State of the Marine Environment
Trinidad & Tobago - 2016
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. 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. For more than 35 years, the IMA has pioneered and participated in numerous programmes locally and regionally, and advised the Government of Trinidad and Tobago on the sustainable management of the coastal and marine resources. 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. Trinidad and Tobago’s marine and coastal environment is extremely important for its development and sustainability. 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.

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The State of the Marine Environment Report 2016 provides a scientifically grounded understanding of the condition of some of Trinidad and Tobago’s important coastal and marine ecosystems, habitats and species. It also details 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. In compiling this report therefore, some degree of insight has been presented into the future prospects for the country’s coastal and marine environment should a ‘business as usual’ scenario be perpetuated into the future.

Pollution of coastal waters has proven to be an ongoing and pervasive problem. In parts of the Gulf of Paria along Trinidad’s west coast the problem is particularly acute. However, country-wide, areas with elevated parameters such as total suspended solids, hydrocarbons, nutrients, faecal coliform and heavy metals have been identified. This pollution problem has been found to be mainly land-based; where run off and effluent from terrestrial sources and activities have negatively impacted coastal sediment and water quality. Health and safety standards at several bathing beaches in Trinidad and Tobago have been compromised and some shellfish species may be unsafe for human consumption.

Coastal water pollution has also partially influenced the observed decline of important ecosystems such as coral reefs and seagrass beds.

Many coral reefs around Tobago have been experiencing phase shifts in benthic cover away from hard coral to species more tolerant of nutrient enriched water. Similarly, waning health and loss of Thalassia dominated seagrass beds in both Tobago and Trinidad, have been linked to poor water quality from land-based pollution (nutrients and sediments). Loss of seagrass beds would result in loss of their ecosystem services such as coastal protection and habitat for fish and other marine species. There is an urgent need to manage, and in some areas, rehabilitate our seagrass community to ensure that they continue to provide a safe haven for rich biodiversity, and protect our coastline.

At the same time, a third major coastal ecosystem, mangroves, has been shown to be undergoing degradation and habitat loss, not so much because of pollution, but through land-use change and development.
Loss of mangrove forest will increase threat to human safety and increase damage to shorelines from coastal hazards such as erosion, flooding, and storm waves and surges. It 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. The range of essential ecosystem services these ecological communities provide cannot be overstated. Thus, reasserted efforts must be made to alleviate negative pressures on them and boost their resilience.

Increased ecological resilience i.e. the capacity of an ecosystem to respond to perturbations by resisting damage and recovering quickly, is especially needed in the face of climate change and its associated hazards. For instance, climate change is expected to worsen incidences of bleaching as a result of elevated sea surface temperatures on Tobago’s reefs, and increase the occurrence of diseases, making the reef less attractive for tourism. Furthermore, the threats posed by climate change may become particularly evident when it comes to coastal erosion. This report has identified a few areas around the country where coastal erosion is already a problem. Accelerated erosion in the future as a result of climate change and sea level rise has the potential to put critical coastal infrastructure and coastal communities at further risk. The ongoing long term coastal monitoring program, which needs to be strengthened, is essential for continued identification of at risk areas, and the designing and implementation of effective ecosystem-based solutions. This would inform development planning in the coastal zone.

Within the context of the ocean-based economy, this report has also shown the imperative need to safeguard Trinidad and Tobago’s fisheries resources – a source of livelihood and nutrition for some of this country’s most marginalised groups and communities. Several species of commercially important fish have been found to be fully exploited or overexploited. However, legislation needed to rectify the virtually open access nature of this country’s fisheries and modernise fisheries practices to make them more sustainable, is in draft form and needs to be urgently laid in Parliament. Fish and shell fish nursery habitats such as mangrove swamps and seagrass beds also need to be conserved and/ or restored to ensure food security.

Updating relevant policy and legislation to enhance the coastal and marine governance framework, making it more effective in the context of Trinidad and
Tobago’s current and projected future reality, is essential if we are to treat with issues highlighted in this State of the Marine Environment Report. Effective implementation of formulated plans and policies also hinge on the adequate resourcing of management and regulatory agencies and ensuring that these bodies, in partnership with civil society, genuinely co-ordinate actions and activities across sectors, space and time. Monitoring and evaluation of management interventions are also critical to facilitate adaptive management in an uncertain future. Integrated Coastal Zone Management (ICZM) explicitly seeks this. The adoption of an ICZM Policy and the mainstreaming into practice of well-established ICZM principles would aid Trinidad and Tobago to sustainably use and develop its ocean and coastal resources while protecting the integrity of critical ecosystems and the services they provide.

Right:
Coral bleaching events are expected to become more frequent due to elevated sea surface temperature associated with climate change

Bottom:
Coastal erosion, which can be exacerbated by impacts due to climate change, threatens coastal infrastructure such as roads
Introduction

Trinidad and Tobago is the southern-most country in the Caribbean archipelagic chain. Trinidad has a surface area of 4,828 km² while Tobago is substantially smaller with an area of 300 km². Collectively the country has a coastline length of 704 km. The country’s jurisdictional sovereignty and responsibility extends beyond the terrestrial into the marine through its archipelagic waters, territorial sea and exclusive economic zone (EEZ). The collective areal extent of these encompasses 77,502 km² of waters surrounding the islands. Trinidad and Tobago therefore has a land to sea ratio of 1:15, which indicates the importance of the marine and coastal sphere to the country (Draft ICZM Policy, 2014).

The country’s economy has long been supported by coastal and marine resources, primarily oil and gas, tourism and fisheries. Data from the Central Statistical Office (CSO) has shown that for the past 10 years, the industrial sector has accounted for more than 50% of the country’s Gross Domestic Product (GDP) while the service sector (including tourism and shipping) has accounted for about 40% GDP, but more than 60% of the labour force. Tourism is especially important in Tobago as approximately 50% of employment is tourism related. The fishing sector, although contributing much less to GDP, cannot be underestimated, as it provides a source of livelihood, subsistence and nutrition, especially to some of the more vulnerable in society. The current population stands at 1,349,667 persons (CSO, 2016) and it is estimated that almost 80% of all socio-economic activities and 70% of the population are located along the coast (CSO, 2007).

New economic policies, aimed at diversifying the economy, have seen investments in the tourism, agriculture, aquaculture and maritime sectors, all of which depend on a healthy coastal environment. However, much of the nation’s coastal resources have already been destroyed, degraded or over-exploited to accommodate a growing population and their economic needs. Climate change, sea level rise and heightened erosion in some areas also exacerbate the problems associated with many interests competing for limited coastal space.

In September 2015, the government of Trinidad and Tobago joined the rest of the world and committed to 17 Global Goals to achieve 3 extraordinary things in the next 15 years - end extreme poverty, fight inequality & injustice and fix climate change. These 17 Sustainable Development Goals (SDGs), unlike Millennium Development Goals (MDGs) derived in 2000, take into consideration the environment and its link to economic and social development. Goal # 14 - Life below waters - speaks to the conservation and sustainable use of oceans, seas and marine resources for sustainable development. This goal has 10 targets one of which speaks to sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts, by strengthening their resilience, and taking restoration action in order to achieve healthy and productive oceans by 2020. In addition, the PNM’s manifesto which highlights the need to conserve the country’s natural assets has become government policy, and the government is in the process of developing a National 2030 Vision.

In recent times, there has been increased awareness of the value of the services our coastal and ocean ecosystems provide, and their significant contribution to our national economy. The concept of the ‘blue economy’ which refers to “living with the ocean and from the ocean in a sustainable relation” (Behnam, 2013; pg. 14) is being given more consideration. Strengthening a national awareness of the role played by the oceans and its existence, and the need to develop an integrated coastal and ocean policy through advocacy and education, formal and informal and at all levels, is the gateway to the future (Behnam, 2013). To achieve this, the Institute of Marine Affairs (IMA) has to translate data collected using standardized and widely accepted scientific methods into pertinent information (knowledge products) that can be used by the decision-makers and civil society when developing policies. This State of the Marine Environment Report 2016 is one such knowledge product.
Approach

The data provided in this report were collected under IMA’s on-going monitoring, and research projects 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 AAAnalyst 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 program (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 IKONOS satellite imagery. In situations where IMA does not have primary data, information from reference sources was used.
Pollution

Pollutants that find their way into Trinidad and Tobago’s rivers through direct dumping or land based run-off can travel downstream and enter the marine environment. Our actions on land “far away”, although not necessarily immediately apparent, can have an impact on the marine environment. In fact, it is estimated that more than 75% of marine pollution in the Caribbean is due to land-based sources and activities.
Temperature, pH and dissolved oxygen concentration in coastal waters are generally within the USEPA (1995) acceptable limits for the protection of aquatic life as well as the Trinidad and Tobago water pollution rules (Table 1). However, poor water quality is noted at major rivers receiving land-based discharge such as Diego Martin, Maraval, Caroni, Madame Espagneole, Couva, Guaracara, Cipero and Godineau. The Gulf of Paria (GoP) on the west coast of Trinidad, receives excessive pollution loading from agriculture, industrial, and domestic sources. This has resulted in several hot spot areas characterized primarily by elevated levels of suspend solids, nutrients and hydrocarbons.

Table 1: Summary of physical measurements from the Gulf of Paria, Trinidad

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>Temperature (°C)</th>
<th>Salinity (ppt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (n=250)*</td>
<td>7.84</td>
<td>6.01</td>
<td>28.1</td>
<td>29.22</td>
</tr>
<tr>
<td>Minimum</td>
<td>7.22</td>
<td>0.51</td>
<td>26.0</td>
<td>0.88</td>
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<tr>
<td>Maximum</td>
<td>8.23</td>
<td>8.53</td>
<td>30.9</td>
<td>36.20</td>
</tr>
<tr>
<td>US EPA 1995 Limits</td>
<td>6.5-8.5</td>
<td>&gt; 5.0</td>
<td>should not exceed 3.0°C above ambient</td>
<td>N/A</td>
</tr>
<tr>
<td>Trinidad Water Pollution Rules*</td>
<td>6.0-9.0</td>
<td>&gt; 4.0</td>
<td>should not exceed 3.0°C above ambient</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Data from 250 measurements in the Gulf of Paria from Banjoo and Ramoutar (2016), Banjoo, (2013a) and Banjoo (2013b).

* Quantity, condition or concentration at which substance or parameter is define as a pollutant. Values not within ranges are considered pollutant.

N/A - No Assessment.

**Total Suspended Solids**

Excessive total suspended solids (TSS) and sediment pollution affects the coastal water of Trinidad particularly near the mouth of the Caroni River (west coast) and the North Oropouche River (east coast) where levels greater than 50 mg/L have been recorded. Levels of TSS found in the GoP are representative of ambient conditions at some locations and elevated at other locations. TSS varied from 7.0 mg/L to 64.0 mg/L in the dry season with an average of 16.2 + 11.3 mg/L and from 9.2 mg/L to 132.1 mg/L in the wet season with an average of 21.5 + 22.2 mg/L. TSS levels in Southwest Tobago were quite variable ranging between 0.5 to 30.5 mg/L in the Bon Accord Lagoon to 66 mg/L in La Guira Bay. Although southwest Tobago does not receive riverine flow, high TSS may be accounted for by resuspension of bottom sediments in shallow areas with turbulent conditions. There is no standard level for TSS in marine waters, but the levels should not affect photosynthetic organisms adversely, by reducing the available sunlight needed for primary productivity. Excessive TSS (> 50.0 mg/L) can result the smothering of benthic organisms, reduced photosynthetic activity, low dissolved oxygen and reduced species diversity and abundance.
Hydrocarbon pollution results from mainly accidental spills via transport, and oil and gas operations. In December 2013, a major spill of refined oil (>7000 barrels) contaminated the Southwestern Peninsula of Trinidad from Pointe-a-Pierre to Cedros. Generally, petroleum hydrocarbon levels in water and sediment are higher on the west coast compared to other coastal areas of Trinidad and Tobago. 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 are considered ambient, and found in other areas away from petroleum sources. Sediment quality off Pointe-a-Pierre, La Brea and Granville indicated hot spot areas with elevated levels (>100.0 ppm) of hydrocarbons as adsorbed and absorbed petroleum hydrocarbons (AAPH). Elevated levels of AAPH (>100.0 ppm) were also found in areas of Port of Spain and Chaguaramas likely due to accidental spills from shipping activity. Levels less than 2.4 ppm in sediments are considered ambient and are found in coastal areas not affected by petroleum hydrocarbons.

Hydrocarbons

Analysis of fish and shellfish tissue samples for AAPH in 2014 indicate low levels that ranged 0.07 - 2.73 ppm in the edible/ muscle tissues of Carite (Scomberomorus brasiliensis), Cavali (Caranx hippos), Croaker (Micropogonias spp.), Mullet (Mugil curema), Red Snapper (Lutjanus synagris), Salmon (Cynoscion jamaicensis) and Shrimp (Xiphopenaeus kroyeri and Panaeus schmitti) samples. There is no standard for AAPHs in biota tissues, but a comparison is made to a study in 1986 were levels were relatively similar ranging from 0.25 - 1.79ppm.

Analysis of oysters (Crassotrea rhizophorae) tissue collected at the Rousillac Swamp in 2014 for AAPH indicate elevated levels ranging between 10.58 and 38.59 ppm. A history of oil contamination of oysters in this area is established from a 2002 study. Caution should be taken when consuming oysters since these organisms are filter feeders that can bio-accumulate toxic hydrocarbons. AAPH measures polycyclic aromatic hydrocarbons which are known carcinogens (US EPA, 1995) that can be harmful to human health if ingested.
Coastal areas off the Point Lisas Industrial Estate and the Caroni River mouth receive excessive nutrients, and have toxic ammonia levels exceeding the USEPA 1995 acceptable limit of 1.43 µM for the protection of aquatic life (Table 2). Higher levels of ammonia and chlorophyll “a” are found in the GoP compared to the East coast of Trinidad (Table 2). Chlorophyll “a” is a common measure of total phytoplanktonic biomass which is the base for marine food webs and the support for fisheries. Average chlorophyll “a” values found in the GoP are above the value of 3.20 µg/L reported by Morrel and Corredor (2001), consistent with eutrophic (nutrient rich) coastal waters. In comparison, marine water in the East Coast of Trinidad averaged 0.08 µg/L which suggests low primary productivity in the East Coast compared to the West Coast.

<table>
<thead>
<tr>
<th>Location</th>
<th>Metric or guideline value</th>
<th>Ammonia (µM)</th>
<th>Chlorophyll “a” (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast, Gulf of Paria</td>
<td>Average (n=68)</td>
<td>0.72</td>
<td>3.52</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>1.52</td>
<td>4.51</td>
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<tr>
<td></td>
<td>Min.</td>
<td>0.01</td>
<td>0.11</td>
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<tr>
<td></td>
<td>Max.</td>
<td>9.05</td>
<td>31.83</td>
</tr>
<tr>
<td>East Cost Trinidad</td>
<td>Average (n=120)</td>
<td>0.34</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>0.39</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
<td>1.97</td>
<td>0.65</td>
</tr>
<tr>
<td>Point Lisas Bay</td>
<td>Average (n=6)</td>
<td>1.74</td>
<td>5.95</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>2.99</td>
<td>2.80</td>
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<tr>
<td></td>
<td>Min.</td>
<td>0.01</td>
<td>3.11</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
<td>7.63</td>
<td>10.83</td>
</tr>
<tr>
<td>Caroni River mouth</td>
<td>Average (n=5)</td>
<td>2.01</td>
<td>2.52</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>3.96</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>0.01</td>
<td>1.60</td>
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<tr>
<td></td>
<td>Max.</td>
<td>9.05</td>
<td>3.19</td>
</tr>
<tr>
<td>Bon Accord Lagoon, Tobago</td>
<td>Average (n=46)</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
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<td>1.8</td>
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<tr>
<td></td>
<td>Min</td>
<td>0.01</td>
<td>0.0</td>
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<td></td>
<td>Max</td>
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<td>5.5</td>
</tr>
<tr>
<td>Kilgwyn Bay, Tobago</td>
<td>Average (n=23)</td>
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<td>0.32</td>
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<tr>
<td></td>
<td>Standard Deviation</td>
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<tr>
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<td>Min</td>
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<tr>
<td></td>
<td>Max</td>
<td>3.24</td>
<td>1.6</td>
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<tr>
<td></td>
<td>US EPA 1995 Limits</td>
<td>1.43</td>
<td>N/A</td>
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</tbody>
</table>
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. They encompass a range of elements including chromium, nickel, manganese and iron, as well as the more toxic mercury, cadmium and lead. Heavy metals occur naturally in the environment but anthropogenic activities increase the bioavailable metal pool. While some of these metals such as copper, zinc and selenium are essential elements that are required for important biochemical functions in organisms, all metals can have toxic effects when present in excess. Trace 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.

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-integrated indication of metal contamination (Schröpp et al., 1990). The most recent island-wide assessment of heavy metals in coastal sediments was conducted in 2011. Total recoverable heavy metal concentrations in coastal sediments from Trinidad and Tobago are shown in Figure 1 and 2. Sediment quality was classed as “very good”, “good”, “fair” or “poor” in this report. This classification was based on how concentrations of total recoverable vanadium, chromium, manganese, iron, cobalt, nickel, arsenic, barium and lead in sediments compared with metal concentrations at the most pristine stations in the assessment or, where available, with Canadian Sediment Quality Guidelines (CCME, 2007). Results of the assessment suggest that heavy metals in sediments at some locations within the coastal area of Trinidad and Tobago may have the potential to adversely affect aquatic life.

Sediment quality is poorest in the GoP, off the west coast of Trinidad (Figure 1). Many anthropogenic activities occur on this coast and in its associated watersheds. These include 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). The main urban areas, residential/ housing areas, commercial areas, employment centres and the two main seaports in Trinidad are also located on this coast. Other factors which may be contributing to sediment quality include the sediment Total Organic Carbon (TOC)/ organic matter content and the semi-enclosed/ sheltered nature of the water body. TOC is the carbon found in organic matter that can be used as an indicator of organic matter, which has an affinity for heavy metals. Only one area off the west coast is classed as “good”- this is in the southwest near Cedros, where there is limited anthropogenic activity.
Sediment quality on the north coast of Trinidad is generally good; only two areas near Saut d’Eau Island and La Filette are classed as “fair” (Figure 1). TOC concentrations in sediment from these areas are higher compared with the other areas on the coast. On the east and south coasts of Trinidad, levels also range from “fair” to “good” (Figure 1). While some land-based sources and activities exist along the east and south coasts (such as small built-up/urban areas, agriculture and fishing), there is much more marine-based anthropogenic activity - extensive areas off these coasts are used for oil and gas exploration and production. Compared with the Gulf of Paria, however, these areas are better flushed and contain more sandy/ stony sediments with lower TOC/ organic matter concentrations so there is a lower potential for accumulation of metals in the sediments.

Sediment quality in Tobago is better than sediment quality in Trinidad. There is very little industrial activity in Tobago: the economy is largely tourism-based. Sediments in Tobago are classed as “very good” or “good” except for one area near the seaport in the capital, Scarborough (Figure 2). Harbour sediments tend to be more polluted due to the associated shipping activities (Denton et al., 2005) e.g. dredging. Harbours are also often located near more urban/ built-up areas, so the coastal sediments are subject to greater anthropogenic input from the associated watersheds.

Figure 1: Heavy metal concentration in coastal sediments off Trinidad
Figure 2: Heavy metal concentration in coastal sediments off Tobago

Industrial activities, both onshore and offshore, could significantly contribute to heavy metal pollution in the marine environment.
Bacteriological water quality studies conducted by the IMA since 1981 reveal that some of our popular beaches are sewage-contaminated. Some sources of sewage contamination for beaches in Trinidad and Tobago are non-functional sewage treatment plants, seepage of sewage from pit latrines built on river banks and along the coastline, as well as from improperly constructed septic tanks and runoff from livestock farming operations. Swimming in polluted water can cause illness. Swimmers could contract any illness that is spread by ingestion of faecal-contaminated water and polluted waters may contain several different disease-causing organisms. Viruses are believed to be the major cause of swimming-associated diseases such as gastroenteritis, hepatitis, respiratory illness and ear, nose and throat ailments. Microbial diseases that can be contracted by swimmers include salmonellosis, shigellosis and infections caused by Escherichia coli bacteria. Other microbial disease causing organisms found at varying concentrations in recreational waters include amoeba and protozoa which cause giardiasis, amoebic dysentery, skin rashes and pink eye.

Swimming-related illnesses are not usually severe or life-threatening. However, some cases of gastroenteritis can be serious for certain people, such as, infants, the elderly and those with compromised immune systems. Swimming-related illness can take a substantial toll in terms of convenience, comfort and the well-being of affected individuals. They can also result in substantial economic costs in terms of lost work/sick days. The swimmer who contracts a sewage-borne illness may also pass the disease on to household members, thus multiplying the effects of the polluted water. 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. Data of this type are available for some of the beaches and bays along the north and west coast of Trinidad (Figure 3).
The IMA assessed bathing water quality at some of the popular beaches by determining compliance with the United States Environmental Protection Agency (USEPA) Quality Criteria for Water (1976), in the absence of any local bathing beach standards.

**North Coast of Trinidad**

**Maracas Beach**

- Eastern section safe for bathing (blue)
- Western section unsafe for bathing in the wet season as well as occasionally in the dry season (green)
- Mouth of the Maracas Bay River unsafe for bathing as water quality was poor (red)
- The main source of pollution for the western Maracas Beach is the sewage contaminated Maracas Bay River.
Las Cuevas Bay

- Western end of the bay, a section of which is now in its second season of Blue Flag Certification, has good bathing water quality (blue)
- Eastern section of Las Cuevas Bay is unsafe for bathing (red)
- The main source of pollution for eastern Las Cuevas Bay is a river which discharged to the bay and is contaminated with effluent from a sewage treatment plant and waste from a fishing depot.
Williams Bay
- Water quality is good at the popular bathing area at the eastern corner, just west of ALCOA (blue)
- Water quality is poor from mid bay to the popular bathing area at the western corner of Williams Bay during the wet season (green).

Chagville Beach
- Water quality is good at the eastern section (blue)
- Western section has poor bathing water quality after periods of heavy rainfall (green). This is attributed to increased land surface runoff and storm water flow as well as increased discharge from drains and Chagville River to the beachfront.

Welcome Bay
- Most popular bathing location at Welcome Bay is mid bay area
- Safe for bathing during the dry season (green)
- Bathing water quality sometimes adversely affected in the wet season when increased rainfall levels results in increased surface runoff, storm water flow, and increased flow from rivers and drains
San Fernando Coastline (from the cemetery on Lady Hailes Avenue to the Marabella River)
South of King’s Wharf
- Unsafe for bathing in the dry season (red).
- Sources of pollution include waste from fish market as well as five drains

North of King’s Wharf to the Yacht Club
- Two bathing areas (1) vicinity of Spring Vale Point and (2) off the iron ladder just south of the second break in the sea wall, approximately 300m north of King’s Wharf Jetty.
- Bathing water quality is poor at both locations during the dry season (red).
- A source of pollution for the bathing area closer to King’s Wharf Jetty is discharge from a large drain nearby.

North of Yacht Club
- Unsafe for bathing (red).
- The main sources of contamination are seepage of sewage from pit latrines dug within a few meters of the seawall and discharge from the polluted Guaracara River and Marabella River.
Beaches and Bays

The IMA has been monitoring the dynamic nature (erosion and accretion rates, littoral processes) of selected beaches and bays throughout Trinidad and Tobago since 1988. Currently, 27 bays in Trinidad (70 stations) and 27 bays in Tobago (55 stations) are monitored.
Beaches are dynamic coastal features which respond to storms, wind, waves, currents and tides differently dependent on its geology. Where the coastal geology is resistant to wave attack, erosion may occur at a reduced rate and where it is more susceptible, it may be eroded at a faster rate (Van Rijn, 1998). In Trinidad, the north coast is mainly rocky cliff, while the west coast is rocky at the north, consists of wetlands and mudflat at its central region and alluvium material toward the south. The south coast is mainly sandstone cliff, and the east coast is varied with rock cliffs at the north and wetlands and cliffs toward the central and southern regions. In Tobago, the coastline consists mainly of rocky cliff to the central and north east of the island with coral limestone in the south west.

During 2011-2015, the north coast of Trinidad experienced the highest winds (range 0.0 -18.1 m/s) from the north-east, and the highest waves (range 0.3 -1.5 m) from a north-easterly direction compared to the other coasts. It also experienced the fastest longshore current speed (range 1.0 -67.0 cm/s) which was generally to the west. The Windward coast of Tobago experienced increased littoral impact compared to the Leeward coast as wind speed (0.1 -8.0 m/s), wave height (0.1-1.5 m) and longshore current (1.2-44.0 cm/s) were all greater on this coastline. Only the breaker height (0.20-2.70 m) was higher on the Leeward Coast.

Beaches can be classified as being in a state of erosion, accretion or dynamic equilibrium (D.E.). Erosion can occur either horizontally, where the backshore recedes landward, or vertically, where the sand elevation decreases along the beach face (Cambers, 1998). Accretion occurs where there is an increase in sediment on the beach face which can extend the beach horizontally increasing the width of the beach (Van Rijn, 1998). The majority of beaches monitored in Trinidad and Tobago appear to be stable or in dynamic equilibrium, where there is no net loss of sediment. It should be noted that between November 9 and 15th 2014, 2.5 km of this road was damaged primarily by runoff from rainfall over several days. The Mayaro - Manzanilla Road is a coastal road built on a sand bar between the Nariva Swamp, a wetland of international importance (Ramsar Site), and the Manzanilla Beach. The road was initially utilised by workers in the coconut industry but in recent times, has been the main access route for coastal communities and workers/material going to the oil and gas industries located in Mayaro/ Guayaguayare. The road and other infrastructure such as electricity poles and houses were damaged as floodwaters from the swollen Nariva and Dubloon Rivers removed sediments from under these structures. The road was repaired by the Ministry of Works and Infrastructure and was reopened to traffic in early 2015.

However, in Trinidad, Columbus Bay on the southwest coast, Cocos Bay on the east coast and Guayaguayare Bay on the south coast experienced erosion during 2011-2015. In Tobago, Richmond Bay, Goldsborough Bay, and La Guira Bay experienced erosion during 2011-2015.

The following maps, photographs and graphs illustrate the dynamic nature of the country’s coasts and in particular, some of the sites of severe erosion. On Cocos Bay (Figure 4) from 2011-2015 the erosion rate was 0.14 m per year at IMA’s monitoring Station 5 (Figure 5). Continued erosion could threaten the Manzanilla/ Mayaro Main Road which runs parallel to the beach and is located approximately 30m landward of the IMA benchmark (Plate 1).
Figure 5: The beach profiles at Station 5 on Cocos Bay, Trinidad (2011-2015)

Plate 1: Coastal erosion occurring at Station 5, Cocos Bay (2013)
At Guayaguayare Bay (Figure 6) erosion at Station 1 has led to landward recession representing an erosion rate of 0.75 m per year (Figure 7). This erosion also threatens critical infrastructure. For example, the erosion illustrated in Plate 2 lies just west of a pipeline landing site.

**Figure 6:** Map of Guayaguayare Bay showing location of monitored stations

**Figure 7:** The beach profiles at Station 1 on Guayaguayare Bay, Trinidad (2011-2015)
Columbus Bay, on the southwest coast of Trinidad continues to suffer from erosion, a problem that has unfortunately ravaged the bay for the past forty years. The most noticeable physical coastline change to date is the erosion of the once protruding headland at Los Gallos Point, to three stacks, which are locally referred to as the “three sisters”.

Shoreline change analysis conducted by the IMA shows that between 1994 and 2007, there was a linear regression of coast as large as 150 m at Corral Point, and an opposite effect of accretion noticed at Punta del Arenal; an area located immediately south of Corral Point. Ongoing monitoring at Columbus Bay (Figure 8) has confirmed erosion continues to occur at the southernmost station with landward regression of the shoreline occurring at a rate of about 1.91m per year from 2011-2015 (Figure 9). Plate 3 illustrates felled coconut trees and a receding shoreline at station 8. The coastal land is privately owned and coastal protection structures were installed along the northern region of the bay to arrest the erosion but have failed.

Figure 8: Map of Columbus Bay showing location of monitored stations
Figure 9: Beach profiles at Station 8 Columbus Bay, Southwest Trinidad (2011-2015)

Plate 3: Coastal erosion at Station 8 on Columbus Bay (2013), southern view.
Mangrove Swamp

Loss of mangrove forest will increase the threat to human safety and increase damage to shorelines from coastal hazards such as erosion, flooding, and storm waves and surges. It 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 the Caribbean have been impacted by human activities, and now they are projected to be negatively affected by sea-level rise especially where they are constrained on the landward side by built development, or starved of sediment. In 2008, the Institute of Marine Affairs began an assessment of mangrove forests in Trinidad and Tobago. Using high resolution satellite imagery (2000-2007), remote sensing and GIS technology, all mangrove forests were mapped and their extent determined (Figure 10 and 11).

In Trinidad, the majority of mangrove forests are found on the sheltered west coast (Gulf of Paria); which is the coastline that is occupied by more than 70% of the population and has experienced the most intense development activities within the past five decades. Current mangrove coverage is estimated at 7,532 ha on the west coast of Trinidad compared to 1,132.8 ha on the east coast, 481.3 ha on the south coast, and 0.3 ha on the north coast.

Figure 10: Map of mangrove forests in Trinidad (Juman and Ramsewak, 2010)
In Tobago, mangrove coverage was estimated at 222.9 ha encompassing 11 systems, most of which are located on the Windward Coast. Seventy percent of the mangroves on the west coast are found in the Caroni Swamp, 10% in the Godineau Swamp and the remaining 20% amongst smaller systems.

While mangroves were cleared along the west coast of Trinidad for housing, industries, agriculture, roads and ports, there has been some regeneration or new growth, but at the expense of other wetland communities (brackish and freshwater marshes) in most instances. In Caroni Swamp, mangrove coverage increased by 1,105 ha between 1942 and 2007 while marshland decreased by 523 ha and agriculture decreased by 393.5 ha. Built development increased by 835 ha while the Beetham landfill expanded from 47.5 ha in 1986 to 73.7 ha in 2007. Generally, natural wetland communities (mangrove, marshes and open water/ pond) increased between 1942 and 2003, as agricultural lands reverted to marsh, and mangroves colonized new areas on the seaward side: mudflats and deposited dredged spoilt. However, between 2003 and 2007, natural wetland coverage declined by about 346 ha as built developed and agricultural lands increased. In Godineau Swamp, mangrove coverage increased by approximately 48 ha between 1969 and 2007 as salt water intruded further inland and colonised marsh area.
Mangroves however, were recently cleared on the seaward side for the construction of the Point Fortin Highway (Plate 4).

Mangroves are also spreading into freshwater marsh and open pond areas in Icacos Swamp, and the reason may be climate induced as opposed to human alteration. The Icacos wetland was predominantly freshwater marsh and open pond with some mangroves fringing Columbus Bay. As the mangroves along the coast are eroding, salt water is intruding further inland and mangroves are now colonizing marshland. Similarly in Los Blanquizales, which is on the south coast, east of Icacos, the mangrove forest continues to undergo erosion.

Plate 4: Strip of mangrove cleared on the seaward side of Godineau Swamp for highway construction (January 2014)
Mangrove forests in the central region of the Gulf of Paria are expanding seaward onto extensive mudflats. Sedimentation seems to have increased from Brickfield in the north to Claxton Bay in the south as fish landing sites located in Brickfield, Orange Valley and Claxton Bay have become shallower and boats have had to be relocated. While the landward margin of these forests is being encroached upon by built development, the mangroves are expanding seawards. Further south on the west coast, in Claxton Bay, Guaracara, Marabella, Cipero, Rousillac and La Brea the mangrove forests are being negatively impacted, and encroached upon by housing developments. The December 2013 oil spill negatively impacted the mangrove forests from Rousillac to Iros Bay (Plate 5), however these systems have since shown signs of recovery/regrowth.

On the east coast, the largest mangrove forests are found within the Nariva Swamp (580.7 ha), North Oropuche/Fishing Pond (268.8 ha) and Ortoire River (215.7 ha). Nariva Swamp is the largest wetland in Trinidad and Tobago (11,343 ha), but it is primarily a freshwater wetland, with mangrove accounting for less than 10%. Unlike systems on the west coast, the wetlands on the East Coast (Atlantic Ocean) are subjected to higher wave energy. These wetlands are not open to the ocean but occur behind sand barriers, which are experiencing problems with coastal erosion.

On the south coast of Trinidad relatively large mangrove forests are found near the Moruga River and at Los Blanquizales. Smaller systems are found within Guayaguayare Bay and Erin Bay. Mangroves were cleared along the Moruga River and in Erin Bay for unplanned housing, while the mangrove forest in Point Galeota has been fragmented by road construction. On the North Coast there are no extensive mangrove forests, only small systems in Maracas and Scotland Bay.

In Tobago, the largest mangrove communities are found at the southwest end of the island which is the most populated and developed part of the island. Mangroves were cleared in the 1990’s for the extension of the Crown Point Airport and for hotel development. In 2007, mangroves were cleared in the Bon Accord Lagoon for proposed resort development and in 2008 for housing. However, there is indication that the Bon Accord mangrove forest is migrating landward as salt water appears to be intruding inland. Even in areas that were recently cleared, there are signs of new growth as many white mangrove seedlings have been re-established.
Whether salt water intrusion is due to channel construction or sea-level rise is unknown and needs to be determined. However, there is a serious concern in this area with regards to ‘coastal squeeze’ as built development occurs on the landward edge of the forest leaving very little space for landward migration of mangroves.

There is little historical data for the smaller wetlands on the Atlantic coast of Tobago such as Louis D’or, Goldsborough, Belle Garden, and Rockly Bay. On this coast where most mangrove systems are found, there are concerns that coastal erosion on the seaward side and encroachment by built development on the landward edge, will lead to coastal squeeze of mangrove forests.

Mangrove forests in Trinidad and Tobago have been negatively impacted, and continue to be threatened by human activities as present and proposed developments are concentrated on the coast. These degraded systems are more susceptible to climate change impacts especially where there is little space for landward migration of mangroves as sea-level rises. Although mangrove coverage has expanded in wetlands such as Caroni, Godineau, Icacos, and Nariva, it has been at the expense of other freshwater communities. The causes for vegetation change may be site-specific or climate related but this can only be determined by undertaking vulnerability assessments, and long-term monitoring of parameters such as relative sea-level and sedimentation rates.
Seagrass Beds

Seagrasses are flowering plants that grow on the seafloor in shallow coastal habitats. They are very productive, faunally rich and ecologically important marine resources that provide nursery habitats for a number of commercially important species such as conch and lobster, and they help sequester carbon dioxide in the ocean.
Seagrasses are semi-permeable filters that stabilize bottom sediments, slow current flow, prevent erosion and filter suspended solids and nutrients from coastal waters. These filters are becoming overloaded as land-use changes in the coastal catchment and in the nearshore environment are impacting negatively on them. Increasing population density in coastal areas has enhanced sediment and nutrient loading and nutrient over-enrichment of coastal waters has been cited as the main reason for seagrass bed decline worldwide.

In 1997, the Institute of Marine Affairs (IMA) began an assessment of seagrass communities around Trinidad and Tobago. The inventory revealed that *Thalassia testudinum* (turtlegrass), the slow growing climax seagrass species in the Caribbean, was being negatively impacted by intense coastal activities and beds once reported in Cocorite, Balandra and Scotland Bay were no longer present. In Cocorite, the beds were destroyed by reclamation for housing and road construction, while in Scotland Bay and Monos Island they have been replaced by sparse communities of colonizer species (*Halodule wrightii* and *Halophila sp.*). The most extensive *Thalassia* dominated seagrass community remaining in Trinidad was found at William’s Bay.

In Tobago, extensive *Thalassia* dominated communities were found in the southwest - in Bon Accord Lagoon, Buccoo Bay, La Guira Bay and Kilgwyn Bay - where there has been extensive development in the tourism and housing sectors. The seagrass community within the Bon Accord Lagoon was negatively impacted by nutrient enriched conditions. Partially treated or untreated domestic wastewater is discharged from water treatment systems and many households in the coastal catchment have soak-away septic systems built into the coralline limestone geology of the area. This limestone is porous, and nutrients from sewage filter down into the water table and then enter the sea. Seagrass areas in La Guira Bay, Tobago were reclaimed in the 1990’s for the extension of the airport runway, but the bed in the bay has recovered. La Guira and Kilgwyn Bays are now utilized by beach goers, since facilities have been provided, and by fishermen. Current land use in the coastal catchment include guest houses, an airport, residential development and an industrial estate.

Since 2002, IMA has been monitoring the health and productivity of selected *Thalassia* dominated seagrass beds around the islands. The healthiest and most productive seagrass sites in the country were found in Southwest Tobago at Buccoo Bay and Kilgwyn Bay, however since 2015, the seagrass beds in La Guira to Kilgwyn Bay have disappeared (Figure 12). This disappearance coincided with the Sargassum bloom in 2015. Bon Accord Lagoon has the lowest seagrass biomass and density in Tobago, but while the monitored sites within the Lagoon are overgrown by macroalgae, seagrasses have spread into adjacent areas near Buccoo Reef. Seagrass coverage in the Buccoo Reef/Bon Accord Lagoon Marine Protected Area has doubled within the past 14 years. The grasses have colonized the Nylon Pool, a very popular shallow, sandy area in the back reef zone, where visitors are allowed to swim at the end of glass bottom boat tours.

In Trinidad, the most productive seagrass site was found at William’s Bay. This area was home to a diversity of species including fishes such as seahorses, grunts and snappers, green turtles and invertebrates such as starfish, conch and urchins. However, since 2012, a decline in seagrass biomass and productivity has been recorded, and this coincides with the development taking place on the peninsula (Figure 12 and Figure 13). *Thalassia* community once found on the eastern side of St Peter’s Bay was destroyed in 2010 while the community on the western side of the bay was destroyed in 2012. These areas are now overgrown with algae (*Caulerpa sp.*) and sparse communities of 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 coastal catchment which have been deforested for housing.
Poor water quality from land-based pollution (nutrients and sediments) and coastal development are the main factors affecting the health of the seagrasses in Trinidad and Tobago. The beds in Trinidad are found along the most intensely developed coastlines, and continue to be subjected to development pressures from the coastal catchment. Loss of seagrass beds would result in loss of their ecosystem services such as coastal protection and habitat for fish and other marine species. There is an urgent need to manage, and in some areas, rehabilitate our seagrass community to ensure that they continue to provide a safe haven for rich biodiversity, and protect our coastline.

Figure 12: Total *Thalassia testudinum* biomass at monitored sites in Trinidad and Tobago

Figure 13: *Thalassia testudinum* areal productivity at monitored sites in Trinidad and Tobago
Coral Reefs

Coral reef communities around Tobago appear to be in a state of flux with the most noticeable trend being a decline in average hard coral cover around the island over the last three decades. The temporal trend in hard coral cover decline on the Tobagonian fringing reefs is not to the magnitude of that reported in some other Caribbean countries but it is still a cause for concern.
With an average 33% decline in hard coral cover across the island since 1985, the extent of coral loss in Tobago is still substantial.

Hard corals are the reef builders – their polyps secrete the calcium carbonate that is responsible for the cementing and expanding coral reef structures over time. Percentage hard coral cover is used globally as an indicator of reef health. Findings of declining cover of these corals on reefs around Tobago is unfortunate but certainly not surprising. The ever increasing pressures on Tobago’s marine environment via a myriad of factors such as population increases; rampant unregulated coastal development; changing watershed and land use that promotes terrestrial run off; increased tourism volume; and rising artisanal fishing effort is negatively affecting the viability and resilience of the reef ecosystems there (Burke and Maidens, 2004; Mora, 2008; Lapointe et al., 2009; Mallela et al., 2010; Jackson et al., 2014; WTTC., 2015).

An examination of the data over the long term reveals the declining hard coral cover in many areas being accompanied by concomitant increases in algae, soft corals, zoanthids and/or sponges (Figure 14). These long term phase shifts away from bottoms dominated by hard corals to those dominated by other organisms are as a result of a combination of factors which kill or weaken corals while promoting the proliferation of alternative space occupiers.
Climate change and its associated impacts is a major contributor to hard coral cover decline around Tobago. For example, Buccoo, Culloden and Speyside were severely affected by temperature induced coral bleaching in 1998, 2005 and 2010. Bleaching occurs when corals expel symbiotic photosynthetic algae that provide the corals with food and give them their vibrant colours. The 2005 mass bleaching event resulted in up to 85% bleaching and up to 75% mortality of important reef-building species in some areas (O’Farrell & Day, 2005; Wilkinson & Souter, 2008; Eakin et al., 2010.).
Grooved Brain Coral, *Diploria labyrinthiformis*, Flying Reef, Tobago

Great star coral, *Montastraea cavernosa*, Man O War Bay, Tobago
Following on from this, the 2010 event was Tobago’s most severe bleaching event on record but in this case, while bleaching extent was high, mortality was low (Aleme, & Clement, 2014). Bleaching however, increases coral susceptibility to disease. Within recent times Tobagonian reefs have been plagued by occurrences of Yellow Band Disease, which primarily affects the *Orbicella* complex, the most dominant framework builders on the island’s reefs. Yellow Band Disease is known to cause partial to total colony mortality and is considered to be one the most widespread and damaging coral diseases (Gil-Agudelo et al., 2004; Bruckner & Bruckner, 2006; Weil et al., 2009). It has therefore been proposed that this disease has been partially responsible for the waning reef health especially in the aftermath of bleaching.

Pulse disturbances such as bleaching and disease coupled with poor water quality encourages benthic cover dominance shifting away from hard corals (Hughes, 1994; McManus et al., 2000; Szmant, 2002; Wolanski et al., 2003; Diaz-Pulido, et al., 2009). Analyses have pinpointed high nutrients to be a problem in several fringing reefs around Tobago with sewage pollution and agricultural fertilizer run off identified as some of the chief sources (Lapointe, 2010; Mallela, 2010). Sedimentation is also problematic in areas such as Charlotteville and other localised regions where land use is changing (Mora, 2008; Lapointe, 2010). Like bleaching, poor water quality can leave corals more susceptible to disease and/or directly cause mortality. The declining cover of hard corals and growth in cover of soft corals, zoanthids and, in particular, algae, in several locations, including parts of Buccoo, Speyside, Arnos Vale, Culloden and Charlotteville, is evidence of cumulative impacts from land based sources of pollution.

Speyside is an interesting location to pay particular attention to because it is considered by some to have the best diving in Tobago. Substantial hard coral declines with concomitant increases in sponge cover from 2009 to 2013 also imply a shifting state here (Figure 14). Presently in Speyside the observed cover of the barrel sponge *Xestospongia muta* is high. Although this sponge is known to be susceptible to bleaching in elevated water temperatures, it is possible that both low mortality and high recruitment contributed to observed population growth in recent times. While Speyside is still relatively healthy and teeming with life, changing benthic assemblages on reefs have implications for reef function and the ecosystem services they provide e.g. food, amenity value, animal habitat.
Soft-bottom Benthic Community

Marine benthic communities are excellent indicators of local ecological health because, unlike migratory species, they generally have low mobility and thus cannot easily relocate when there are changes in environmental quality. In addition, several macrofaunal taxa, such as polychaetes, are considered sentinel species that may be amongst one of the first groups to respond to anthropogenic change such as eutrophication, sewage pollution or fisheries depletion.
Benthic invertebrates play a key role in the nutrient cycling, pollution metabolism and energy flows through the marine food webs. Epibenthic and benthic conditions can, in turn, have significant direct and indirect effects on fisheries, as well as species of conservation concern such as; sea turtles or rays that feed on the sea floor. Monitoring of key ecosystem indicators is an important component of successful management in marine protected areas. Monitoring can help identify stresses on the environment which may lead to early mitigation of the problem, and is also crucial to detect large-scale changes in environmental systems such as climate change so that resource managers can adjust conservation strategies.

A study published by Gobin (2010) off five islands in Chaguaramas provided one of the first comprehensive lists of hard substrate marine polychaetes for Trinidad. The study yielded a count of 2,377 polychaete worms belonging to 19 different families and comprising 89 species. Analysis suggested that more than 25% of these polychaete worms could be new species. Another study on Salybia Bay, Guayaguayare and Chagville beach identified 41 macroinvertebrate species (Fanovich, Nelson, & Lawrence, 2010). The phylum Annelida, represented by polychaete worms, was the most species rich group, with most species being found in Chagville. Only at Salybia was this group surpassed in richness by the arthropods, consisting of isopods and amphipods with 11 species. In comparison, 10 species of annelids were identified. Porifera and Cnidaria were also present only at Salybia.

In 2009 the IMA studied the benthic macro-faunal communities characterized in *Thalassia testudinum* (turtlegrass) dominated beds in Bon Accord Lagoon and La Guira Bay in Tobago and Williams Bay in Trinidad. A total of 461 species comprising 6,488 individuals were recorded; 206 species in Williams Bay, 130 species in Bon Accord Lagoon and 125 species in La Guira Bay. Polychaetes accounted for 48% of the species while amphipods accounted for 17%; decapods 12%; non segmented worms 11%, molluscs, other arthropods, echinoderms and miscellaneous accounted for the remaining 12% indicating a highly diverse benthic community. The diversity-stability hypothesis suggests that communities containing more species will vary less through time in response to various disturbances thus conferring a higher resilience to changes that may occur over time. As a contrast, when sampling was conducted in oil polluted areas from Pointe-a-Pierre to La Brea, 25,129 individuals were collected from only 204 species (Gobin and Agard, 1992). A smaller number of species were able to thrive in disturbed communities, thus such a community would be less resilient and more vulnerable to disturbances.

In 2015, the IMA sampled the benthic community along the Caroni Swamp in the months of April and August. Of the three major bodies of water flowing through the Caroni Swamp, the Blue River was found to have the healthiest benthic community with the most species, number of individuals and highest diversity. One thousand one hundred and thirteen (1113) organisms were collected during the two sampling periods. Thirty four (34) species were recorded in the dry season and 44 species in the wet season. Arthropoda accounted for 52% of organisms found, polychaetes 45% and all other organisms 3%. Evidence from this study showed that the Caroni Swamp is dominated by species that are tolerant to pollution. This coupled with the presence of few pollution intolerant species supports the hypothesis that the Caroni Swamp is slightly to moderately polluted as it receives polluted water in its catchment area from industrial, agricultural and domestic sources. Gobin and Agard (1992) have suggested that areas of impoverished benthic fauna are characteristic of being moderately disturbed.
Marine Fisheries

Marine fisheries is important both economically and socially for many rural/coastal communities who depend either entirely or partially on fisheries for their livelihood (Potts et al., 2003; Ferreira and Martin, 2005; GOTT, 2005). Fisheries contributes towards food security, poverty alleviation, foreign exchange earnings, culture, recreation and tourism.
A total of 1,013 finfish species belonging to 474 genera, 170 families and 36 orders (Ramjohn, 1999) have been identified in the waters of Trinidad and Tobago. However, only a small percentage of these species is caught and landed by the commercial fisheries (Table 3). Other coastal and marine resources present include crustaceans (shrimps, lobsters, crabs), cephalopods (squids), mollusks or shellfish (oysters, conch, mussels) and sea turtles (Kenny and Bacon 1981; Chan A Shing, 2002). Some of the main species exploited are listed in Table 4.

Table 3: Main finfish species exploited in Trinidad and Tobago (Chan A Shing, 2002)

| Finfish       | Catfish (Arius spp., Bagre spp.); cavalli and other jacks (Caranx spp., Trachinotus spp., Seriola spp., Decapterus spp., Selene spp.); shark (Carcharhinus spp., Rhizoprionodon spp., Sphyra spp.); snook (Centropomus spp.); herring (Opisthonema oglinum, Harengula spp., Sardinella spp.); dolphinfish (Coryphaena hippurus); flyingfish (Hirundichthys affinis, Cheilopogon spp., Cypselurus spp.); blinchi (Diapterus spp.); grunt- (Haemulon spp., Anisotremus spp., Genyatremus luteus); snapper (Lutjanus spp., Rhomboplites aurorubens, Etelis oculatus); mullet (Mugil spp.); ancho (Pomatomus saltator); salmon/croaker (Cynoscion spp., Macrodon ancyodon, Micropogonias furnieri); mackerel/tuna (Thunnus spp., Scomberomorus brasiliensis, S. cavalla, Acanthocybium solandri, Euthynnus alletteratus); grouper (Epinephelus spp., Mycteroperca spp., Cephalopholis spp.); barracuda (Sphyraena spp.); cutlassfish (Trichiurus lepturus); swordfish (Xiphias gladius) |

Table 4: Marine fisheries resources exploited in Trinidad and Tobago (finfish excluded)

<table>
<thead>
<tr>
<th>Shrimps</th>
<th>Brown shrimp (Farfantepeneaus subtilis), pink shrimp (F. notialis), pink-spotted shrimp (F. brasiliensis), white shrimp (Litopenaeus schmitti), seabob (Xiphopenaeus kroyeri)</th>
</tr>
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<tbody>
<tr>
<td>Lobster</td>
<td>Caribbean spiny lobster (Panulirus argus)</td>
</tr>
<tr>
<td>Crabs</td>
<td>Cirque/serrette/swimming crabs (Callinectes spp.); blue crab (Cardisoma guanhumi); hairy crab (Ucides cordatus)</td>
</tr>
<tr>
<td>Shellfish</td>
<td>Oysters (Crassostrea rhizophoreae); Queen Conch/Lambie (Strombus gigas); Black conch (Melangena melangena); Rock mussel (Perna perna); Green mussel (Perna viridis); mok (Mytella spp.); Pachro/Sea Cockroach (Chiton marmoratus, C. tuberculatus; Acanthopleura granulata); Chip chip (Donax denticulatus, D. striatus)</td>
</tr>
<tr>
<td>Turtles</td>
<td>Leatherback (Dermochelys coriacea); hawksbill (Eretmochelys imbricata); green (Chelonia mydas), olive ridley (Lepidochelys olivacea), and loggerhead (Caretta caretta)</td>
</tr>
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</table>

**Shellfish, Crabs and Turtles**

Collection is on a small scale casual basis for most species, by villagers living in some coastal areas and by families on recreational visits to beaches (Kenny and Bacon, 1981). Bullock and Moonesar (2003) found that oysters (*Crassostrea rhizophoreae*), mok (*Mytella guyanensis*) and green mussels (*Perna viridis*) were sold at roadside stalls. Oysters and ‘mok’ were sold raw with sauce as cocktails whilst green mussels were bought unopened by customers and cooked before consumption. The Queen conch (*Strombus gigas*) is found on Trinidad’s North Coast and Tobago’s Lagoons, sandy bottoms and turtle grass beds (Kenny and Bacon, 1981). Stocks in Tobago are perceived to be commercially endangered. Over the past three decades, a drastic decline has been observed in the catch per unit effort of conch on traditional harvesting grounds (Lovelace, 2002).

Several species of crabs (Table 4) are also utilized for food locally. The blue crab and the hairy crab are the two most important species in terms of numbers sold in markets throughout Trinidad (Kenny and Bacon, 1981). Due to limited studies however, the level of present exploitation for most species is unknown.
There are five (5) species of marine turtles occurring in the waters of Trinidad and Tobago (Table 4). The Protection of Sea Turtle and Turtle Eggs Regulations, promulgated under Section 4 of the Fisheries Act, stipulates that: no person shall, kill, harpoon, catch or otherwise take possession of or purchase, sell, offer or expose for sale or cause to be sold or offered or exposed for sale any turtle or turtle meat. Despite this, illegal poaching is a pervasive problem on both islands. For example, it is not uncommon to have turtle meat being served in Tobago at harvest festivals. Additionally, this resource is threatened by incidental catch (the accidental entanglement of sea turtles in nets set for fish). Several hundred leatherback turtles are ensnared each year along the north and east coasts of Trinidad, a number which may represent at least 25% of the nesting females active in that area (Bachan, 2009).

**Finfish and Shrimp**

The finfish and shrimp resources exploited in Trinidad and Tobago can be broadly categorized into the following groups based on the type of sea bottom substratum and oceanographic conditions (Fabres and Kuruvilla, 1992):

1. Coastal pelagic (mainly gillnetting for carite, kingfish, flyingfish, and shark)
2. Soft substrate demersal (trawl fishery for shrimps and a number of bottom methods for associated groundfish i.e. salmon, croaker, snapper and catfish)
3. Hard substrate demersal (mainly snappers and groupers; bycatch may include lobster and grunts)
4. Oceanic (highly migratory) pelagic (targets tunas and swordfish; dolphinfish, marlins, sharks and wahoo are considered bycatch; main fleets are semi-industrial longline, semi-industrial multi-gear and recreational (Ferreira and Martin, 2005))

Except for the oceanic (highly migratory) pelagic fishery, all fisheries are coastal. In terms of landings, the artisanal gillnet fishery for coastal pelagics is one of the most important fisheries of Trinidad and Tobago accounting for the largest finfish and shark catches of any fishery. It is second only to the trawl fishery in terms of landings and revenues (Ferreira and Soomi, 2001). Estimated annual landings for some commercially important species groups in the marine capture Fisheries of Trinidad and Tobago is given in Figure 15.
<table>
<thead>
<tr>
<th>SPECIES</th>
<th>ASSESSMENT YEAR</th>
<th>STOCK STATUS</th>
<th>MANAGEMENT RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carite (Scomberomorus brasilienis)</td>
<td>1991-1992</td>
<td>Fully exploited</td>
<td>No increase in fishing effort; minimum mesh size of 4.75”; encourage line fishing (Henry and Martin, 1992)</td>
</tr>
<tr>
<td>Kingfish (S. cavalla)</td>
<td>1996-1998; 2004</td>
<td>Overexploited</td>
<td>Improve input data for generating growth parameters; reduce fishing mortality; implement close season; enforce fish or mesh size regulations; do not increase fishing effort (Martin and Hoggard, 2007)</td>
</tr>
<tr>
<td>Shark (Carcharinus porosus)</td>
<td>1992</td>
<td>Under exploited</td>
<td>Precautionary approach to harvesting due to the vulnerability of sharks to overfishing (Walker, 1992)</td>
</tr>
<tr>
<td>Four-winged flyingfish (Hirundichthys affinis)</td>
<td>1990-1992</td>
<td>Fully exploited</td>
<td>Conservative approach to increasing local effort; reduce foreign fishing effort (Samlalsingh and Pandohee, 1992).</td>
</tr>
<tr>
<td>Lane snapper (Lutjanus synagris)</td>
<td>1980-2004</td>
<td>Uncertain; possibly growth-overfished</td>
<td>Preliminary assessment; monitor fishing effort and do not increase until further research (Soomai and Porch, 2007)</td>
</tr>
<tr>
<td>Caribbean red snapper</td>
<td>1990-1991</td>
<td>Fully to overexploited</td>
<td>Restrict fishing effort and increase age of first capture to 3 years (Manickchand-Heileman and Phillip, 1992 and1996)</td>
</tr>
<tr>
<td>Vermillion snapper (Rhomboplites aurorubens)</td>
<td>1990-1991</td>
<td>Overexploited</td>
<td>Restrict fishing effort and increase age of first capture to 3 years (Manickchand-Heileman and Phillip, 1992)</td>
</tr>
<tr>
<td>Shrimp fishery (All shrimp species)</td>
<td>1995 - 1998</td>
<td>Fully to overexploited. Stock biomass declining</td>
<td>A 20% reduction in existing levels of effort to improve profits to the fishery and reduce the probability of the biomass falling between sustainable levels (Seijo et al., 2000; Ferreira and Soomai, 2001)</td>
</tr>
<tr>
<td>Shrimp Fishery</td>
<td>1975; 1988 - 2004</td>
<td>Overexploited. Stock biomass declining</td>
<td>Implement closed season for trawling; increase stakeholder involvement; limit number of trawlers in the fishery; enforce regulations (Ferreira and Medley 2007)</td>
</tr>
<tr>
<td>Croaker (Micropogonias furnieri)</td>
<td>1989-1997</td>
<td>Overexploited</td>
<td>No increase in fishing effort; limited entry into fishery; reduce fishing mortality (Soomai et al., 1999);Alió et al., 1999)</td>
</tr>
<tr>
<td>Salmon (Cynoscion jamaicensis)</td>
<td>1989-1997</td>
<td>Overexploited</td>
<td>No increase in fishing effort (Soomai et al., 1999)</td>
</tr>
<tr>
<td>Groundfish Fishery</td>
<td>1989-1997</td>
<td>Fully to overexploited</td>
<td>Limit fishing effort for all fleets (Soomai and Seijo, 2000)</td>
</tr>
<tr>
<td>Yellowfin Tuna (Thunnus albacares)</td>
<td>ICCAT Database – annual submissions from countries exploiting the resources and findings of scientific research papers</td>
<td>Fully to overexploited</td>
<td>Implement Total Allowable Catch (TAC) Limits on a yearly basis; establish Observer Programme and Port Sampling Plan; contracting and operating parties to implement a Multi-annual Management and Conservation Programme for 2012-2015; implement a time-area closure for FAD associated fishing.</td>
</tr>
</tbody>
</table>
Stock assessments using a variety of methods have been conducted to determine the status of marine fisheries resources in Trinidad and Tobago since the late 1980s. Some of these assessments have been in collaboration with neighbouring Venezuela due to the shared nature of the resources. Table 5 shows a subset of these assessments. Research findings suggest that the marine fisheries resources of Trinidad and Tobago are either heavily exploited or over exploited. There does not appear to be any potential for expansion of the coastal fishery for shrimp and groundfish, or the coastal pelagic fishery for carite and kingfish (Henry and Martin, 1992; Martin and Hoggarth, 2007; Ferreira and Soomai, 2001; Soomai and Seijo, 2000). Hard bottom demersal stocks such as snappers are fully exploited (Manickchand-Heileman and Phillip, 1992) and over-capitalization is evident in the trawl fishery (Seijo, et al., 2000; Ferreira and Soomai, 2001). Highly migratory pelagic species are currently the management responsibility of the International Commission for the Conservation of Atlantic Tunas (ICCAT) of which Trinidad and Tobago is a contracting party. Assessments are conducted and reviewed annually by ICCAT. These assessments indicate that the main species exploited by the local oceanic pelagic fishery are fully to overexploited.

Main Factors Impacting on the Exploitation and Status of Marine Fisheries Resources

1. An open access fishery for marine resources result in an environment of competition rather than management. The ultimate result is over fishing with assessments indicating that most coastal marine resources are either heavily exploited or over-exploited.

2. There are large quantities of by-catch discards from the trawl fishery which includes undersized fish of commercially important species.

3. Illegal fishing by foreign vessels of neighboring countries (Venezuela, Barbados and occasionally Guyana) also exploit local resources.

4. Given the over exploited state of man commercial species and the over-capitalization of some fleets, financial incentives provided by concessions, rebates and subsidies to encourage development of the fisheries sector may be supporting inefficient operations and contributing to overfishing.

5. Very little is known about recreational fishery. Studies are needed to determine the impact of recreational fisheries on the resources.

6. Lack of implementation and enforcement of regulations pertaining to the management of marine resources.

7. The absence or lack of accurate verifiable data on fisheries is a major impediment to the planned strategic approach to fisheries management.

8. Out-dated and inadequate fisheries legislation as a legal basis for a modern national fisheries management system. The legislation provide for rudimentary controls (type and mesh size of fishing nets, closed seasons and areas) as far as fisheries management is concerned.
Emerging Issues

- Climate Change
- Sargassum
- Lionfish
The occurrence of anthropogenic 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. Climate change is a process whereby increasing concentrations of greenhouse gases in the atmosphere, especially carbon dioxide (CO₂) emitted through the burning of fossil fuels and deforestation, is causing average global temperatures to rise. These atmospheric alterations are bringing with it a suite of meteorological and oceanographic changes which threaten a number of species, ecosystems and livelihoods in the marine and coastal sphere.

Modelling forecasts of climate change impacts for Trinidad and Tobago have found that the two islands would experience rising sea levels, less frequent but more intense rainfall, sea surface temperature increases and extreme events, including hurricanes and storm surges, occurring more regularly. In addition, it has been observed that some of the extra CO₂ in the atmosphere is absorbed by the world’s oceans and seas leading to the pH of their waters decreasing – a process known as ocean acidification.

Through climate change our coastlines would be more at risk to erosion and flooding, coastal aquifers more vulnerable to salt water intrusion and coral reefs are anticipated to experience more frequent and prolonged bleaching. Less understood, but no less likely, are a range of potentially negative species specific and trophic level interactions that come with the changing physical and chemical oceanographic conditions. Climate change impacts represent added stressors to the marine environment which compound the numerous challenges our aquatic and coastal flora and fauna have to overcome in order to survive. Through all these impacts, the climate change phenomenon therefore threatens the viability and sustainability of a number of important coastal sectors including tourism, oil and gas and fisheries. It will necessitate the protection of existing coastal infrastructure located in vulnerable areas and will require livelihood diversification and adaptation throughout coastal communities.

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) program which Trinidad and Tobago is seeking to implement.
Sargassum is a genus of brown macroalgae (Class Phaeophyceae) that has both attached and free-floating forms. The former has always been a part of Trinidad and Tobago’s local marine flora with at least eight species documented. The latter consists of just two species, Sargassum natans and Sargassum fluitans which are only found in the Atlantic Ocean and have never been part of this country’s marine flora. However, first occurring in 2011, massive quantities of the floating form of Sargassum seaweed have intermittently fouled beaches off the windward coasts of Trinidad and Tobago. In incidents occurring in Tobago, mats up to 0.6m thick have washed ashore at Pinfold Bay, King’s Bay, Hope Beach, Kilgwyn and Little Rockly Bay while in Trinidad, east coast communities from Cumana to Guayaguayare have been impacted.

An area spanning across the tropical Atlantic, near to the equator, has been identified as the source region for the Sargassum plants affecting Trinidad and Tobago and the wider Caribbean within recent times. A combination of factors have been postulated as contributing to the flourishing of the floating plants there: warming sea surface temperature; increased nutrient input from land-based sources via massive continental rivers such as the Amazon and Orinoco in South America and the Congo in Africa; and fertilization from iron rich Sahara dust. Changing oceanic circulation patterns subsequently transport mats of Sargassum northwards into the Caribbean basin where they break up and come ashore when influenced by local currents.

During Sargassum invasion events fishers have difficulty launching their boats and accessing fishery resources, while the sight and smell of piles seaweed deter foreign and local tourists and beach-goers. Ecologically, both adult and juvenile sea turtles can become entangled in the thick masses while the prolonged presence of the seaweed could have negative effects on the natural environment as it shades the sea floor and marine habitats such as coral reefs and seagrass beds. During past Sargassum events the Tobago House of Assembly (THA) and affected Regional Corporations have had to dispense resources to remove and dispose of the beached Sargassum plants which emanate noxious fumes upon decay. Decomposing Sargassum has had human health impacts, which is one of the main reasons that clean-up activities need to be conducted when influxes occur in populated areas. Most recently, in July 2015, the coastal village of Speyside, Tobago was inundated with Sargassum in an overnight event which necessitated the THA spending millions of dollars in clean-up efforts over the course of 30 days.

Sargassum invasion of Trinidad and Tobago’s beaches is a relatively novel phenomenon for which we have been largely unprepared for in the past. However, with climate change causing continuous warming of the oceans, it appears that future events are likely. In preparation for these, consultations with key stakeholders from government, academia, community-based organisations (CBOs), non-governmental organisations (NGOs) and the private sector have been taking place in an effort to develop a National Sargassum Response Plan. The Plan will foster a coordinated approach to the problem involving key sectors and stakeholders, and will include an early warning component, communication mechanism and strategy for clean-up and disposal/utilisation of plant material.
The Indo-Pacific lionfish’s (*Pterois spp.*) presence in the Atlantic was first reported off Florida’s coast in 1985. Non-native to this hemisphere, it was not until the year 2000 that the species began to be regularly sited off the south east Atlantic coast of the United States. Subsequently, a rapid spread of this invasive fish took place throughout the wider Caribbean region. Its anticipated arrival in Trinidad and Tobago’s waters was confirmed in February 2012 in Castara, Tobago.

Lionfish are recognised as a significant threat to reef ecosystems. This voracious predator feeds on resident marine species, particularly small and juvenile reef fish, shrimp and lobster. Being non-native to this region, there is a scarcity of natural population controls such as predators, parasites and/or diseases. This, coupled with its high fecundity and wide environmental tolerance, has led to populations rapidly expanding in the coastal waters surrounding Trinidad and Tobago. This expansion, especially threatens Tobago’s reef ecosystems as the potential exists for lionfish to decimate organisms that serve important ecological roles e.g. herbivorous fish that keep algae in check on reefs, and also out compete other reef predators for food.

Efforts to control the proliferation of lionfish in this country have centred around attempts to actively cull individuals. From 2013 to present the Green Fund financed a lionfish removal program where dive professionals were paid to shoot the fish, and lionfish derbies were hosted in Tobago. About 1000 lionfishes were removed from the environment during derbies held in 2014, 2015 and 2016. As well as seeking to control the growth of the population, these activities gave some indication of hotspots (North east Tobago) and changing population structure in the early years of the invasion. Outreach and education were also a major component of this project.

What is required now is for culling activities to become more self-sustaining through the creation of a lionfish fishery. Lionfish has proven that it can be a versatile, tasty meal and might now be on the cusp of entering the seafood mainstream appearing on menus as a sustainable option alongside salmon, shrimp, and the occasional mahi mahi. They are being marketed as a sustainable eco-friendly food option with the added appeal that eating Lionfish is beneficial to reefs and marine ecosystems.
LAWS OF THE REPUBLIC OF TRINIDAD AND TOBAGO
Policy Intervention

In Trinidad and Tobago, there are 24 policies that touch on aspects of coastal and ocean management. The Draft Fisheries Management Policy (FMP) (2011), National Forest Policy (2011), National Protected Areas Policy, and the National Policy and Programmes on Wetland Conservation for Trinidad and Tobago (2001) deal with conservation of biodiversity. The National Climate Change Policy (NCCP) focuses on climate mitigation.
Additionally, economic and planning policies that affect the marine and coastal environment include the National Tourism Policy (2010), the draft Yachting Policy, the Draft National Spatial Development Strategy for Trinidad and Tobago (2013) and the Comprehensive Economic Development Plan for Tobago: Clean, Green, Safe and Serene. Alongside these the National Environment Policy (2005) and the Integrated Solid Waste / Resource Management Policy for Trinidad and Tobago (2012) treat with pollution. Trinidad and Tobago has also acceded to the Cartagena Convention - Land-Based Sources (LBS) Pollution Protocol which requires the adoption of measures aimed at preventing, reducing and controlling pollution of coastal and marine areas from land-based sources and activities. In 2008, a National Plan of Action for the Protection of the Coastal and Marine Environment from Land-based Sources and Activities, 2008-2013 was submitted to Cabinet for approval. However, this plan was never adopted and therefore not implemented.

The main issues with respect to many policies are that they are outdated, lack specificity, or have been inadequately implemented. In addition, the various policies address problems in the coastal and marine environment in a piecemeal and fragmented manner (Ramlogan, 2013) and does not allow for a comprehensive, coordinated approach.

To complement policy there are also some 20 pieces of legislation that can potentially address problems in the coastal and marine environment. These include the State Lands Act (revised 2011), Fisheries Act 1916 (amended 1966; 1975), the Water Pollution Rules 2001, Shipping Act (revised 2011), the Archipelagic Waters and Exclusive Economic Zone Act (1986), and the more recent Planning and Facilitation of Development Act (2014). While it is perceived that sufficient laws exist in the country to enable effective planning and management of coastal and marine resources and activities, most of the laws are worded in a general manner, with the intent being the passage of regulations to provide for specificity. Unfortunately, there has been a reluctance to use such regulatory powers and this has resulted in some laws being largely unenforceable (Ramlogan, 2013).

The many laws and policies impacting on coastal and marine areas give rise to as many as twenty-nine (29) institutions having a defined legal and/or policy role in aspects of coastal and ocean management. The sheer number of agencies with responsibility for coastal and marine area management creates problems such as overlapping jurisdiction and improper co-ordination with regards to enforcement. The work of these agencies is hindered by insufficient capacity and resources. A further setback faced by enforcement agencies is the absence of sanction levels that offer a strong deterrent to breaching laws. These low financial penalties have contributed to the lack of enthusiasm on the part of agencies for bringing court actions in order to enforce the law (Ramlogan, 2013).

Global climate change and climate variability adds to the continuous pressure on the coastal and marine environment, especially since Trinidad and Tobago is faced with a limited resource base, logistical challenges and rising pressures for economic development. A key challenge would be minimising, and adapting to sea level rise, and in particular the increased coastal erosion and salinization of coastal aquifers that may result. High levels of threat exist to coastal infrastructure, housing and other built development, but this can be minimized by promoting sustainable land-use and better planning and development control, including controlling land-based sources of coastal and marine pollution which degrades coastal ecosystems that can protect coastal developments. Mainstreaming climate change mitigation and adaptation across all sectors should help improve the way the government “does business” and achieves sustainable development. This will be via stimulating actions that strengthen vertical policy, planning and budgeting processes between national (Trinidad and Tobago) and sub-national institutions (e.g. Tobago House of Assembly), and horizontal cross-sectoral initiatives that aim to contribute to coastal sustainability.
An important part of climate change mainstreaming is climate risk analysis, which aims to define the extent of the current and future climate risk within the sector or area under consideration. Climate risk analysis should become an integral part of strategy or policy development in all sectors and areas. When the climate risk is appropriately addressed at the national level within strategic plans and policies, this creates an enabling environment for government agencies to engage with climate risk reduction and risk management, and for the private sector and communities to take their own steps to reduce risks and manage residual risks. Climate-responsive policies and strategies thus pave the way for practical on-the-ground activities that manage the climate risk (Sustainable Seas Ltd., 2014b).

A major issue is ensuring that changes to national plans, and impacts from new sectoral priorities start to reach people on the ground. This will require continued coordination across the range of different activities going on at the national, sub-national, and local levels. Mainstreaming experience has demonstrated that, for example, many national development goals are interlinked, and that achieving the goal of coastal and marine conservation will not be possible if other related goals, including poverty reduction, are not met. Newly emerging ideas of measuring coastal community and the environmental dimensions of livelihood, and going beyond measurements of GDP, are gaining traction internationally. Experience from many nations has shown that quality of life can be expressed beyond the measure of GDP per capita and that the integration of social and environmental factors are equally important in ensuring wider development goals are reached. Going beyond government-led mainstreaming, issues such as “green jobs”, social enterprises, and wealth accounting are among other initiatives which are increasingly being seen as ways to address the integration of true social and environmental costs for a better quality of sustainable development.

For Trinidad and Tobago to achieve the Sustainable Development Goals there must be an enabling legislative and policy environment that allows for cooperation and co-ordination among state agencies, the private sector and civil society organizations. The draft ICZM Policy Framework attempts to create such a platform. It seeks to address impacts from climate change, and to attenuate anthropogenic impact from the range of coastal stakeholders across the land-sea continuum and 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. In pursuing this policy, all state and non-state agencies would have to instill public awareness about the dangers of the degradation of environmental conditions in the country’s coastal zones and oceans, and encourage active participation of the people in all undertakings to conserve and enhance these resources. Scientific research conducted/undertaken by state agencies would need to be policy-driven and policy-relevant using sound methods and the best available technology. Data would have to be readily available, and translated into pertinent information (knowledge products) that can be used by the decision-makers and civil society when developing policies.

Stakeholder consultations have proven to be integral to the policy formulation process
Conclusion
1. The Gulf of Paria (GoP) receives excessive pollution loading from agriculture, industrial, and domestic sources. This has resulted in several hot spot areas characterized primarily by elevated levels of suspended solids, nutrients and hydrocarbons.

2. Excessive total suspended solids (TSS) and sediment pollution affects the coastal water of Trinidad particularly near the mouth of the Caroni River (west coast) and the North Oropouche River (east coast) where levels greater than 50 mg/L have been recorded.

3. Petroleum hydrocarbon levels in water and sediment are higher on the west coast compared to other coastal areas of Trinidad and Tobago. Dissolved dispersed petroleum hydrocarbon (DDPH) concentrations above 10.0 part per billion (ppb) were found close to oil and gas operations.

4. Sediment quality off Pointe-a-Pierre, La Brea and Granville indicated hot spot areas with elevated levels (>100.0 ppm) of hydrocarbons as adsorbed and absorbed petroleum hydrocarbons (AAPH).

5. Analysis of oysters (*Crassotrea rhizophorae*) tissue collected at the Rousillac Swamp in 2014 for AAPH indicate elevated levels ranging between 10.58 and 38.59 ppm. Caution should be taken when consuming oysters since these organisms are filter feeders that can bio-accumulate toxic hydrocarbons. AAPH measures polycyclic aromatic hydrocarbons which are known carcinogens (US EPA, 1995) that can be harmful to human health if ingested.

6. Heavy metal pollution of sediments is reported at sites within the GoP

7. Bathing beach quality was poor -
   - near the mouth of the Maracas River, Maracas Bay
   - eastern section of Las Cuevas Bay
   - mid bay to the western section of William’s Bay, Chaguaramas in the wet season
   - western section of Chagville Bay, Chaguaramas after heavy rainfall
   - Welcome Bay, Chaguaramas in the wet season
   - south of King’s Wharf, Sean Fernando
   - north of Yacht Club, San Fernando

8. While most of the beaches and bays (27 in Trinidad and 27 in Tobago) monitored are in dynamic equilibrium, during the 2011-2015 period, erosion was recorded at Manzanilla, Columbus and Guayaguayare Bay, Trinidad and at Richmond, Goldsborough and La Guira Bay, Tobago.

9. Mangrove forests continue to be cleared to facilitate built development, and are more susceptible to impacts from climate change (coastal squeeze). However, in Caroni, Godineau, Nariva and Icacos Swamp mangrove coverage is increasing at the expense of freshwater marsh communities.

10. *Thalassia* dominated seagrass beds were lost along the north-western peninsula of Trinidad and in Kilgwyn and La Guira Bay in Tobago due to poor water quality. Seagrasses have spread into Nylon Pool as consequence of nutrient pollution.

11. Coral reefs are negatively impacted by land-based sources of pollution (nutrients and sediments) making them more vulnerable to impacts from climate change (bleaching) and diseases. Many coral reefs around Tobago have been experiencing phase shifts in benthic cover away from hard coral to species more tolerant of nutrient enriched water.

12. Several species of commercially important fish have been found to be fully exploited or overexploited.

13. The degradation of coastal and marine ecosystems mainly from anthropogenic impacts (pollution) make them more vulnerable to impacts from climate change, and other emerging issues like impacts from invasive alien species (IAS) such as lionfish, and Sargassum blooms.

14. To arrest the degradation of our coastal and marine resources, immediate policy and legislative interventions are required.

15. Increase in citizen awareness of the fragility, importance, and benefits derived from our marine resources is required.


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