappeared in 2012. These areas are now overgrown with algae (*Caulerpa* sp.) and sparse communities of pioneer seagrasses (*Halodule wrightii* and *Halophila* sp.). St Peter's Bay has been impacted by land reclamation activities over the past decade, and receives sediment laden waters from the Carenage coastal catchment area which has been deforested for housing.

The only extensive seagrass community still existing in the country is located within the Bon Accord Lagoon/Buccoo Reef, Tobago. These grass beds have extended into the Nylon Pool as they are subjected to nutrient enriched conditions emanating from land-based sources. However, in September 2018, the total seagrass biomass at sites within the Bon Accord Lagoon declined by more than two fold when compared to March 2018. In the September 2018 sampling, seagrass areas in the Bon Accord Lagoon were observed to be smothered by dead *Sargassum*, and *Sargassum* had washed up on Pigeon Point Beach (Plate 5). This was the first year that *Sargassum* was reported on the Leeward Coast in large quantities. *Thalassia* dominated beds once found on the Atlantic Coast of Tobago at La Guira and Kilgwyn Bays disappeared in 2015 after *Sargassum* inundated the shoreline in that area and smothered the grassbeds. Poor water quality from land-based pollution (nutrients and sediments) and unrelenting coastal development continue to be the main factors affecting the recovery of seagrass beds in Trinidad and Tobago after they were decimated by chronic pollution and/or shock events such as *Sargassum* inundation.

Loss of seagrass habitats result in decline in their associated fauna. In 2007, 206 macro-invertebrate species were found within *Thalassia* dominated beds in William's Bay, Trinidad but by 2016, when the *Thalassia* beds were lost, only 79 species were recorded. This has negative implications for the food web in the area and ultimately the fisheries. There is an urgent need to rehabilitate seagrass communities to ensure that they continue to provide a safe haven for rich biodiversity including the juveniles of commercial species, and protect our coastline.

Plate 5:
Dead *Sargassum* piled up on eastern side of Pigeon Point Beach near Bon Accord Lagoon

The only remaining *Thalassia* (turtlegrass) beds are in Bon Accord Lagoon, Tobago. Loss of seagrasses has resulted in loss of macrofauna biodiversity which negatively impact food webs, and ultimately fisheries.

Coral Reefs

Coral Reefs

Coral reefs are a precious resource that supports our local biodiversity and contributes significantly to Tobago's economy. Estimates have placed tourism and tourism related activities at a yearly value of $100-130 million USD to Tobago's GDP (Burke *et al*., 2008) and its contribution is expected to rise in the following years. Tobago's reefs also provide an estimated $18-33 million USD annually in shoreline protection. This is also expected to increase with rising sea levels and increasing storm activity associated with climate change. Coral associated fisheries in Tobago have been valued at $0.8 – 1.3 million USD (Burke *et al*., 2008).

Due to the importance of our coral reefs, the IMA conducts yearly surveys of nine reefs (6 reefs have been under long-term monitoring while 3 have recently been added) around Tobago. Various indicators of reef health such as the percentage of hard coral cover and changes in the composition of the hard coral community are evaluated. The IMA also regularly monitors for the presence of thermally bleached coral colonies and colonies infected by a number of coral diseases.

Globally, reefs face a variety of threats, many driven by humans, and Tobago is no exception. Arguably, the current greatest threat to reefs is climate change and the resultant increases in sea temperatures that are occurring as a result. During a bleaching event in 2010, many reefs in Tobago suffered extensive loss of hard coral cover. In some areas this loss was as much as 50% and reefs have seen little recovery in terms of hard coral cover since this time. Instead, hard coral cover has remained relatively stable at the monitored reefs in the past 8 years and the average coral cover around Tobago has remained around 18% (Figure 39).

CuE	Culloden Reef - East
CuW	Culloden Reef - West
BuO	Buccoo Outer Reef
BuW	Buccoo Reef - West
Spey	Speyside
Ply	Plymouth
Cas	Castara
BJH	Black Jack Hole, Speyside
Char	Charlotteville

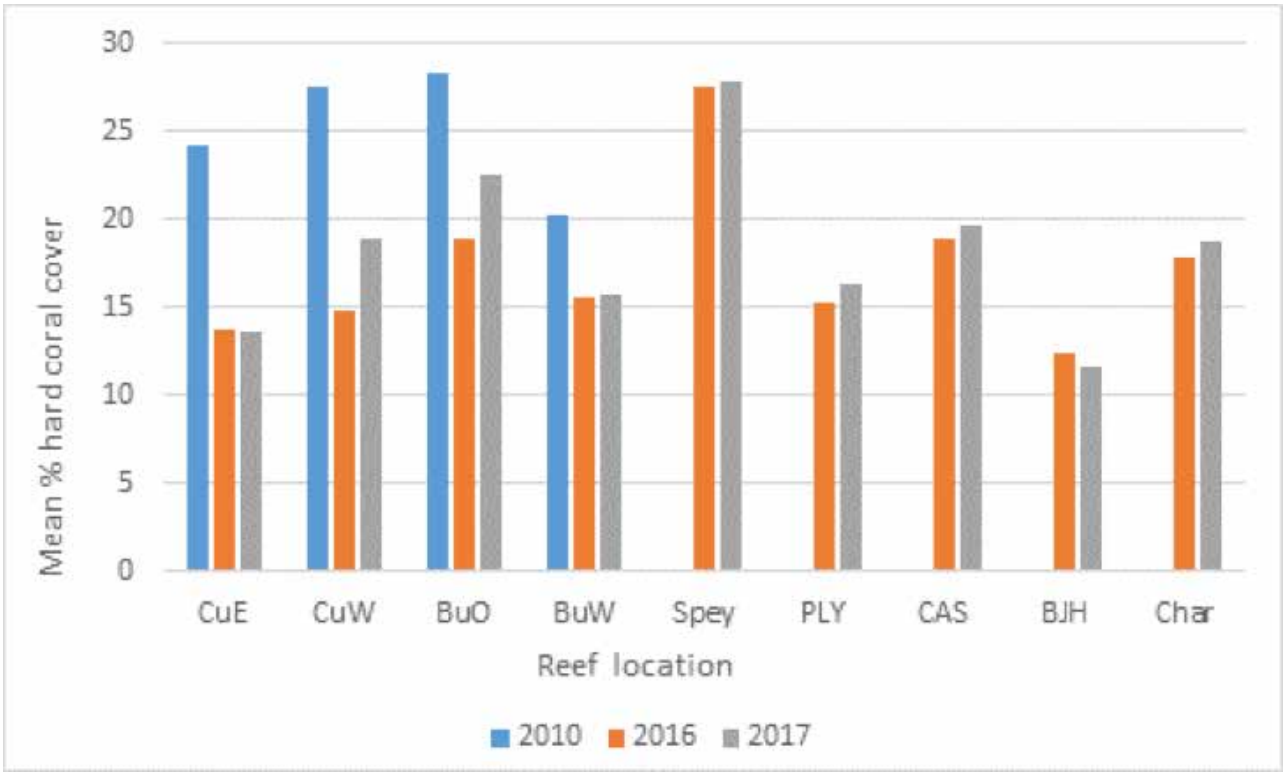


Figure 39:
Mean % hard coral cover of surveyed reefs in 2016-2017 and in 2010 where available

Though it is encouraging that there have been no dramatic decreases in coral cover since 2010, this does not necessarily indicate that coral cover will remain stable or recover to pre-2010 levels. While Tobago has experienced other minor bleaching events since then, a growing concern is the emergence of coral diseases. Many coral diseases are capable of killing entire coral colonies and several diseases are triggered by thermal bleaching stress. Colonies that survive a thermal bleaching episode may still succumb to disease and even those that do not bleach may be sufficiently weakened to become infected by various coral diseases. Disease outbreaks may be short-lived or extended and mortality can be high.

Outbreaks did occur after the 2010 bleaching event and mortality was high at that time, up to 50%. Recent surveys (2017-2018) have noted that yellow-band disease, a coral disease that affects several species including the endangered mountainous star coral, has had incidence rates up to 10% following periods of prolonged elevated sea surface temperature. Climate change will continue to induce periodic bleaching/stress events and as a small island, our only response may be to build reef resilience through mindful mitigation and management measures. Alleviating other potential stressors on coral reef environments, like poor water quality due to pollution, are tactics that may be employed to boost reef resilience.

Degraded coral reefs are more susceptible to impacts from climate change including coral bleaching, and to coral diseases. Alleviating other potential stressors on coral reef environments, like poor water quality from land-based pollution, are strategies that may be employed to boost reef resilience.

Elkhorn coral *(Acropora palmata),* Culloden Reef Tobago

Marine debris along the shoreline in Brickfield, Central Trinidad

Emerging Issues

Emerging Issues

Marine Debris, Plastics and Microplastics

Marine debris in general, and plastics in particular, is one of the most notable environmental concerns of our time. Major oceans of the world including the Indian Ocean, the North Atlantic Ocean and the North Pacific Ocean, are home to so-called "garbage patches", some as large as 15 million square kilometres. These garbage patches are made up of about 90% plastic debris with this non-biodegradable material representing up 60-80% of marine debris in the oceans globally. It is estimated that 8-12 million tons of plastics reaches the marine environment every year, where it is found at all depths of the water column down to the ocean floor (GESAMP, 2015).

Concerns are repeatedly expressed over the increasing number of species affected by entanglement or ingestion of marine debris and its potential to harbour and transport alien invasive species. Along with this, the persistent nature of plastics presents further concerns as the material tends to break down into increasingly smaller pieces as micro-plastics and nano-plastics (GESAMP, 2015). It has been noted that plastics therefore could accumulate as they move up through the food chain, taking with them persistent, bio-accumulative and toxic chemicals and environmental contaminants. They therefore present a potential threat to the health of a range of marine species, the humans that consume them and food security in general.

Most of what is known about the quantities and types of marine debris in Trinidad and Tobago's coastal waters has come about due to the collections done annually by volunteers with the International Coastal Cleanup. Although not a strictly scientific data collection exercise (the effort and methodology varies every year) it has been especially useful in providing some sense, over time, of the marine debris profile of Trinidad and Tobago (Table 8).

It is recognised that there is still scope for research and information gaps to be filled as it relates to marine debris. This is especially as it relates to the impacts of debris on marine life including what species are prone to ingesting debris, behavioural and life cycle impacts and eco-toxicological effects especially on marine species that are consumed by humans. There is also scope for increased research in ghost fishing and the impact on catch losses as a result of discarded or lost fishing gear. It should be stressed however that research into the impacts of marine debris can be expensive and human resource intensive.

Resources need to be made available to facilitate this type of research. Long term monitoring programs to quantify the amounts of marine debris being deposited on shorelines and document the debris profile can also be implemented. However, this sort of initiative is more adequately paired with intervention measures so that efficacy of those measures can be tested.

Table 8: International Coastal Cleanup Ocean Trash Index for Trinidad and Tobago
(Source: Cleanup Reports – The International Coastal Cleanup)

Year	People	Kilograms collected	Kilometres of coastline cleaned	Total items collected	Plastic Bottles	Plastic Bags	Foam Take-away Containers	Glass Bottles
2015	2137	10,539	32	116,884	24,880	4,408	NDA	8,264
2016	465	1,827	12.7	20,776	4,459	1,040	553	2,000
2017	1900	11,315	40	126,846	27,320	5,234	2,585	NDA

NDA – No data available

When considering policy and legislative interventions that could help minimise occurrences of marine debris, plastics and micro-plastics, Trinidad and Tobago currently has a weak framework in the most obvious method to tackle the problem – recycling and the strengthening of a circular waste economy. In 2015, the country did develop a National Waste Recycling Policy. However, sorting and recycling of wastes in Trinidad and Tobago still is not mandatory. This, and minimising the use of single use plastics only occurs on an ad hoc basis in a minority of households and environmentally conscious businesses and/or those with a corporate social responsibility culture. Within recent years, the Environmental Management Authority (EMA) has attempted to raise public awareness and participation in recycling through the iCARE Programme. The Government of Trinidad and Tobago has also announced the intention to implement a ban on styrofoam products by 2019 which would aid in the reduction of debris impacting coastal and marine areas.

Legislative mechanisms for tackling the marine debris problem also need to be enhanced. The Waste Recycling Bill, 2015, which seeks to establish a Waste Recycling Management Authority and Resource Recovery Fund to coordinate and implement waste recycling, has never made it through parliamentary debate. The Beverage Containers Bill, a law designed to, among other things, provide for the establishment of the Beverage Containers Advisory Board, a deposit and refund system for prescribed sizes of beverage containers and a regime for the collection of beverage containers to reduce their disposal into the environment, was laid in Parliament in 2012. However, it too has never been fully debated and approved. Passing of these Bills would offer a good platform to start to address Trinidad and Tobago's marine debris problem, especially as it relates to plastics.

Additionally, Trinidad and Tobago has earmarked shipping as a sector that is ripe for expansion in attempts to diversify the economy. Indeed, port expansion projects have been identified and executed as priority areas for successive governments. Against this back drop, Trinidad and Tobago's commitments under the International Convention for the Prevention of the Pollution from Ships (MARPOL), to which we are party, must be considered when addressing the marine debris problem. Specifically, we must be cognisant of Annex V of MARPOL and the responsibility as a Port State, in terms of providing adequate port reception facilities to docking vessels. In addition, it is the right of Port State control officers to verify mechanisms on board vessels such as garbage plans and garbage record books, to ensure that waste is being properly disposed. The Shipping (Marine Pollution) Bill, which would address these issues, also still needs to be debated in Parliament.

Marine debris, plastics and micro-plastics have come into sharp focus because of the direct impact it has on health, safety and livelihoods of people and in particular, coastal populations. Economies are starkly affected when activities at sea such as fishing, tourism and navigation, are hindered. The need for a double pronged approach to tackle the problem to prevent marine debris from entering the oceans has been underscored. This entails both addressing marine debris, plastics and micro-plastics downstream through improved mechanisms for waste management, disposal and recycling, and upstream, by addressing consumption and production patterns.

Climate Change

Human induced climate change is now a largely undisputed phenomenon which has far reaching implications for the current and future management of Trinidad and Tobago's coastal and marine environment. Trinidad and Tobago is among 51 small island developing states (SIDS) that are especially vulnerable to the effects of climate change as a result of their developing status, small physical size, low-lying coastal areas, low availability of resources, small but rapidly growing population and increasing pressures on natural resources, remoteness, susceptibility to natural disasters, excessive dependence on international trade and vulnerability to global developments (Chin Sang, 2015).

Our understanding of the ways and extent to which climate change will impact Trinidad and Tobago's coastal and marine space and resources is becoming more clear as the ability to model climate, and thereby forecast changes, is improved. Climate researchers are developing more powerful models that are able to predict changes at a finer scale. PRECIS (Providing Regional Climates for Impacts Studies) is one such Regional Climate Model (RCM) for the Caribbean. Scenarios were developed for future changes in temperature and precipitation for the months of February and July, and for the years 2035, 2050 and 2075 using the A2 (worst case) and B1 (best case) scenarios as defined by the Intergovernmental Panel on Climate Change (IPCC). Climate predictions for Trinidad and Tobago for 2100 are presented in Figure 40. February was chosen on the basis of it being the coolest month on average and July being the wettest month on average.

Micro-climatic changes can sometimes be predicted through these models. For example the results suggest that in terms of precipitation, Tobago, and in particular southwest Tobago, will experience little change or potentially a small rainfall reduction (approx. 0.5 mm per day), but an increase in temperature between 1 to 2.5 °C.

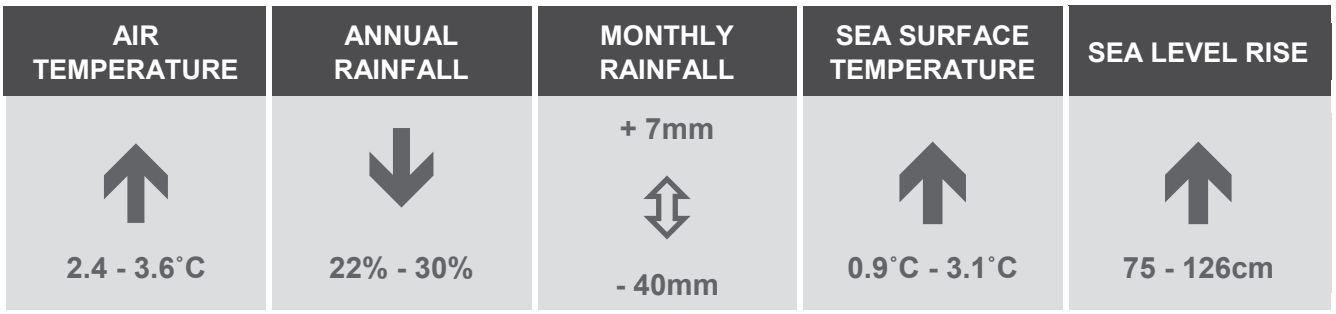


Figure 40:
Climate Predictions for Trinidad &Tobago for 2100. (Ministry of Planning and Development, 2019)

Projections however, do suggest an increase in intense rainfall events over shorter periods that will result in lower surface water quality and reduction in the recharge of ground water as runoff would be at a maximum. An increase in longer dry spells and drought events coupled with warmer temperatures are also predicted. These would increase agricultural irrigation demands, affect crop scheduling, increased health impacts, coral bleaching and saline intrusion.

RCM-Regional Climate Model; GCM-Global Climate Model

While not on the hurricane track, the coast of Trinidad and Tobago is highly vulnerable to natural hazards, particularly small storm and flooding events that tend to disrupt economic activity. In fact, there is evidence that the frequency of these small events has increased five-fold between 2005 and 2015 when compared to the previous decade (DesInventar data base). Depending on location, even small storms are usually accompanied by severe coastal erosion and flooding, including in densely populated areas where the buffering effect of coastal habitats has been lost. Climate change is likely to worsen vulnerability to natural hazards. With climate change, probable maximum loss and average annual loss would increase by 14% and 17%, respectively. It is estimated that the Caribbean Region could lose up to 5% of GDP over the next decade if governments fail to step up their resilience efforts and adapt to climate change (Caribbean Development Bank, 2018)

We have already observed that storm events (rough seas) have damaged fisheries infrastructure, such as the fish landing sites in Matelot, and have resulted in the loss of fishing days for many who depend on this trade for their livelihood. Disruptive impact to businesses, logistical networks, rural settlements and private property are also readily apparent in the flooding and erosion events reported in coastal areas: Charlotteville to Pigeon Point (2013), Manzanilla Beach (2014), Columbus Bay (2014), Matelot and Grande Riviere (2016), Chaguaramas (2017), and Cedros (2018). A 2013 IDB financed study estimated that probable direct loss due to floods and storms in 2012 was US$1.1 billion (with a 1/100 return period) and average annual loss was US$55.7 million.

Further, climate change could result in average summer temperature increase of over +3.5°C, with a similar warming effect anticipated in the ocean, which could have negative impacts on marine and coastal biodiversity. The sectors projected to be heavily impacted by climate change include: agriculture, human health, human settlements, coastal zones and water resources (McCue, 2014). A Global Assessment of biodiversity and nature's contribution to people states that human-induced climate change, which affects temperature, precipitation and the nature of extreme events, is increasingly driving biodiversity loss and the reduction of nature's contributions to people, worsening the impact of habitat degradation, pollution, invasive species and the overexploitation of natural resources (IPBES, 2018).

For successful future mitigation of and adaptation to climate change impacts in Trinidad and Tobago, a multi-pronged approach is required. Strategies include conducting coastal vulnerability and risk assessments and applying this to development planning; maintaining and restoring environmental integrity through alleviation of pollution and protection of critical ecosystems; continuous monitoring and research so that management decisions are informed by sound science and the effect of interventions can be properly assessed; and extensive sensitization, awareness raising and education of various publics to the climate change phenomenon and methods to limit its social, economic and environmental impacts. These strategies and several others aiming to mainstream climate change mitigation and adaptation into management of coastal and marine resources are all inherent to the Integrated Coastal Zone Management (ICZM) Programme which Trinidad and Tobago is seeking to implement.

Policy Interventions and Project Initiatives

Policy Interventions and Project Initiatives

Since 2014, a Draft Integrated Coastal Zone Management (ICZM) Policy Framework to mitigate negative impacts on Trinidad and Tobago's coastal and ocean environment was developed by a multi-sectoral steering committee. After release of the SOME, 2016 and in view of the findings therein, Cabinet approved an action plan for implementing this draft ICZM Policy Framework. Subsequently, in 2018, an Inter-ministerial committee to guide the implementation of this action plan was established. The ICZM Inter-minsterial Committee is made up representatives from the Ministry of Planning and Development (Chair), Institute of Marine Affairs (Vice-Chair), Ministry of Energy and Energy Industries, Tobago House of Assembly, Coastal Protection Unit, Fisheries Division and Office of Disaster Preparedness and Management. Terms of reference for this Inter-Ministerial Committee include:

- To review and finalize the draft ICZM Policy Framework based on a public consultative process;
- To oversee the implementation of the ICZM Policy Framework to mitigate the negative impacts on the coastal and marine environment;
- To identify key targets and indicators and appropriate timelines as per the action plan;
- To assign action items to the most relevant agency and co-opt other Ministries/Divisions/Agencies as may be required for the implementation of the action plan;
- To co-ordinate the production of a biennial State of the Marine Environment Report.

The strategies contained in the Draft ICZM Policy address impacts from climate change, and will attenuate anthropogenic impacts from the range of coastal stakeholders across the land-sea continuum. They will also encourage sustainable management aimed at maintaining and where necessary, enhancing, the functional integrity of the coastal and marine resource systems while enabling sustainable economic development through rational decision-making and planning. Importantly, they will also reduce conflict and encourage intra and inter-sectoral collaboration in ocean and coastal management, across time and space.

The National Environmental Policy (NEP) strongly supports the implementation of local ICZM plans for Trinidad and Tobago's coastal areas. This 2018 Policy improves upon the 2006 NEP. In addition to calling for ICZM implementation, the policy also encourages designation of additional marine protected areas (MPA) across the country – at present the Buccoo Reef remains Trinidad and Tobago's sole MPA; enforcing building setbacks from the shoreline; and aiming to have more beaches in the country Blue Flag certified. To get Blue Flag certification, water pollution issues will have to be addressed. Cognizant of this, the NEP 2018 also seeks to strengthen water pollution regulation. Indeed, the EMA is currently in the process of revising the Water Pollution Rules so that the permit fees collected from polluters, instead of being fixed, are calculated based on pollutant loadings. This will better allow the EMA to correct environmental damage. The revised rules will also include ambient water quality standards for Trinidad and Tobago for the protection of aquatic life and ecologically sensitive aquatic ecosystems, recreational uses and freshwater water supply uses.

Greater national focus is needed in treating industrialised wastes and the release of toxic pollutants entering the environment through the use of best available technologies and best management practices. A trade effluent standard to limit the level of pollutants entering public sewers was issued in 2015 by the Trinidad and Tobago Bureau of Standards. This standard needs to be implemented. In addition, a Draft Upstream Effluent Management (UEM) Policy was developed for the oil and gas sector and submitted to Cabinet for approval in 2018. This Policy aims to make wise use of, protect and conserve the environment from toxic effluents.

Increasing protected area acreage and management capabilities is also critical to safeguarding ecosystems and their associated services, habitats and resources in the coastal and marine environment. A crucial endeavour taking place in this regard is the Improving Forest and Protected Area Management in Trinidad and Tobago (IFPAMTT) Project. This Global Environment Facility (GEF), Food and Agriculture Organization of the United Nations (FAO) and GORTT supported project began in 2015, with activities ongoing until 2019. It aims to contribute to developing a new national Protected Area (PA) system with a key feature of the project being to create management plans for six pilot sites through a highly participatory process. Four of these pilot sites are coastal/marine in nature – Caroni Swamp; Nariva Swamp and coastal zone; Matura Forest and coastal zone; and the Northeast Tobago Marine Protected Area (MPA).

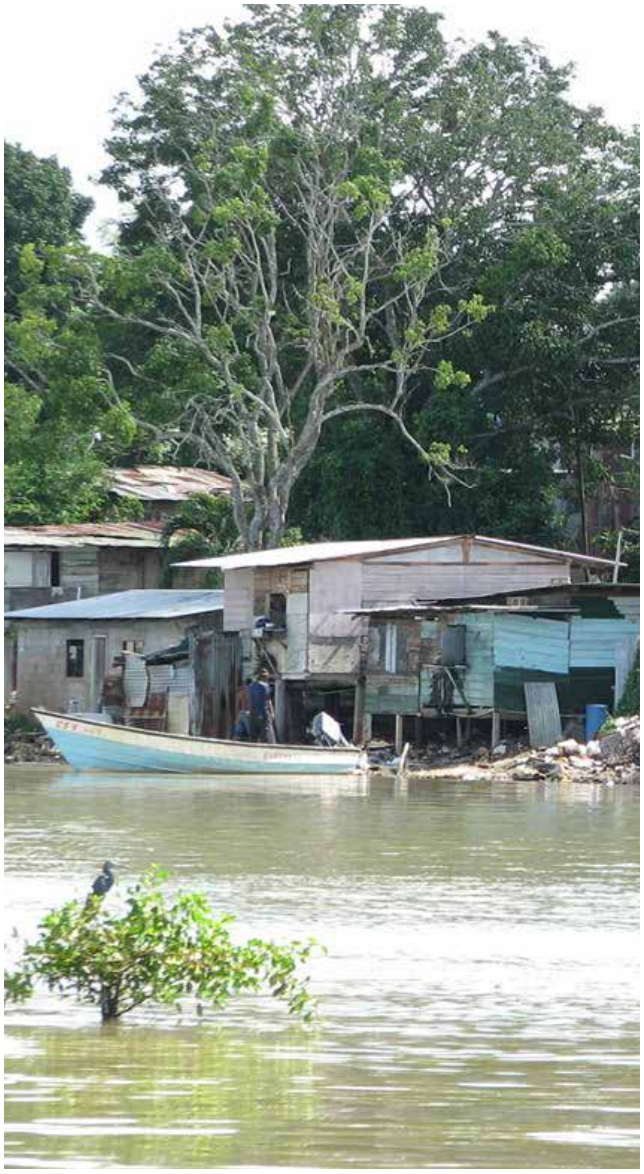
The other two, the Trinity Hills and eastern extension and the Main Ridge Forest Reserve, house critical watershed areas where activities take place that influence the quality of the coastal environment. It is important to note that the proposed Northeast Tobago MPA, which would cover a 67,300 ha coastal strip from Roxborough to Castara, would significantly boost the extent of marine area under protection. At present, less than 0.0001% of our marine area is under protection, significantly less than the 10% by 2020 objective set by SDG 14 and the Convention of Biological Diversity's Aichi Biodiversity targets.

Other anticipated outputs of the IFPAMTT Project are draft legislation for establishing and managing protected areas and a sustainable financing system for long term management of PAs. A comprehensive network of managed protected areas is also seen as important sustaining the coastal and marine environment in the face of climate change. Indeed, a myriad of climate change impacts have been highlighted throughout this report as palpably threatening ocean and coastal ecosystems and resources.

Trinidad and Tobago is party to the United Nations Framework Convention on Climate Change (UNFCCC). In 2018, the country also finally ratified the Paris Agreement, which builds upon the UNFCCC by bringing all nations into a common cause to undertake efforts to combat climate change and adapt to its effects. Its main goal is to strengthen the global response to the threat of climate change by keeping the global temperature rise this century less than 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. The Paris Agreement requires all Parties to put forward their best efforts through Nationally Determined Contributions (NDCs) and to strengthen these efforts into the future. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

With these commitments made, the country is undertaking data collection and situational analyses to fulfil reporting requirements and chart a climate resilient future for the Trinidad and Tobago. This includes garnering an updated quantification of our greenhouse gas emissions by sector. This greenhouse gas inventory would inform a mitigation analysis which develops and implements emission reduction measures. Although our country's emissions make up less than 1% of global emissions, emission reduction is still important in light of an October 2018 Intergovernmental Panel on Climate Change (IPCC) Report. This Report found that urgent and unprecedented changes globally, including contributions from countries who are not major emitters, are needed to keep warming to below a maximum of 1.5°C. It goes further to predict that warming above 1.5°C would significantly worsen the risk of drought, coastal flooding, extreme heat, eradication of coral reefs and poverty for hundreds of millions of people.

Adaptation would be needed in the face of such impacts. Comprehensive assessment of the vulnerability of the coastal zone and coastal sectors to projected climate changes is therefore yet another analysis that this country would be undertaking. This assessment would quantify the projected extent of loss and damage and facilitate actions to curtail negative effects on economic growth, poverty reduction, human health and livelihood opportunities. These analyses and others would all feed into our Third National Communication, Biennial Update Report and NDC reporting documents for the UNFCCC and Paris Agreement.



Unplanned housing in Marabella

The aforementioned initiatives are worthwhile and importantly help Trinidad and Tobago work towards fulfilling some of the commitments and responsibilities under a number of international agreements which the country is party to. These include the Convention on Biological Diversity (CBD), the UNFCCC, the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Cartagena Convention) and its associated Protocols and the United Nations Convention on the Law of the Sea (UNCLOS).

However, more can and needs to be done to fulfil obligations under these and other agreements that have been ratified or acceded to. For instance, the increased national focus on development of aspects of the maritime, shipping and pleasure craft industries make it important that the International Convention for the Prevention of Pollution from Ships (MARPOL Convention) and the International Convention for the Control and Management of Ships' Ballast Water and Sediment (BMW Convention) are given adequate standing in the local legislative framework. In this regard, updating shipping legislation and passing legislation that comprehensively deals with shipping pollution are essential. However, advancements in this regard have been an elusive goal for well over a decade.

With the championing of the Blue Economy, that is the sustainable use of ocean resources for economic growth and improved livelihoods while preserving the health of ecosystems, Marine Spatial Planning (MSP) would become a critical tool be adopted. This process is used to chart a vision for future development while at the same time rationalising current use of marine spaces to minimise environmental and other user conflicts.

The draft ICZM policy recognises MSP as critical to sustainable marine management in Trinidad and Tobago and especially encourages the development of plans for various high intensity use and/or ecologically sensitive areas around the country, for example the GoP and Southwest Tobago. MSP will also bring to bear several fundamental principles that are supposed to form the basis on which our policies for management of the marine environment are premised including the precautionary principle; prevention principle; principle of intergenerational equity; public participation in decision making; and the equity principle where there is access to information and environmental justice. Comprehensive marine spatial plans for the entirety of Trinidad and Tobago's coastal and marine space is a future goal to which all policy makers, marine managers and stakeholders should commit, to bring into fruition.

Marine Fisheries

Most of the commercially exploited stocks in Trinidad and Tobago are either near full exploitation, fully exploited or over-fished (Ferreira and Soomai, 2013; 2001; Soomai and Seijo *et al*., 2000; Manickchand-Heileman and Phillip, 1992). Over-capitalization is evident in the trawl fleet (Ferreira and Soomai, 2001; Seijo *et al*., 2000); the incidental capture of non-target species is a problem in the gillnet fisheries and there is a high level of bycatch discard of juvenile finfish of commercial importance in the artisanal and semi-industrial trawl fleets (Amos, 1990; Maharaj, 1989). Challenges faced in managing our marine fisheries resources include, an open access fishery that promotes an environment of competition rather than sustainable use; illegal, unreported and unregulated (IUU) fishing; inadequate monitoring and surveillance; a lack of enforcement of existing regulations; outdated and inadequate legislation; and climate change impacts. During the period 2016 -2018, efforts were made by the GORTT to address some of these issues:

1. **Modernization of the Fisheries Legislation** – The principal legislation governing domestic fishing in Trinidad and Tobago is the Fisheries Act of 1916 and subsequent amendments to the Act: the Fisheries (Amendment) Act 1966 and 1975. This Act currently regulates fishing in all rivers and tidal waters of Trinidad and Tobago and to the 12 nautical mile territorial sea; it does not apply to the EEZ. Overall, it is inadequate as a legal basis for a modern national fisheries management system, providing only for rudimentary controls including type and mesh size of fishing nets (thereby restricting the size of fish, shrimp, crabs and turtles caught, and prohibiting their sale or preventing the catching of these species, either absolutely or by season or area) for management.

   Over the years there have been several unsuccessful attempts to modernize this legislation. The most recent attempt is in progress and comes in the wake of Trinidad and Tobago being pre-identified ("yellow carded") by the European Union as being a non-cooperative state in the global fight against IUU fishing. According to the press release "T and T has a large fleet operating internationally and authorities do not control and inspect foreign vessels nor cooperate with flag states." A red card would not only tarnish our international image, encourage trade sanctions and the loss of port services by foreign entities, but would result in economic losses.

Fishing boats at Ortoire, Mayaro

The FAO under the FAO-TCPF Project "Strengthening Fisheries Legislation in Trinidad and Tobago: Focus on IUU Fishing" has been assisting the local authorities in updating the legislation. This project is being implemented through the Fisheries Division of the Ministry of Agriculture, Land and Fisheries. A "Draft Fisheries Management Bill 2018" (DFMB) was presented for stakeholder consultation in June 2018. Public comments have been sought, collated and reviewed. This revision will address coastal, flag, port and market state responsibilities; and develop IUU Fishing Regulations. As of June 2019, the Draft Bill was being reviewed by the Chief Parliamentary Council.

Some of the key features of the DFMB include:

- Expanded geographical coverage to include local vessels in the EEZ.
- Making provisions for the Minister to formulate regulations for the establishment of a mechanism for stakeholder participation in the decision-making process for the conservation and management of fisheries.
- The development of "Fisheries Management Plans" for the different designated fisheries.
- Regulated access to the fishery through a licensing system with rights and responsibilities.
- Strengthened monitoring, control, surveillance and enforcement measures.
- A permit system for recreational fishers, high seas fishing, trans-shipment, fisheries scientific research, bunkering and provisioning, and the import/export of fish and fish products.

The DFMB which is based on the Ecosystem Approach to Fisheries (EAF) management also incorporates important principles such as the precautionary approach, the use of scientific research to guide management and a participatory approach.

2. **Fisheries Sector Policy** – The Government of the Republic of Trinidad and Tobago (GORTT) is committed to the principle of sustainable development and the effective use and proper management of its marine fisheries resources. In 2017, the GORTT engaged a consultant to conduct a diagnostic review of the Fisheries Sector with the aim of developing a strategic plan 2018-2023. Key challenges hampering the development of the Sector were identified and policy recommendations were presented. The strategic priorities and the recommendations outlined in the strategic plan has been sent to Cabinet for approval as Trinidad and Tobago's Policy on the Fisheries Sector.

3. Sustainable Management of Bycatch - Through the Fisheries Division of the Ministry of Agriculture Land and Fisheries, Trinidad and Tobago is participating in the Sustainable Management of Bycatch in Latin America and Caribbean Trawl Fisheries project (REBYC-II LAC). Funded by GEF for the period 2015-2020, REBYC-II LAC aims to reduce negative impacts and achieve more sustainable shrimp trawl fisheries in the region. It will address the barriers to better management of bycatch and in this way support the sustainable development of the trawling sector and the people who depend on it. Local activities under this project include:

- Gear trials (bycatch composition surveys) to determine appropriate bycatch reductions devices (BRDs) for implementation on trawl nets.

- The implementation of an observer programme for all fleets.

- The introduction of mandatory log books for the semi-industrial and industrial fleets.

- Socio-economic assessments to determine the impact of potential management strategies on livelihoods and the identification of alternative livelihoods.

The other participating countries are Brazil, Colombia, Costa Rica, Mexico and Suriname.

4. IUU Fishing Action Plan – During the period March-August 2017, an inter-sectoral committee was appointed by Cabinet to finalize and initiate the implementation of an action plan to address IUU fishing in the ports and waters under the jurisdiction of Trinidad and Tobago. This plan was completed and has been submitted to Cabinet for approval. Further, to address IUU Fishing Trinidad and Tobago is one of five CARICOM countries participation in the US/NOAA Port State Measures Support Project, which seeks to improve the capability of countries for effective implementation of the FAO Agreement on Port State Measures (PSMA) and complementary international instruments and regional mechanisms to prevent, deter and eliminate IUU fishing. In 2018 a national workshop was convened under the project to conduct a gap analysis and develop a National Strategy and Road Map for compliance with the PSMA.

5. Climate Change Adaptation – Trinidad and Tobago is participating in the FAO/GEF "Climate Change Adaptation of the Fisheries Sector in the Eastern Caribbean" (CC4FISH) Project. The objective of this project is to increase resilience and reduce vulnerability to climate change impacts in the Eastern Caribbean Fisheries Sector, through introduction of adaptation measures in fisheries management.

Below:
Villagers pulling seine on the east coast, Trinidad

Summary of Findings

Summary of Findings

1. Pollution of our oceans particularly from land-based activities continues to be a challenge and this has negatively impacted coastal ecosystems such as coral reefs and seagrass beds and other marine resources.

2. The GoP in particular continues to receive excessive pollution loading (nutrients, sediments, heavy metals, hydrocarbons) from agriculture, industrial, and domestic sources.

3. The Caroni Swamp Ramsar site received nutrient laden runoff from the vastly populated Caroni River Basin and from extensive agricultural fields in the Caroni plains; the main source of nitrogen pollution in the rivers flowing into the southern side of the swamp is agriculture while the main source of nitrogen pollution to the northern side (Caroni River) is wastewater.

4. Trinidad and Tobago experiences several oil spills annually which impact our coasts and cause discomfort to beachgoers, fisherfolk, the general public and results in economic loss. In 2017, 104 spills were reported to the EMA, and between January to September 2018, 36 spills were recorded.

5. Study of hydrocarbon levels (PAHs) in fish and shrimp samples collected in the GoP in September 2016 has indicated that the levels measured in the seafood samples do not appear to pose a health risk for consumers based on the risk assessment criteria established by US FDA for the Deepwater Horizon oil spill response (US FDA, 2010).

6. Poor bathing beach quality was reported for parts of the coastline from Bonasse Beach to Fullerton Beach in Cedros, Guapo Beach to Clifton Hill Beach at Western Guapo Bay, L'Ebranche River to Ortoire River at Cocos Bay and St. Joseph Village to Indian Bay at Mayaro Bay. Higher bacterial levels were recorded in the wet season due to increases in land-based runoff. Sources of sewage pollution were identified.

7. High bacterial levels were also recorded in Bon Accord Lagoon, Kilgwyn and La Guira Bay, Tobago.

8. Many of our beaches and bays are subjected to coastal erosion and this is expected to intensify with the impacts of climate change, particularly sea level rise and increases in storm surge.

9. The Coastal Protection Unit, Ministry of Works and Transport have been implementing projects to arrest erosion at some of the most vulnerable sites (Cocos Bay, Manzanilla, San Souci, Matelot, Quinam). A combination of hard and nature-based solutions are being considered to alleviate erosion.

10. Shoreline change analysis confirm erosion at Columbus Bay and Pigeon Point and accretion in the Central GoP (Pt Lisas).

11. Projected sea level rise is expected to exacerbate coastal erosion and result in coastal flooding. Any plans for coastal development must give consideration to projected sea level rise.

12. Mangrove coverage declined in Trinidad by 252.4 ha from 2007 to 2014, while in Tobago it declined by 16.6 ha. Loss of mangrove forest is expected to increase threat to human safety and increase damage to shorelines from coastal hazards such as erosion, flooding, and storm waves and surges.

13. The only extensive seagrass community currently existing is located within the Buccoo Reef Marine Park. Seagrass beds that were decimated along the northwest peninsula of Trinidad and on the Atlantic side of Tobago (La Guira, Kilgwyn Bay) have not recovered.

14. Loss of seagrass beds result in loss of macro-faunal biodiversity which impacts food webs, and ultimately the fisheries.

15. Hard coral cover has remained relatively stable at Buccoo Reef, Culloden Reef and Speyside in the past eight years and the average coral cover around Tobago has remained around 18%.

16. Thermally induced coral bleaching and coral disease remain a serious threat to coral reefs in Tobago. Coral disease outbreaks did occur after the 2010 bleaching event and mortality was high at that time, up to 50%.

17. Surveys conducted in 2017-2018 have noted that yellow-band disease, a coral disease that affects several species including the endangered mountainous star coral, has had incidence rates up to 10% following periods of prolonged elevated sea surface temperature.

18. Most of the commercially exploited fish stocks in Trinidad and Tobago are either near full exploitation, fully exploited or over-fished. Challenges faced in managing our marine fisheries resources include an open access fishery that promotes an environment of competition rather than sustainable use; illegal, unreported and unregulated (IUU) fishing; inadequate monitoring and surveillance; a lack of enforcement of existing regulations; outdated and inadequate legislation; and climate change impacts. Efforts were made by the Government during the 2016 -2018 period to address some of these issues.

19. Marine debris in general, and plastics in particular, is one of the most notable environmental concerns of our time. Trinidad and Tobago has to strengthen its legislative framework in the most obvious method to tackle the problem – recycling and the establishment of a circular waste economy.

20. Human induced climate change is now a largely undisputed phenomenon which has far reaching implications for the current and future management of Trinidad and Tobago's coastal and marine environment. Impacts such as extreme rainfall events and associated flooding, and increase in storm surges are already being felt and costing millions of dollars in economic loss.

21. For successful adaptation to climate change impacts, a multi-pronged approach is required. Strategies include conducting coastal vulnerability and risk assessments and applying this to development planning; maintaining and restoring environmental integrity through alleviation of pollution and protection of critical ecosystems; continuous monitoring and research so that management decisions are informed by sound science and the effect of interventions can be properly assessed; and extensive sensitization, awareness raising and education of various publics to the climate change phenomenon and methods to limit its social, economic and environmental impacts.

22. During the 2016-2018 period, the Government commenced policy initiatives and legislative action to address the degradation of our coastal and marine environment. However, there needs to be enhanced urgency in arresting this degradation if we are to develop the blue economy.

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