State of the Belize Coastal Zone Report 2014-2018

Final report

BELIZE COASTAL ZONE MANAGEMENT AUTHORITY & INSTITUTE

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Marine Conservation and Climate Adaptation Project

Preparation of the State of the Belize Coastal Zone Report 2014-2018

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The MCCAP is being implemented by the Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development and Immigration (MAFFESDE) through a dedicated Project Implementation Unit (PIU) housed within the Fisheries Department and the Fiduciary Management by the Protected Areas Conservation Trust (PACT). MCCAP is funded by the World Bank under the project number P131408. With the support from MCCAP, and under the leadership of the Coastal Zone Management Authority and Institute a consultancy is conducted to aid in the process of preparing the State of the Belize Coastal Zone Report 2014 – 2018. This consultancy is executed by Biosfera Desarrollos S.A. de C.V.

Executive summary

This document presents the State of the Belize Coastal Zone Report for the period 2014-2018. The purpose of the report is to answer the following questions: What changes in the coastal zone happened since the last report? Moreover, how effective have the management actions included in the Integrated Coastal Zone Management Plan (ICZMP) been? Inputs for the report came from existing sectoral reports, raw secondary data, interviews with national experts and data collected from an online questionnaire which was used into a grading system to assess each of the topics analysed. A first draft of the findings was elaborated and then validates through a national workshop involving experts in coastal resource management.

The Belize coastal zone is a complex dynamic terrestrial-marine system in which several abiotic, biotic and social systems interact and evolve. In order to reflect that dynamics, this report was organized using a Pressure-State-Response model to inform the main features of the coastal zone, their status and trends. The report is composed of four sections describing the resources and main findings.

Key findings for the period under review

Management and sustainable use of the coastal zone

A description of the main usages and dynamics that are pressing the coastal zone is presented.

Climate, weather and climate change

The Belize coastal zone is still highly vulnerable to the effects of meteorological events due to its regular climate pattern and climate change scenarios. The main hazards are three types of flooding:

Fluvial flooding: It is expected that in the next 10 years there will be potentially damaging and deadly fluvial flooding at least once.

Pluvial flooding: It is expected that in the next 5 years there will be potentially damaging and deadly pluvial flooding at least once.

Coastal flooding, It is expected that in the next 10 years there will be heavy surge that flood the coast at least once.

Population growth and urban development

The overall population in Belize has grown at a yearly average rate of 2.07%. This rate decreased from 2.28 % towards 1.94 % between 2014 and 2018. The overall population in the country reached an estimated 398,050 inhabitants and 37% of those were concentrated in coastal settlements. While there was no evidence of any increase in settlement areas, urban development is still pressuring the coastal zone by having impacts on sea turtle nesting areas and displacement of other fauna. There is inadequate wastewater treatment and garbage disposal. Marine dredging to fill in swamp areas removes sand sediments from the seabed altering the marine habitats.

Coastal development and land use

Infrastructure development along the coast continues to occur for urban, industrial and tourism development. However, the development is concentrated in pockets along the cayes and coastline. Two development infrastructures have impacts on the coastal zone: piers and defence structures. While the pier regulations state that piers should be constructed 1,000 feet apart, this piece of legislation is not followed and a result there is a congestion of piers especially in San Pedro Town, Ambergris Caye, Belize. On another hand, once a coastal development erects defence structures such as walls and breakwaters, the adjacent beaches will rapidly erode because these structures change the wave action and littoral current dynamics along the beach. As a result, there is the urgent need to either protect or reclaim beach front properties. The erection of defence structures is destructive as seagrass beds are lost in reclamation involves dredging. However, there is not data to quantify this hazard.

An important change on coastal development management began in 2015 with a centralized waste management system that collects garbage from San Pedro, Caye Caulker and Belize City and is forwarded to a centralized inland landfill. This system reduces a portion of the estimated 53,149 tons a year of solid waste generated in the coastal zone.

Tourism and recreation.

Tourism is a key sector for the Belize economy with inflows contributing 10.45% of GDP in 2017 and providing 13.3% of the employment in the country or approximately 1 in every 8 persons employed. In the review period, tourism arrivals grew in Belize with an average increase of 10.75 % a year resulting in 489,261 overnight tourist and 1,208,137 cruise visitors. Most of the tourist were concentrated in tourism destinations along the coastal zone where the largest portion of the tourism infrastructure is located. Recreational activities also increased. Tourism growth is one of the main drivers for urban development along the coastal zone and it is a source of pressure on mangroves, littoral forest and sandy beaches. Other impacts from tourism in the coastal zone include water supply demand, pollution from inadequate wastewater treatment and garbage disposal, and habitat modification for nesting, feeding and breading for wildlife. Nation-wide, there is a strong interest for continual growth in the tourism sector which is guided by the Tourism Sustainable Master Plan and the Enhancing Emerging Destinations Plan with the aim to three-fold the number of visitors.

Energy and resource extraction

There was no petroleum exploration and extraction activities in the coastal marine environment for the years in review. This complies with the Petroleum Operations (Maritime Zone Moratorium) Act which imposes a moratorium on the exploration and exploitation of petroleum and in the maritime zone of Belize. The legislation was enacted to prevent pollution from installation devices and vessels used in the exploration or exploitation of petroleum resources in the seabed and subsoil of the maritime zone. Petroleum is imported through the Belize PUMA Energy terminal in Belize City and is further distributed via marine transportation to the Cayes. Belize uses most of the imported fuel for transportation as 60% of the electricity consumed is purchased from neighbouring Mexico and

nationally produced with hydropower and biomass. Belize Natural Energy is the only oil producing entity in Belize. It is presently producing 500 gallons of crude a day, down from 2,000 gallons/day in 2010. The oil is exported and some is sold locally due to the high light sweet grade quality.

Land-Water interface

Sea Level Rise is one of the biggest concerns on the coastal zone due its impacts on settlements, economic sectors (like tourism and fisheries) and damages to infrastructure. An analysis conducted as part of this report using a Digital Elevation Model shows that at least 37 settlements with more than 200 inhabitants located below a height of 1 meter might be impacted as result of 1-meter increase in sea level.

Sediment transport

Two sources of sediments contribute to the dynamics of the shoreline. The first one is terrigenous sediments from the inland basins and the carbonate sediments from the coral barrier reef and carbonate continental shelf. Infrastructure such as roads and water storage dams could modify the free dispersion of sediments for the terrigenous sediments and piers and ports for the carbonate sediments. The combined effect of river discharges and ocean currents is to distribute sediments mostly at the northern edge of each discharge contrary to what is experienced when an obstacle such as coastal infrastructure is in the water current. In areas adjacent to fluvial discharges, beaches will have new materials for stabilization and/or growth while areas on the southern edge of river mouths will have less sediment and possible intensification of erosion processes.

Erosion

A net displacement of the Belize coastal erosion rates for the period 1969-2017 were determined for this report. This analysis finds that there are severe erosion problems along the entire coast of Belize with rates of up to 2.61 m/year and beach losses of 113 meters in 50 years. Such is the case of the Corozal District. Beach growth areas of up to 80.55 m were recorded in the Stann Creek District.

Coastal waters

Nutrient pollution

There are two main water pollution concerns. One is eutrophication of the coastal lagoons and the second is the inadequate capacity for wastewater and sewerage treatments. Treatment is offered only in the most populated areas of the country such as Belize City (secondary treatment), San Pedro Town (secondary treatment) and the Belmopan City (primary treatment) (Grau et al. 2013, p.11; Silva, 2013, p. 38). For industries, hotels and housing in some villages packet plants, septic tanks, latrines and lagoon discharge are used (Silva, 2013, p. 102).

The lack of adequate infrastructure and technology for wastewater treatment remains a problem. Inadequately treated wastewater pollutes groundwater, streams, rivers and soil in certain areas in contrast to the good water quality (Sweetman et al., 2019) found in the Port Honduras Marine

Reserve. The relatively good water quality in the reserve is due to factors such as the absence of beaches, limited coastal development and low population density in the Toledo District.

The effects of substances on the marine environment such as detergents and pesticides that are used in villages and agricultural sectors or the presence of faecal coliforms, are well known but the lack of data only allows for partial conclusions about the state of the different habitats and species that use them. The sources of pollutions are not well documented.

Additionally, in this section a description is made on activities such as dredging, land and beach filling.

Fishing

This economic sector is relevant due to its capacity to generate employment (2,000 – 2,500 fishers for the period in review) and benefit fifteen thousand Belizeans indirectly through family affiliations. An additional 1,200 are employed in processing and marketing services. The fishing industry ranks fifth in the national economy in revenue inflows through the exports of lobsters, conch, sea cucumber and shark products which in 2018 netted 18.89 USD Million. An important management innovation was implemented in 2016 with the roll out of the Managed Access Program with the aim to protect the rights of traditional fishers by giving them exclusive access to fish in certain areas. This is achieved by issuing annual licenses to fishers according to criteria developed in consultation with fisher representatives. Licenses allow fishers access to specific areas and require them to comply with regulations and to report their catches.

Aquaculture

The currently cultivated species are the Pacific white shrimp (*Litopenaeus vanammei*) and Nile tilapia (*Oreochromis niloticus*) in Dangriga, Riversdale, Monkey River, Ladyville and south of Belize City. The Pacific white shrimp remains the most lucrative product, and in 2016 represented 97% of the revenue generated by aquaculture despite the collapse of production in 2015 (Fugazza et al., N.D.). Historically, shrimp production has been approximately 10 tons per year, but production declined dramatically in 2015 and 2016 due to Early Mortality Syndrome (EMS). Consequently, the production revenue fell from $ 28.6 million in 2014 to $ 3.6 million in 2016

Belize is the first developing country in the world to earn (in 2015) the Aquaculture Stewardship Council (ASC) certification for demonstrating that production was obtained with minimal impact on the environment and the communities where the farms are located.

Invasive species.

Lion fish

The lionfish invasion in Belize is extensive. As a result, the implementation of control efforts is a priority. A number of control measures are utilized, including culling, design and implementation of marketing schemes, establishment of cooperation schemes between fishers, restaurants and hotels to encourage consumption of the species, removal of lionfish from MPAs by fisheries managers and promotion of recreational spear fishing for the species (CRFM Implementation Report 2015). Belize

has a National Lionfish Response and Management Plan that needs updating. The current Fisheries Legislation authorizes the Fisheries Administrator to issue permits for SCUBA divers to engage in culling of lionfish. However, the spears used need to be approved by the administrator. Many lionfish derbies are held annually where thousands are removed and consumed.

Sargassum

Since 2011, the proliferation of populations of brown macro algae of the genus *Sargassum* (*Sargassum natans* and *Sargassum fluitans*) around the Greater Caribbean Region has been observed even in places where, until recently, they were absent or were extremely rare. The potential impacts identified by the arrival of Sargassum in the shallow areas of the coastline and the beach are economic (tourism, fishing, nautical activities), environmental (disturbance of marine species, erosion of beaches, effects on mangroves, corals and seagrasses) and sanitary (algae decomposition and release of hydrogen sulphide).

Important actions carried out in Belize were 1) support to the municipalities in the cleaning of beaches with an investment of BZ $ 1.5 million dollars through the Belize Tourism Board, 2) formation of a Sargasso Working Group, 3) tax relief for properties severely affected by sargassum, 4) duty exemption for imported machinery and equipment to support cleaning efforts, 5) municipal assistance support that includes collection, disposal and storage, 6) launching of social media awareness campaigns so that tourists and interest groups know what is being done and what are the best practices when it comes to getting rid of Sargassum, and 7) forecast , where a system has been developed to help predict the influx of sargassum on the coast of Belize. The reports are published every Wednesday, Thursday and Friday along with the weather forecasts.

Sport fishing

Belize is known worldwide for its excellent sport fishing (reef, deep water and fly). It is most famous for its fly fishing for Bonefish, Permit and Tarpon. Fishing for these three species is primarily conducted on shallows or back reef flats throughout the country from Northern Ambergris Caye, along the coastline and up to Punta Gorda. Tarpon is caught in channels, creeks and rivers. Reef fishing is mainly conducted inside the barrier reef and its channels. Most common catches will include snapper, barracuda, grouper and jacks. Sportfishing for billfish and other pelagics is starting to increase in popularity as up to four major fishing tournaments are held yearly. Tuna, blue marlin, dorado, king mackerel, wahoo, amberjack and kingfish are the most common pelagic catches.

The total number of anglers permitted to sports fish in Belize has been increasing. There were 500 daily permits issued in 2015 while there were more than 1,000 in 2018. Additionally, there were less than 1,500 weekly permits issued in 2015 while there were more than 2,000 in 2018 according to the Coastal Zone Management Authority and Institute (CZMAI).

State of the coastal zone

This section presents a review of the current conditions of ecosystems and species characteristic from the Belize coastal zone.

Water quality

In general, there was an increase in the chlorophyll content in seawater for the 2014-2018 period with the average values being higher than before. Maximum values of up to 2.45 µg /L of alpha chlorophyll were detected in the Amatique Bay, Port Honduras. Also, high values of 0.53 and 2.29 µg /L of alpha chlorophyll were detected in the inner lagoon with values contrasting with the minimum offshore values of 0.19 and 0.181 µg/L. Probable causes for these increases are sea temperature rise and nutrients from wastewater discharges.

Coastal habitats

Mangroves

In between 2014-2018, Belize lost 0.13% of its mangroves. Land clearing for urban development was the main cause of mangrove deforestation.

Littoral forest

Coastal littoral forests are defined as a narrow band of trees which grow along the sandy beaches bordering the coastlines. Coastal littoral forests are severely threatened and can become globally extinct. These forests are highly specialised ecosystems that apart from protecting the soil from erosion, also provide nesting grounds for turtles, feeding and roosting for indigenous and migratory birds and homes for small mammals and reptiles. Littoral forests in Belize cover the smallest land area (25 square Km or 0.11% of the landmass). The average loss is 15.84 ha/year.

Coral reefs

Despite its enormous contribution to the overall Belizean economy, this climate range dependent fragile ecosystem is still threatened by a variety of anthropogenic sources such as coastal and tourism development; pollution from excess nutrients, pesticides and agricultural run-off from point and non-point sources; coastal aquaculture and domestic waste on the reef; over-fishing; increased tourism activities and sedimentation caused by dredging, landfill and inland deforestation. It is additionally subjected to periodic natural phenomena including episodes of warmer temperature, flooding, bleaching, outbreaks of disease, storms and hurricanes. Some of the human activities may be aggravating the impacts of these natural events, resulting in the inability of the ecosystems to recover as rapidly as they might have done under natural circumstances.

In 2015, the Healthy Reefs Report stated that the overall reef health in Belize remained in 'poor' condition with a reef health indicator (RHI) score of 2.5. The coral cover was scored as 'fair' (15%) but had declined slightly from 18% since the last report of 2012 likely related to an increase in macroalgal cover and declining water quality.

In 2018 the Healthy Reefs Report stated that the overall reef health in Belize was in fair condition with an RHI score of 2.8. The coral cover was still fair (average of 16%) compared to 2015 even though some areas such as Lighthouse Reef had 19% coral cover. In Belize, parrotfish biomass

continued to increase after protection in 2009 causing a slight decline in fleshy macroalgae for the first time.

Seagrass

Seagrass in Belize are found between the main barrier reef and the mainland. The seagrass beds are home and nursery areas for juvenile lobsters, conch, shrimp and fish. Manatees and turtles feed on the seagrass. The seagrass beds also filter water runoff from the mainland reducing nutrients and pesticides from reaching the barrier reef system.

Seagrass is the most extensive ecosystem within the Belize Barrier Reef and three atolls. These seagrass meadows start immediately west of the back reef and spread through the lagoons stabilizing sediments found on the seabed and maintaining productive lobster fishing grounds. The three species of seagrass in Belize are: the turtle grass (*Thalassia testudinum*), the manatee grass (*Syringodium filiforme*), and the shoal grass (*Halodule wrightii*). Other important algal components of this ecosystem, such as Halemida and Laurencia species are found distributed throughout the seagrass beds. The latter is known to induce settlement of the Queen conch, *Strombus gigas*, larvae where they spend the first year of their life buried in the sediments.

The seagrass ecosystem can be susceptible to degradation due to industrial, agricultural and domestic pollution. There is some damage to seagrass meadows from lobster fishing gears known as the “Cuban casitas” or shades. The fishing gear covers the seagrass which eventually die as there is no sunlight for photosynthesis. The extent of the impact is unknown as there is no data on the number of shades and the areas where they are deployed. A more recent threat for seagrass during the years in review, is the heavy influx of pelagic sargassum.

Protected areas

Belize presently has 21.6% (4,050.5 km^2) of its territorial waters under protection as marine protected areas. Eighty-point six percent (3,268.2 km^2) of the total marine protected areas falls under the legislative management of the Fisheries Department. The total replenishment areas (no-take) compose 15% of the protected areas but account for only 4% of the total territorial waters. The recent expansion of the Hol Chan Marine Reserve included sensitive habitats consolidating the already long accomplishment of the AICHI Target 11 under Strategic Goal C.

Species populations

Manatees

Belize has the largest population of West Indian manatee in the region mainly due to legislation and public environmental education. Manatees are endangered throughout their range as there is loss of habitat; they are also exposed to chemical pollution, climate change and injury by vessel collisions and propellers. According to the Belize Marine Mammal Stranding Network (BMMSN) and Clearwater Marine Aquarium (CMA) statistics, manatee strandings increased from 2016 due to human-induced mortalities from collisions with watercraft (45%). Most of the strandings (69%) occurred in the Belize District due to heavy boat tourist traffic and water taxis. There were more

females strandings than males. Many female mortalities result in abandoned orphans that perished if they were not immediately rescued.

Fish Spawning Aggregations

The Nassau grouper spawning aggregation sites are considered multi-species as they are used by various other species. These species include the mutton, cubera and yellowtail snappers.

In 2002, a coalition of seven non-governmental organizations along with the Belize National Spawning Aggregation Working Group lobbied the Government of Belize to completely protect 11 of the 13 Nassau grouper spawning sites. Regulations were enacted in 2003 and introduced year-round protection for the 11 sites and a four-month closed season at the national level except for the Maugre Caye and Northern Two Caye spawning aggregations at the Turneffe Atoll and Lighthouse Reef Atoll respectively. The regulations of 2009 established fishing minimum and maximum sizes and landing of whole. In 2014, all 13 Nassau grouper spawning aggregations were fully protected as the two sites where traditional fishers were given special fishing licences were closed as landings drastically decreased and the same fishers requested that the sites be fully protected.

Data for the Nassau grouper for 2014 -2018 shows that Sanbore, Lighthouse Reef Atoll, was stable with around 3000 - 4000 individuals and North East Point, Glovers Reef Atoll, declined from 1,442 individuals in 2014 to a low of 413 in 2017 and increased to 925 in 2018. All the other spawning aggregation sites had less than 1,000 individuals.

Marine turtles

Five of the seven existing marine turtle species are found in Belize; these are the green (*Chelonia mydas*), hawksbill, (*Eretmochelys imbricata*), and loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*). Current legislation protects all marine turtles but threats to marine turtles continue due to illegal fishing, loss of habitats caused by development activities, vessel collisions, strandings in gillnets, shark attacks, and climate change.

Results from monitoring of the nesting sites show that:

- The number of hawksbill turtle nests has maintained stable between 60-80.
- Loggerhead turtle nests are more predominant on northern Ambergris Caye and Lighthouse Reef Atoll while the hawksbill turtle nests are most abundant at Manatee Bar, Gales Point.
- Only hawksbill turtles have been reported to nest on West Snake Caye. Turtles may nest on other areas that were traditionally used but may not be reported so the data is not included in the national report.

Effectiveness of integrated coastal zone management

Integrated Coastal Zone Management (ICZM) is a process of governance consisting of the necessary legal and institutional frameworks to ensure that development and management plans are integrated with environmental goals and having the full participation of stakeholders. ICZM

maximises the benefits provided by the coastal zone and minimises the conflicts and harmful effects of activities on the environment and resources. In order to have sound ICZM, it is imperative to have research and monitoring to make decisions based on useful data. There is a need for the collection and analysis of data on the state of coastal resources and take mitigation actions to address environmental degradation.

In this section a review of several management topics on integrated coastal zone management are provided.

Governance and management

Governance

ICZM is guided by the recently published Belize Integrated Coastal Zone Management Plan which is holistic and covers in detail the following:

a) Full description of the coastal zone including the barrier reef and associated habitats.

b) Description of the resources for fisheries, tourism etc.

c) Coastal issues for national actions including urban expansion.

d) Implementation of the plan describing the various stakeholders and legislative authorities.

e) A vision for a sustainable coast including adaptation and mitigation for climate change.

The BICZMP presents the state of the coastal and marine resources and what would be the scenario with development based on informed decisions. According to the BICZMP, research is increasing but it is still ill-defined and not centralised, so it requires an integrated approach at the national level to get the desired data for decision making. The National Environmental Appraisal Committee, under the Department of the Environment and composed of various government and non-government organisations, is an important instrument used for monitoring and advising on coastal and marine development in Belize. However, development regulations is not fully enforced.

Examples of interinstitutional coordination to move forward towards the ICZM vision and objectives are:

Intergovernmental cooperation. Different Belizean governmental institutions have made efforts to collaborate in reaching the objectives established in the BICZMP: 1) focus management activities that are already being carried out ensuring that they are integrated and 2) highlight additional activities and actions that could be taken to help meet the challenge of ensuring a sustainable future. Also, the different government institutions or sectors are forced to 1) establish work agendas between two or more institutions and 2) solve problems related to the coastal zone.

Multisectoral cooperation. The creation and operation of the CMAI Advisory Council, which is a high-level group composed of different government institutions, non-governmental organizations

and private sector representatives, must address different issues related to the development and protection of the coastal zone, such as the preparation of policy projects, plans and programs related to the management of coastal areas.

Management

CZMAI has developed the regional coastal zone management guidelines (CZMG) for nine zones in order to support planned development and resource management along the coastline and in marine areas throughout the country. These guidelines are the best example of how planning processes are implemented through concrete actions.

Coastal area planning and development

The BICZMP and the *Coastal Zone Management Guidelines* establish the permitted and restricted uses for different areas representing a significant advance for the management of the coastal zone.

In the case of the tourism sector, through the *National Sustainable Tourism Master Plan 2030* and the *National Destination Physical Plan* (NSTMP-NDPP), it was proposed that the development of tourism activities be undertaken through physical planning for different scales to protect the natural and cultural heritage of potential impacts. This NSTMP-NDPP combination provides maps on development plans and recommendations and defines six categories of tourism development that can be carried out in the coastal zone. It also establishes that when there is an overlap of new developments with some natural heritage, it must be ensured that the impacts are compatible with the environment and that any of the effects can be evaluated and mitigated.

Per each one of the sections a qualitative assessment was conducted with inputs from key stakeholders and national experts. Also, recommendations are provided for the future.

The State of the Belize Coastal Zone Report 2014-2018

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Acronyms and abbreviations

ASC	Aquaculture Stewardship Council
BTB	Belize Tourism Board
BMMSN	Belize Marine Mammal Stranding Network
BWS	Belize Water Services
CMA	Clearwater Marine Aquarium
CSR	Corporate and Social Responsibility
CZMAct	Coastal Zone Management Act
CZMAI	Coastal Zone Management Authority and Institute
CZM-AC	Coastal Zone Management Advisory Committee
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EMS	Early Mortality Syndrome
GDP	Gross Domestic Product
GOB	Government of Belize
ICZM	Integrated Coastal Zone Management
IES	Invasive Exotic Species
IUU	Illegal, Unreported and Unregulated
MCCAP	Marine Conservation and Climate Adaptation Project
MPA	Marine Protected Areas
NCCPSAP	National Climate Change Policy Strategy and Action Plan
NPAS	National Protected Areas System
NEMO	National Emergency Management Organization
NGO´s	Non-Governmental Organizations
NSTMP	National Sustainable Tourism Master Plan
NMSB	National Meteorological Service of Belize
PACT	Protected Areas Conservation Trust
RMDPAC	Revised Master Development Plan for Ambergris Caye
SoME	State of the Marine Environment
SLR	Sea Level Rise
WTTC	World Tourism and Travel Council

Introduction

This document presents the State of the Belize Coastal Zone Report 2014 -2018. Belize is in the Western Caribbean located on the Caribbean coast of Central America and is bordered by Mexico on the north and Guatemala to the south and west. It is the only English-speaking country in Central America. The area of study for this report includes the marine as well the terrestrial environments defined by the Belize Integrated Coastal Management Plan (BCZMP) that is defined by the following boundaries (Figure 1):

Marine Boundaries: The area under the territorial sea of Belize (also the outer limits of the coastal zone) is the limit provided by law (Maritime Areas Act of 1992 and further defined by the Coastal Zone Management Act[1]) measured from the mean low water mark to 12 nautical miles outward in most places. In southern Belize from the Sarstoon River to Ranguana Caye, the outer limit is measured 3 nautical miles from the mean low water level to act as a compromise in consideration of Guatemala's proximity to Belize. Finally, in areas where there are fringing reefs, the outer limit is measured using the mean low water level on the fringing reef itself. Therefore, the three atolls (Turneffe, Lighthouse Reef and Glovers Reef) are included within the territorial waters of Belize. There are other specialized boundaries defined within territorial waters.

Terrestrial boundaries: Includes all features found within three kilometres westward from the mean high-water mark. The zone encompasses all coastal communities as well as the distribution of natural features and resources found in marine and coastal ecosystem where water levels (a) are influenced by tidal action, (b) are contiguous with sea-level, (c) have a saline influence, or (d) facilitate migration of fauna between fresh and saline water. This includes extensive riverine, estuary, and wetland systems of the coastal area.

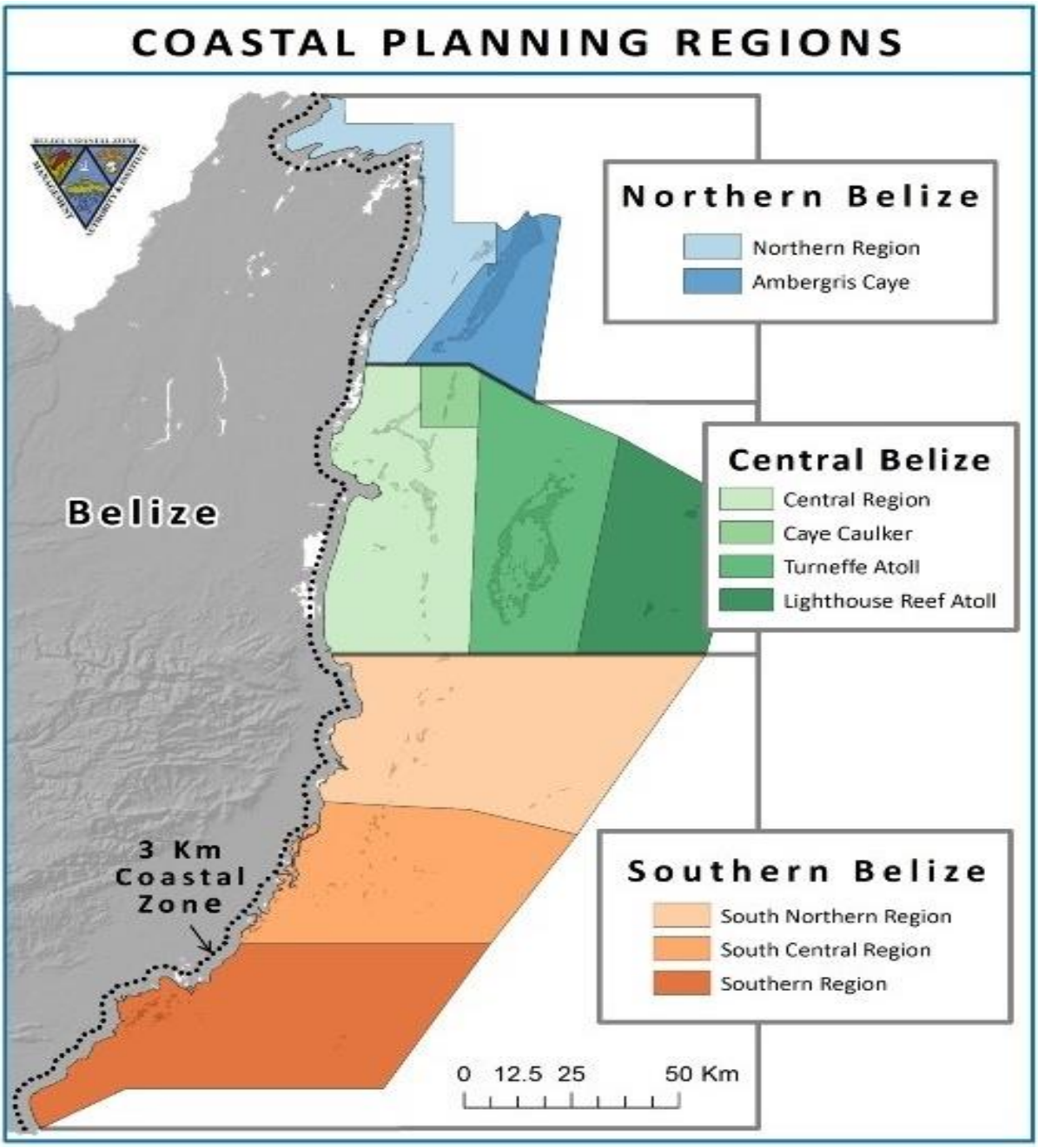
Context and challenges

This report follows the Coastal Zone Management Authority and Institute (CZMAI) commitment to inform the government and the people of Belize about the state of the coast as a way to create awareness on the relevance of the coastal zone for the survival and way of life in Belize.

The coastal zone is one of Belize's greatest assets. Its complex and dynamic marine ecosystems support innumerable ecological processes and a vast array of marine life and habitats. In addition to these important ecosystem functions, the coastal zone is vital to the Belizean way of life. The Belize Barrier Reef not only supports vibrant tourism, fishing industries, and livelihoods for communities but also shelters Belize's extensive coast from erosion and coastal damage caused by wave action. It has been estimated that the value of ecosystem services (fishing, tourism, shoreline protection) generated by the coral reefs and mangroves contributes between US$395–559 million per year that represents between 15% and 22% of GDP in Belize (Cooper, Burke, & Bood, 2008).

[1] Defined "*the area bounded by the shoreline up to the mean high-water mark on its landward side and by the outer limit of the territorial sea on its seaward side, including all coastal waters*" (Coastal Zone Management Act, Chapter 329, Laws of Belize, Revised Edition 2000).

Figure 1 Coastal Planning Regions



SOURCE BICZMP

Also, the coastal zone has essential social and cultural values to the Belizean people, especially to the approximately 40% of the population that reside on the coast and in offshore areas (Statistical Institute of Belize, 2010).

With the aim to improve management of coastal and marine ecosystems for the maintenance of ecosystem integrity and provision of ecosystem services into the future via an integrated approach, the CZMAI published in 2016 the Belize Integrated Coastal Zone Management Plan (CZMA 2016). This plan required years of preparation and involved extensive multi-stakeholder participation to ensure that its management measures were multisectoral. This State of the Belize Coastal Zone Report 2014-2018 pursues the goal to inform the Belizean society about the main trends in the Belize coast to be considered into any new coastal zone management plan.

The Approach for the state of the Belize Coastal zone Report 2014-2018 in comparison with the previous ones.

The first report was presented in 1995; the idea was to present a document which summarised the state of knowledge about the country's coastal resources and the threats posed to them by current usage and management efforts to address them (CZMAI, 2014). The second report was delivered in 2003, and covered the period of 1999-2002, with the goal "*to improve our population's understanding of the important contributions that the coastal zone makes to the environmental, economic, political, social and cultural fabric of the Nation of Belize and, perhaps more importantly, how human survival is linked to it*" (CZMAI, 2014). The third report was published in 2014 covering the 2003-2013 period and was the result of presentations made at a forum called the "State of the Coastal Zone Summit" held on June 7th, 2012 in which 26 papers, representing the work of at least 34 research scientists/investigators were included (CZMAI, 2014). The State of the Coastal Zone Report 2014-2018 is just a much-needed instrument to give a synoptic picture of the present and future development in the coastal zone, and a review of the coastal zone management actions under the ICZM Plan.

Objectives for this report

Different planning efforts have been undertaken in Belize towards Integrated Coastal Zone Management. Recently under an adaptative management approach, the ***Belize Integrated Coastal Zone Management Plan*** (CZMAI), 2016) was approved and published. The BICZMP provides a comprehensive value of the coastal zone, an in-depth review of the critical issues on the coastal zone and sets a future vision for the coast based on an informed management scenario. The BICZMP establishes a set of 26 strategic actions and finally, coordinates the implementation of those actions by a wide set of governmental and non-governmental organisations. Therefore, it is relevant to report on two complementary aspects: What changes in the coastal zone have happened since the last report? Moreover, how effective have the management actions included in the ICZM Plan been? This State of the Belize Coastal Zone Report 2014 – 2018 for Belize answers these questions. This Report encompasses statistics from 2014-2018 and uses an approach of the Pressures-State-Effectiveness evaluation system. Therefore, this report includes:

- Identification of pressures that may be affecting the coastal zone currently or which may affect the coastal zone in the future.
- An update on the management activities being carried out in Belize's coastal zone including all significant research and monitoring programs as well as the effectiveness of these

programs.

- Identification of the management roles of different institutions and agencies as it pertains to the coastal zone; and
- A qualitative and quantitative assessment of the state of the coastal zone and the effectiveness of ICZM.

The overall objective of this report is:

To increase the Belizean capacities for collaborative ICZM by reviewing the state of the coast and apprising the management activities that are being implemented.

Furthermore, its specific objectives are:

1. Provide expertise that will enable CZMAI to develop and present a new State of the Belize Coastal Zone Report for the years 2014 to 2018.
2. To promote integrated coastal zone management involving participation for both managers and stakeholders.
3. To provide an update on the status of significant aspects of the Belize coastal ecosystem.
4. To update on management activities that are being carried out on various aspects of ICZM across the country.
5. To define a list of indicators about the state of the coast suitable for the ICZM in Belize.
6. To gather data that is representative of the indicators of the state of the coast.
7. Compile data in an organised manner that is aligned with the framework of strategic objectives for the ICZM Plan.
8. Establish a collaboration between present updates to CZMAI and the Project Implementing Agency Group (PIAG) to allow for guidance during the process of compiling the report; and
9. Present data in a user-friendly manner.

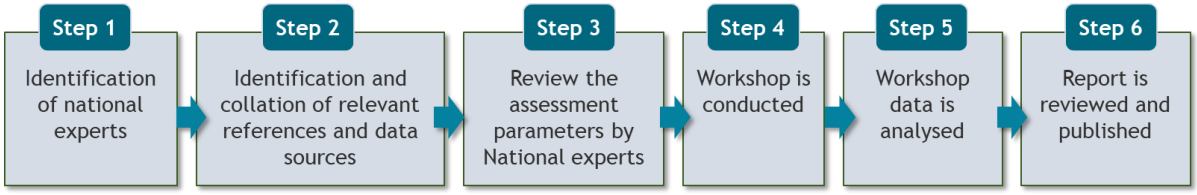
Methodology

This report was elaborated using the Pressure – State – Effectiveness model as it is described in the Annex 1 and with extensive inputs from a panel of experts on the Belizean coastal zone. The participation of the national experts was facilitated by using the modified Delphi method known as the State of the Marine Environment (SoME) methodology (GRID-Arendal, 2015). This is a procedure based on rapid expert elicitation process (a scientific consensus methodology) (Figure 2) that synthesizes existing assessments, data, and information in conjunction with the subjective judgment of experts across a broad base of evidence. The reasons to use this procedure include:

1. It has been successful worldwide tested to elaborate the Belize State of the Coastal Zone Report on countries with different context and background.
2. It is a cost and time effective to undertake integrated assessments in front of restrictions of sound information and time because it utilizes the existing knowledge of experts and it can incorporate non-conventional knowledge and information; and

3. Its participatory approach prevents to be overly influenced by information that is limited only to places or issues that are well studied since this might result in outcomes that are not balanced or properly represent conditions across the whole of a region.

Figure 2 Methodology used for the elaboration of the Belize State of the Coastal Zone Report 2014-2018



SOURCE: OWN ELABORATION BASED ON GRID-ARENDAL, 2015

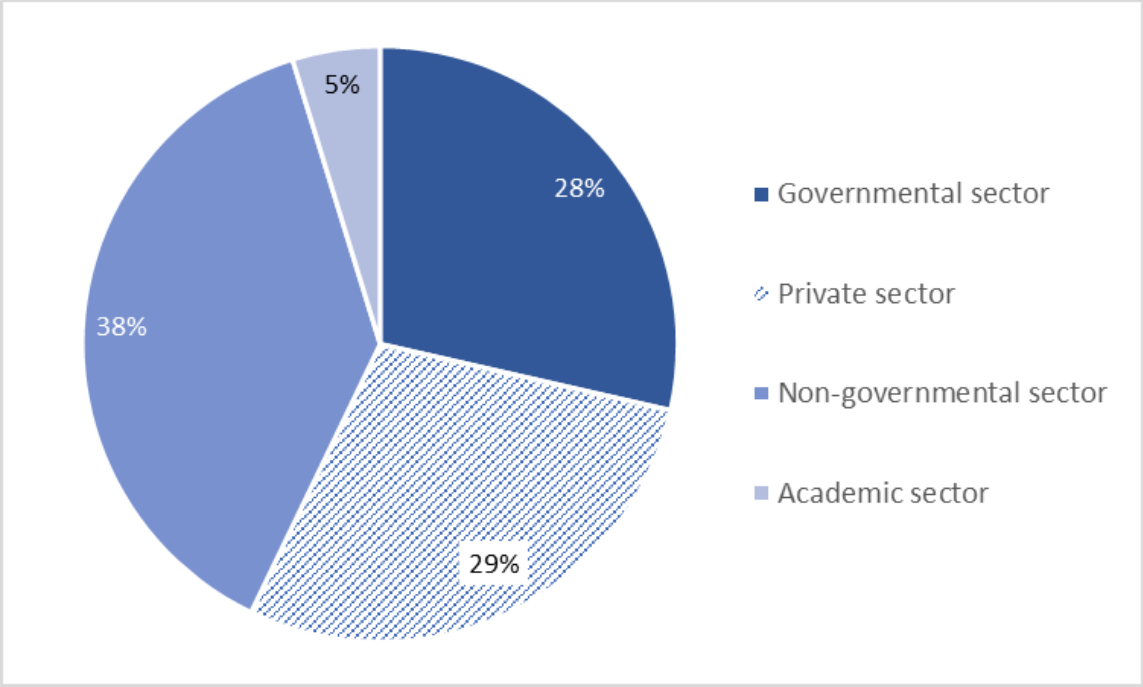
The specific steps followed to elaborate the State of the Belize Coastal Zone Report 2014-2018 were the following:

Step 1. Identification of national experts. More than 80 national experts were identified from the public, academic and non-governmental sectors and working groups. A database was elaborated with the contact information from those experts.

Step 2. Identification and collation of relevant references and data sources. More than 100 documents were reviewed and studied, including raw data as well reports and papers elaborated by national institutions and national experts. Based on that review the consultancy team elaborated a working document was used during the national workshop. The documents reviewed are presented in the References chapter

Step 3. Review the assessment parameters by national experts. Based on the topics and themes indicated in the terms of reference for this consultancy, we elaborate the model Pressures-State-Effectiveness evaluation system which is described in the Annex 1. With this model, an online survey was prepared, and key stakeholder were invited to answer it. The questionnaire was made available at https://drive.google.com/open?id=1L75vbGFFiZ-47szt2n7FZ0v5D0YNhfOo9ninaxhsqjY . Key stakeholders from the governmental, private, non-governmental, and academic sectors answered the questionnaire (Figure 3)

Figure 3 Stakeholders that answered the questionnaire by sectors



SOURCE: OWN ELABORATION

Step 4. A national workshop was conducted with the goal to review that online survey results and to build consensus on the state of the pressures, resources and responses as well on its trends. Th Annex 4 shows a summary of this workshop.

Step 5. Workshop data was analysed. The consultancy team compiled and analysed the data generated in the workshop and made the appropriate changes to the document and online survey results.

Step 6. Report was reviewed, revised, and published. A couple of iterations were conducted between the consultancy team and CZMAI to finalize this report.

Following the Pressures – State – Effectiveness model, this report is organized as follows. In chapter 1 we present the different pressures on the coastal zone. Then Chapter 2 describe the state of the ecosystems and flagship species. in Chapter 3, a description effectiveness of the integrated management zone and finally in chapter 4 an integration about how the previous conditions contribute towards the resilience of the Coastal Zone.

I. Management and Sustainable Use of the Coastal Zone

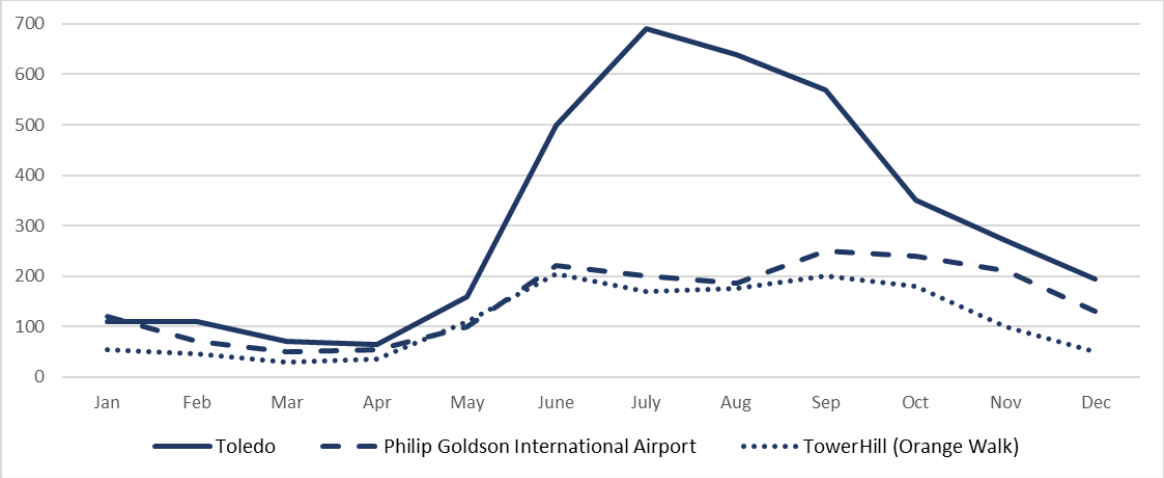
a. Climate, weather and climate change

i. Climate and weather

Belize's climate is characterized by a rainy season (from June to November) and a dry season (from December to May). It can be observed that the transition from dry to rainy season throughout the country is very pronounced (Figure 4) (National Meteorological Service of Belize, 2019).

The average annual rainfall in Belize varies from 60 inches (1524 mm) in the north to 160 inches (4064 mm) in the south. Rainfall can be variable from year to year in the southern regions (National Meteorological Service of Belize, 2019).

Figure 4 Monthly rainfall in three locations (Period 1979-2014)



NOTE: ONLY MONTHLY AVERAGE DATA TAKEN FROM NATIONAL METEOROLOGICAL SERVICE OF BELIZE

The main synoptic characteristics that produce rain are tropical waves, tropical storms, and hurricanes that move westward across the Caribbean from June to November. Tropical waves can be active or inactive systems whose maximum activity occurs during June and July. Tropical storms and hurricanes peak during September and October, although these phenomena vary in number each year (National Meteorological Service of Belize, 2019).

The transition from rainy to dry season is an abrupt process as a result of the incursion of frontal systems from November to May, with a dry-warm period from March to May when high-pressure systems in the Atlantic produce stable and windy south winds (National Meteorological Service of Belize, 2019).

The temperature in the country is more extreme in the high elevations, while the sea breeze moderates the temperature along the coast. The average temperature varies from 81 ° F (27 ° C)

along the coast to 69 ° F (21 ° C) in the highlands. The coldest month is January, while the highest temperatures are experienced during May (National Meteorological Service of Belize, 2019).

As it is shown in the Table 1 (maximum and minimum average annual temperatures of three different stations), the maximum average temperature variation in Belize (8.7 ° F or 4.8 ° C in between Mountain and coast stations) is due to the difference in height (National Meteorological Service of Belize, 2019).

Table 1 Maximum and minimum average annual temperature

Location	Station	Maximum average	Minimum average
Mountain	Cooma Cairn	77.5°F (25.3°C)	63.8°F (17.7°C)
Inland	Central Farm	88.3°F (31.3°C)	68.9°F (20.5°C)
Coast	Philip Goldson International Airport	86.2°F (30.1°C)	72.6°F (22.6°C)

SOURCE: NATIONAL METEOROLOGICAL SERVICE OF BELIZE

Although there are particular analyses of the temperature and annual precipitation in Belize, in a study conducted in the southern, central and northern regions of the Americas, extreme precipitation and temperature values were evaluated, which are a strong indicator of climate change (Aguilar, et al, 2005, page. 3). The results showed in general that the region is warming up, while precipitation did not show a significant increase (Aguilar et al., 2005, p.14). On the other hand, in the specific case of Belize, the temperature is increasing, and the precipitation decreases (Richardson, 2009, p. 17). However, it should be recognised that the magnitude of these predicted changes is not exactly known and, consequently, the process of estimating economic damages is subject to significant uncertainty (Richardson, 2009, p. 17).

ii. Change in intensity and duration of severe storms

An important concern about the consequences of climate change is the potential increase in tropical cyclone activity. Theoretical arguments and model studies indicate that tropical cyclonic winds should increase with rising ocean temperatures (Elsner et al., 2008, p. 92). On the other hand, several recent articles have documented global increases in the proportion of very intense cyclones and the reliability in the projections continues to increase, as the quality of the simulations is improved (Walsh, 2016, p. 81).

Belize is one of the countries of Central America that has been most affected by hurricanes. Since 1930, there have been 16 hurricanes, 8 of which were major hurricanes that touched land or passed close enough to cause damage or loss of life. Seventeen systems of less intensity touched land like tropical storms (Belize City Council, 2019).

The Natural Disaster Hotspots report, A Global Risk Analysis (Dilley, 2005), mentioned that some of the areas subject to hydrometeorological risks are found in Central America and western South America. Many of these areas are also densely populated and developed, leading to a high potential for victims and economic losses due to the possible interactions between different hazards such as

landslides and cyclone floods (Dilley. 2005, p.2). In the case of Belize, the country was in the group of 96 countries that present a relatively high mortality risk due to multiple risks (Dilley, 2005, p.9).

In an analysis conducted by Guinea-Barrientos et al. (2015, p. 86) it was mentioned that the records of the International Disaster Database (EM-DAT) show that 248 of 486 disasters recorded in Central America between 1990 and 2013 were disasters caused by rain events. The same database also reveals that in Belize and Honduras, natural disasters induced by rain represent more than 90% of the total number of victims, as well as more than 90% of the economic damage of all disasters recorded in the same period.

The importance that has been given to disasters caused by floods and landslides, as a result of rains caused by tropical cyclones, has forced the country to take actions to reduce the risk on the population, infrastructure and economic activities. An increase in the intensity of phenomena such as tropical cyclones would force gradual adjustments to the current strategies, considering models that allow knowing more precisely the intensity of the cyclones and their effects on the territory and the population.

Belize is extremely vulnerable to three major types of flooding hazards: river flooding (fluvial), surface water flooding from extreme rainfall (pluvial), and coastal flooding from storm surges. The probability of being impacted by these three types of flooding is high and can lead to the following scenarios:

Fluvial flooding: It is expected that in the next 10 years at least once there will be potentially damaging and deadly fluvial flooding.

Pluvial flooding: It is expected that in the next 5 years at least once there will be potentially damaging and deadly pluvial flooding.

Coastal flooding: It is expected that in the next 10 years at least once there will be heavy water surges that flood the coast.

The following table shows a summary of the hurricane and flooding events in Belize in the review period:

Table 2 Summary of main meteorological events that impacted the coastal zone in the review period

Date	Type of event	Main impacts	Main areas affected
August 4th 2016 (1)	Hurricane Earl	In total, 10,355 people (2,071 families) were affected	While it impacted the whole country, Belize City and Ladyville were the most affected areas.
October (15th through the 18th) 2015 (2)	Pluvial flooding	Loss of agricultural crops	Belize city, communities surrounding the Hondo, Mopan and Belize rivers
October (14th through the 17th) 2014 (3)	Pluvial flooding	Loss of agricultural crops	Communities in Toledo district

Sources: (1), (2), (3)

Several studies in Belize increase the understanding of the risk and potential impacts from the weather on the coastal zone. The Flood Hazard Mapping Report was released on May 2016 while the Advancing Disaster Risk Finance Report was prepared in order to provide recommendations towards a disaster risk finance strategy. The latter report estimated that "*On average, in the long term, the GoB would need to cover losses of approximately USD 29.5 million (BZ$ 59.0 million) annually—1.69 percent of Belize's gross domestic product (GDP)—to address its contingent liabilities related to hurricanes and floods."*

iii. The effect of climatic variability in coastal habitats

The actions that have been put in place to address the effects of the change in temperature variability, precipitation, intensity and frequency of phenomena such as hurricanes or tropical storms in the coastal zone have concentrated on assessing the economic impact, reducing the level of risk generated in the population and attention to disasters (see Adger et al., 2005).

On the other hand, climate change leads to changes in the earth's climate, which in turn has the potential to change the magnitude and frequency of coastal hazards (Mukhopadhyay et al., 2012, p.60). Considering the above, more emphasis should be placed to establish management actions that reduce the effects of coastal hazards on habitats and their processes, in order to maintain the environmental characteristics of the area, the flow of benefits derived from the use of the spaces for the development of activities and the use of coastal resources by society.

According to Mukhopadhyay et al. (2012, p. 58), coastal hazards are coastal erosion, storms (which includes winds, storm surge, sea-level rise and storm surge), tsunamis, coastal flooding and recently sea level rise. It is essential to add that the threats can occur in the coastal plains and coastal lagoons caused by heavy rains that generate floods, landslides, sediment flows and freshwater towards the coastal area. Additionally, there are effects caused by the increase in temperature in shallow waters near the coast and the water column.

In Belize, some impacts caused by coastal hazards have been briefly described by Neal et al. (2008) for the reefs (p. 25) the mangroves (p.27) and the seagrasses (p. 29). However, the impact received by other habitats such as the different types of coastal vegetation, sandy beaches, sand bars, coastal dunes, coastal lagoons and benthos in shallow areas, should also be studied in terms of the magnitude of the damage and recovery capacity.

The effect of climate variability, associated with the environmental impacts generated by productive activities along the coastal zone, jeopardises the permanence of different habitats and their environmental services mainly due to the cumulative effect of the impacts.

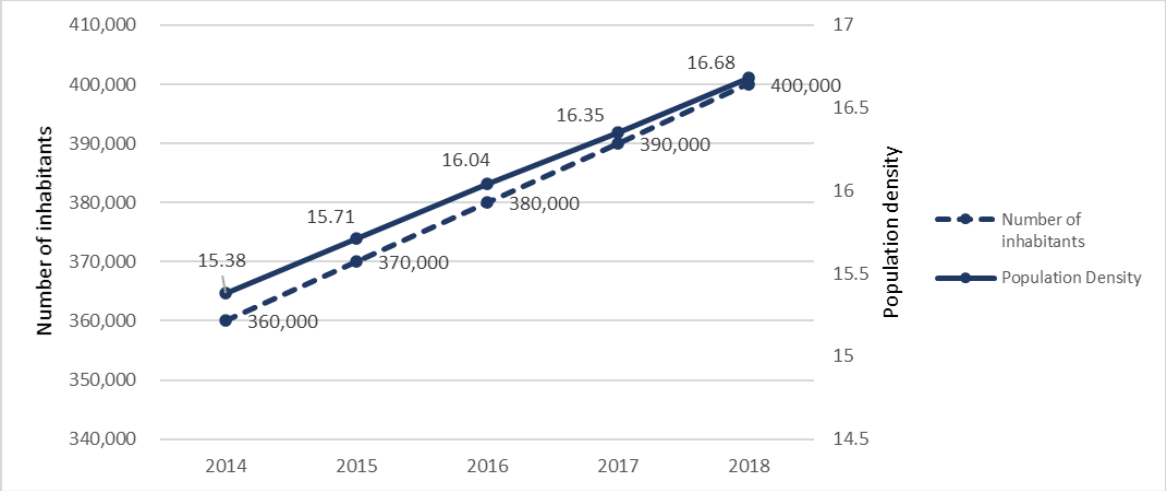
The recovery time that each habitat needs to restore to its natural condition after being impacted will depend on the extent of the damage to the habitat, the magnitude of the damage, the presence of other impacts that affect the habitat and the management measures taken to favour habitat recovery. These elements should be considered as part of the different programs that are

contemplated to preserve the natural capital of the coastal zone and gradually increase the chances of recovery in those areas where there are major effects on habitats.

b. Population growth and urban development

The population in Belize was estimated at 358,899 in 2014 to 398,050 in 2018 based on the 2010 population census of 324,500 (Figure 5). With an area of 8,867 square miles, it had a density of seventeen people per square mile in 2018 (Figure 5). This is the lowest in Latin America and 178th globally (www.worldpopulationreview.com).

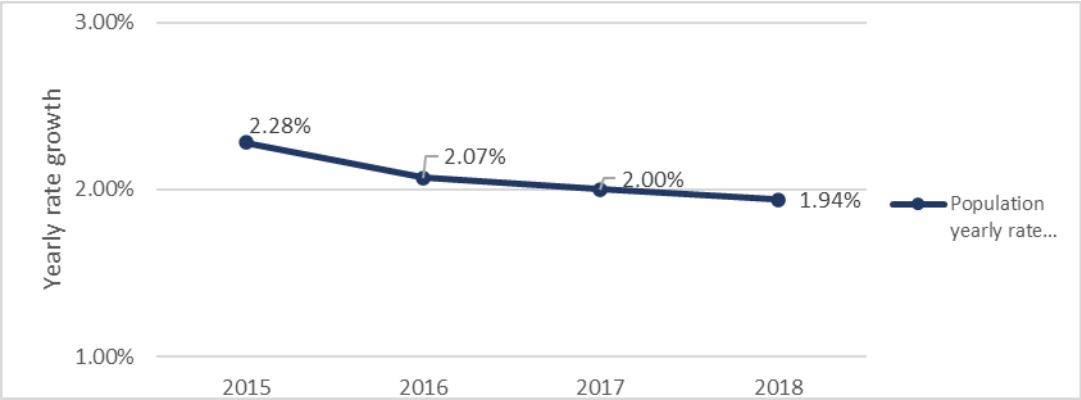
Figure 5 Belize overall population and densities 2014 -2018



i. Population growth rate

Belize has a population growth rate of 1.94% in 2018 down from 2.28% in 2014 (Figure 6).

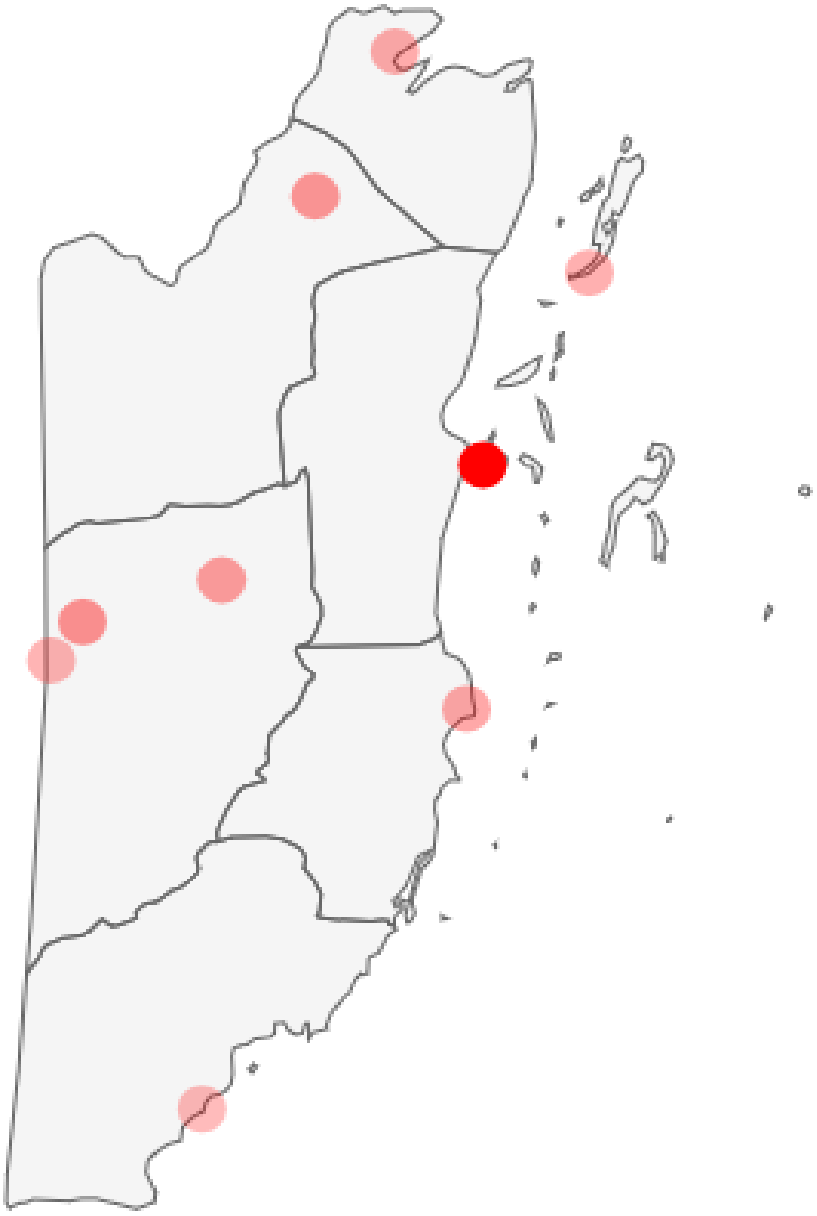
Figure 6 Belize Population Growth Rate 2014 - 2018



ii. Distribution of the population

Figure 7 shows the distribution of the main population areas. Only five are shown along the coastal zone. However, there are more settlements along the coast. Belize City has the largest number of inhabitants.

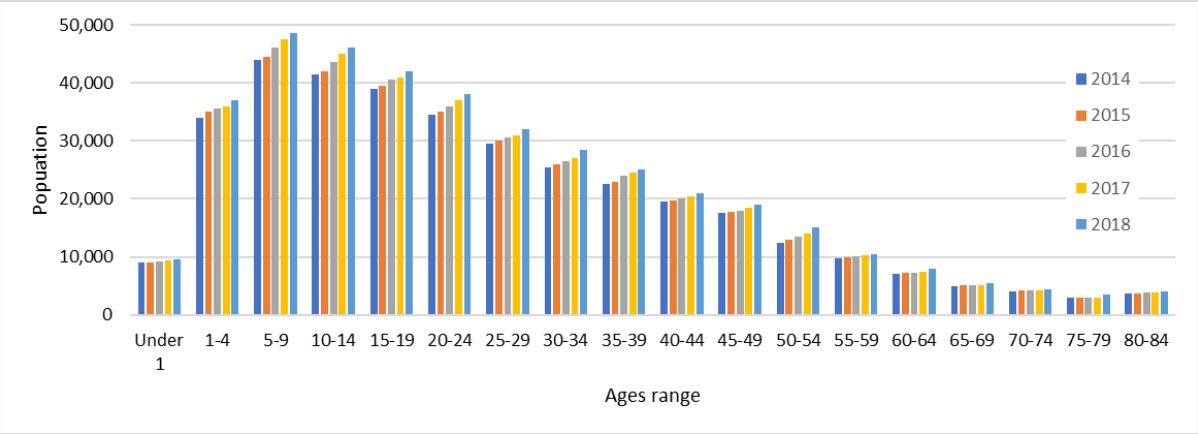
Figure 7 Belize Population Distribution 2018



iii. Age structure

Figure 8 shows the age structure for 2014 – 2018. It can be deducted that Belize has a young population (under 1 to 49 years of age).

Figure 8 Belize Age Structure (2014-2018)



SOURCE: SIB 2018

Table 3 shows that there is a slightly growing percentage of females as compared to males from 2014 to 2018.

Table 3 Growing percentage of females as compared to males from 2014 to 2018 in Belize

Year	Population	% Male	% Female	Density (Km2)	Population Rank	Growth Rate
2018	383,071	49.81%	50.19%	16.68	178	1.94%
2017	375,769	49.84%	50.16%	16.36	179	2.00%
2016	368,400	49.88%	50.12%	16.04	179	2.07%
2015	360,933	49.91%	50.09%	15.72	179	2.28%
2014	35,8899	49.94	50.06%	15.38	179	2.21

SOURCE: WORLDPOPULATIONREVIEW.COM

iv. Main urban cities along of the coast

The urban populations along the coastal zone are Corozal Town, Copper Bank Village, Chunox Village, Sarteneja Village, San Pedro Town, Caye Caulker Village, Belize City, Hopkins Village, Dangriga Town, St. Bights Village, Rivers Dale, Placencia Village, Monkey River Village and Punta Gorda Town.

v. Size of the cities (number of inhabitants)

The number of inhabitants in Belize are shown in Table 4. The numbers shaded in blue are settlements within the coastal zone.

Table 4 Inhabitants in Belize settlements along the coastal zone in 2018

Settlement	Population	Percentage of the total Belize´s population
Belize City	63,423	16%
Dangriga	10,217	3%
Corozal	46,471	12%
San Pedro	19,477	5%
Punta Gorda	6,027	2%
Total Population in the coast	**145,615**	**37%**
Total population in the country	**398,050**	

Source: SIB 2018

vi. Impacts on coastal zone

As the population grows in Belize there is the need for settlement expansion. For the Coastal zone, the expansion involves clearing of littoral or mangrove forests. Clearing of mangroves for settlement expansion is accompanied by dredging to fill in and construct solid land. Expansion areas need the development of streets and roads, electricity and water supply as well as sewage systems. Only Belize City and San Pedro Town core areas have centralized sewage systems. However, these are only primary treatment systems which involve **sedimentation of solid waste within the water.** The effluents are discharged directly into the sea or surrounding mangrove areas.

Access to new development along the coast also leads to destruction or loss of habitat (Figure 9 A). For instance, sea turtle nests are constantly being destroyed by vehicular traffic in northern Ambergris Caye, Belize. Marine dredging to fill in swamp areas removes sand sediments from the seabed (Figure 9 B). The dredged areas leave large holes in the seabed that eventually will be refilled by sediments from the shoreline by wave actions and currents.

Figure 9 Impacts on coastal zone due to settlement expansions

A. Turtle Eggs in an area used as a road

B. Marine sand from dredging used to fill swamp lands

c. Coastal development and land use

i. Infrastructure along of the coast (urban, industrial, tourism)

Infrastructure development along the coast continues to occur for urban, industrial and tourism development. However, the development is concentrated in pockets along the cayes and coastline. Tourism has outpaced the rest of the economy in terms of growth in Belize's development and is concentrated in San Pedro Town, Ambergris Caye and Caye Caulker in the north, and Placencia in the south. Some development is occurring in other areas along the mainland coast such as the Corozal Bay, Corozal District, and Hopkins Village, Stann Creek District. These developments are for infrastructure to cater for overnight tourist as compared to the cruise ship tourists who just spend hours in the country.

Wherever there is infrastructural development for the tourism industry, there is urban expansion to accommodate living quarters for the direct workforce as well the indirect workforce related with tourism.

ii. Coastal infrastructure (ports, piers, defence structure)

Ports

There are two types of ports (municipal and international) in Belize. The municipal ports cater for the transporting of goods and materials at the national level. The international ports handle the commercial imports and exports. Various international ports are used exclusively for processing the arrival and departure of tourists and visitors to the country (Table 5).

Table 5 Pier types and locations

Location	Port Type	Description
San Pedro Town	Municipal International	Primarily used for transporting goods and construction materials from Belize City. Sand Pedro Terminal - departure and arrival of passengers.
Caye Caulker	Municipal	Used for transporting goods and construction materials from Belize City.
Belize City	International	Port of Belize – is the largest port in Belize where most of the commercial imports and exports are processed.
Belize City	International	Fort Street Tourism Village – catering to cruise ship tourist arrivals. Cruise ships anchor in front of Belize City where the tourists are shuttled from the vessels to the terminal by tenders.
Belize City	International	PUMA Port – used exclusively for offloading fuel.
Stann Creek	International	Harvest Caye Port – exclusively for the Royal Caribbean Cruise Line to cater for its tourists.
Stann Creek	International	Port of Big Creek - is primarily used for banana and oil exports. Other products that pass through the port includes shrimp, fertilizer, citrus pellets, and of recently sugar.
Stann Creek	International	Commerce Bight Port – used for citrus exports; however, it is presently closed.

The **Belize Port Authority** is responsible for designating a port, training marine pilots, assisting in becoming shipping agents, permitting water taxis, providing maritime security at ports, assisting boat builders in building safe vessels, responsible for port of call entries, aiding in navigation by providing and maintaining lighthouses and lighted navigational buoys, assisting the evacuation of residents from the cayes in the threat of direct hits by hurricanes, registration and permitting national vessels for navigation and permitting the erection of over the water structures. These structures include buoys and markers so that they do not endanger navigation. The Belize Port Authority works closely with the Physical Planning Unit in permitting the erection of piers.

Piers

Piers in Belize are part of the tourism infrastructure. Almost every business along the coastline would like to have its own pier to house dive shops, bars, restaurants or to embark and disembark its tourists. The pier regulations state that piers should be constructed 1,000 feet apart. This piece of legislation is not followed and a result there is a congestion of piers especially in San Pedro Town, Ambergris Caye, Belize (see Figure 10).

Figure 10 Piers erected less than 1,000 feet apart

Defence Structure

Beach and coastal erosion lead to the loss of land. Once a development erects defence structures such as walls and breakwaters, the adjacent beaches will rapidly erode because these structures change the wave and littoral current dynamics along the beach. As a result, there is the urgent need to either protect or reclaim beach front properties. The erection of defence structures in itself is destructive as seagrass beds are lost in reclamation (see Figure 11) and involves dredging.

Figure 11 Erection of defence structure to reclaim land and stop erosion

The Physical Planning Unit, under the Ministry of Natural Resources, functions as the Secretariat of the Land Utilization Authority, with the primary function to offer recommendations on the subdivision of lands. It also has responsibility over the management of the seabed. The Unit accepts and reviews applications for land subdivision; prepares proposed subdivision plans for Government projects; coordinate the development and execution of the National Land Use Policy and accepts and reviews all applications for pier licenses. The Physical Planning Unit works closely with the local governments and other permitting agencies in approving coastal and inland developments. The Department of the Environment is the permitting agency for any development project or activity that may have impact on the environment. Depending on the scope and type of development, an environmental impact assessment (EIA) may be needed. The National Environmental Appraisal Committee, under the Department of Environment, is composed of government and non-governmental organization and makes recommendations in the EIA process.

iii. Main issues between coastal development and traditional land uses along of the coast

The main issues between coastal development and traditional land uses along the coast is the size of the developments especially in the tourism and agricultural industries. In order to erect the necessary infrastructure or plant monocultures, there is the need to clear the land from its existent vegetation, either being littoral or mangrove forests. Clearing of mangroves exposes the coastal land to erosion due to wave action and sea level rise. Clearing of littoral forests is alarming as these areas are found only along the coastal areas in patches. The mangroves and littoral forests are habitats,

refuge, nursery and feeding areas for fauna especially bird species. These habitats also serve as biological corridors. Figure 12 shows clearing of littoral and mangrove forests from the shoreline to the inland lagoon for a large tourism development.

Figure 12 Clearing of all vegetation from the sea to the back lagoon

Clearing within the three kilometres of the shoreline for agricultural monocultures mainly citrus and bananas continues in southern Belize especially the Stann Creek District, Belize (Figure 13). Freshwater that empties from the rivers is diverted for irrigation. As a result, the sediment loading has drastically declined to the point that certain beaches are not replenished leading to catastrophic erosion and loss of properties (Figure 14).

Figure 13 Clearing for agriculture within the 3 miles of the coastal zone

Figure 14 Catastrophic beach erosion in Monkey River

PHOTO COURTESY: DR. ARLENE ROGERS

Urban development in the coastal zone, especially in the Cayes, requires the cutting of mangrove forest and filling the swamps to create solid land. However, since filling materials (sand and rocks) are scarce and expensive, the areas are filled with sargassum and all types of garbage. If not immediately covered with sand, the biological materials start to decompose releasing sulphide

gases and reducing the dissolved oxygen levels in the surrounding waters (Figure 15). Properly addressed, land reclamation is solid and aesthetic (Figure 16).

Figure 15 Filling with sargassum and other plant materials

Figure 16 Proper landfill of mangrove swamps with stones and sand

Garbage

Studies conducted in 2011, show that the average solid wate from San Ignacio, Belize City, San Pedro and Caye Caulker varies between 0.99 and 1.24 kilograms per capita. Considering a kilogram per person and a population of 145,615 inhabitants (Figure 5) in the coastal zone, there is a challenge to collect and dispose 53,149 tons a year of solid waste generated in the coastal zone. With the increase in population, tourism and the catering workforce, there is an increase in the production

of garbage in Belize. San Pedro Town and Caye Caulker Village had local dump sites where the garbage was incinerated. However, in 2015 the garbage in these municipalities started to be collected and transferred to the Regional Sanitary Landfill on the George Price Highway. The garbage from Belize City, San Ignacio and Burrel Boom is also transferred to the regional landfill, while the northern (Corozal and Orange Walk districts) and southern (Stann Creek and Toledo districts) regions dispose their municipal solid waste in open dumps with little or no environmental and health safety control. As a consequence of the lack of comprehensive waste management, several concerns arose in regards to the inadequately disposed waste being moved by runoff water during high rainfall events ultimately ending up in the recreational waters of Placencia and in the coastline of Punta Gorda (The National Sustainable Tourism Master Plan).

The Belize Solid Waste Management Authority is responsible for providing technical assistance to the municipalities on solid waste management and conduct public awareness, education and participation on waste treatment.

Sewerage and Grey Water

With the increase in population and tourism there is also an increase in the production of sewerage. The Belize Water Services operates and maintains the sewerage systems in these municipalities. Unfortunately, only San Pedro Town and Belize have sewerage treatment in the coastal zone. In both of these municipalities, the centralized sewerage systems do not cover the urban expansions after they were originally installed. The sewerage treatment is primary using conventional gravity sewers. In Belize City, the effluents are discharged in the Caribbean Sea while in San Pedro in the surrounding areas. The private homes and hotels that are not connected to the sewerage systems have their own septic systems, secondary or tertiary treatment plants. The effluents are discharged in the lagoons. The impacts of the nutrients from these sewerage systems on the Belizean environment is unknown. However, information from similar situations in the Florida Cayes, USA, shows that nutrient and chemical loading in the marine environment is detrimental to the coral reef systems.

d. Tourism & Recreation

Belize is experiencing an increase in tourist arrivals guided by the adopted *National Sustainable Tourism Master Plan 2030 (NSTMP).* This plan is targeted to triple the amount of overnight tourist arrivals, while extending their stay, duplicate the number of hotel rooms (from 6.8 thousand in 2010 to 13.7 thousand by 2030) and increase the annual economic contribution by five. From the seven tourism destinations defined by the NSTMP, five are located in the coastal zone and have the largest portion of the tourism infrastructure (Figure 17). For these destinations, the NSTMP assigns the priorities shown in the Table 6. According with the NSTMP, *tourism development plans* were elaborated in 2016 for three coastal emerging destinations (Toledo, Corozal, and Caye Caulker).

Figure 17 Location of the tourism infrastructure in Belize

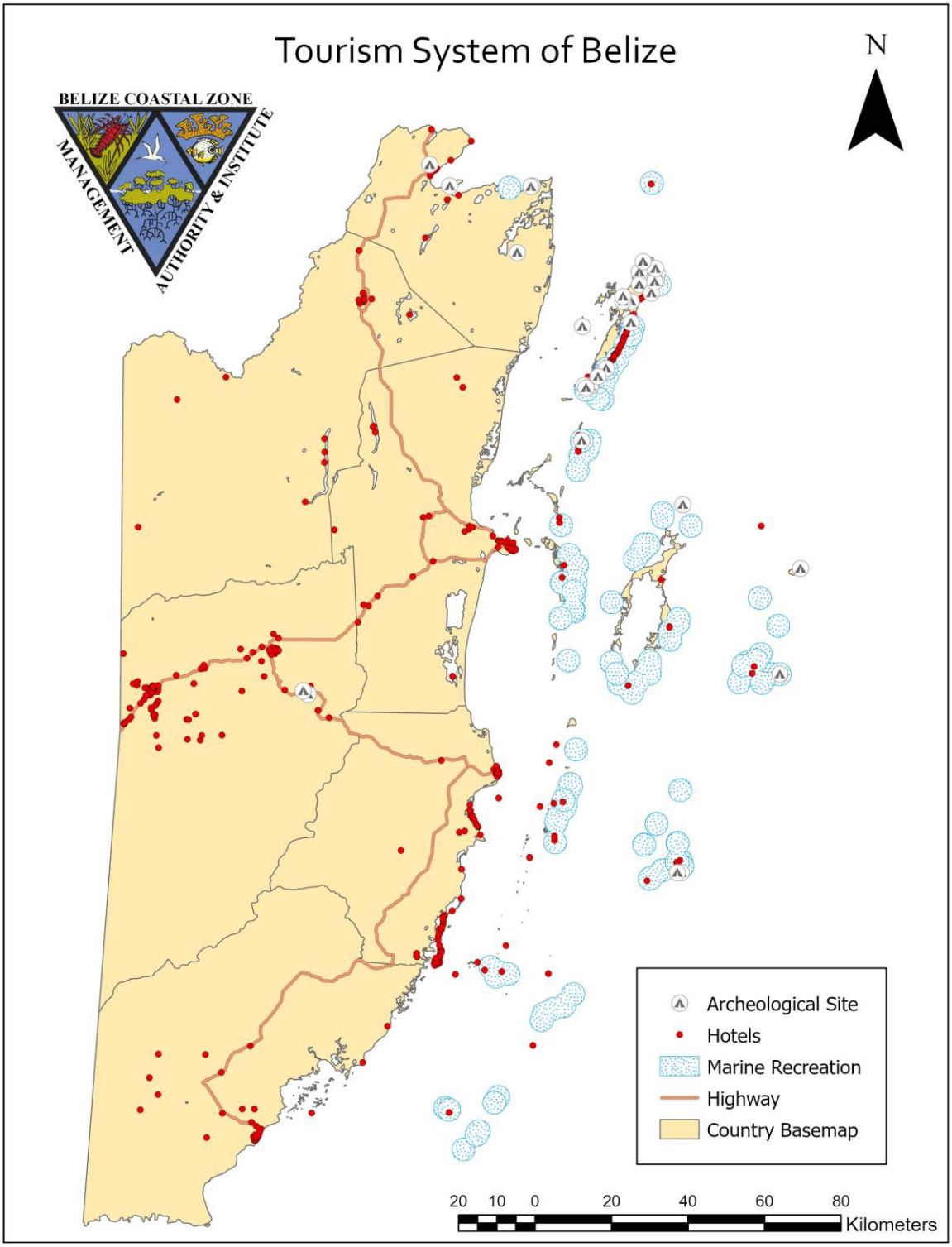


Table 6 Tourism development priorities for the Belize tourism destinations on the coast

STMP destination	Priorities
Central Coast Belize	Urban renovation
Northern Islands	Constrain development and consolidate
South eastern coast	Constrain development and consolidate / New development
Southern Belize	Constrain development and consolidate
Reef barrier	Constrain development and consolidate

In the period of analysis, Tourism was the fastest growing industry in Belize as a result of increasing local, regional and global markets. Belize is experiencing an increasing demand for services from a growing number of international travellers in two categories: tourist (overnight travellers) and excursionist (travellers that visit the country but not stay overnight). In the tourist category, between 2014 and 2018, the number of international tourists that visited the country grew an average of 10.75 % a year (with the lowest growth rate of 6.21 % in 2015 and the highest rate of 14.56 % in 2018). This was a high yearly increase considering that Belize' neighbours growth rates were under 10 % per year (8.01 % and 9.01 % in average in the case of Guatemala and Quintana Roo, Mexico for the same period) (Table 7). This growing trend puts Belize as the second largest growth in all the Caribbean in 2018 (Belize Tourism Board, 2019). Most of these tourists came to Belize for leisure purpose (Figure 18)[2]. The tourists required lodging facilities as well recreational services. In the first category, most of the tourist used some of the following lodging facilities: (1) Hotel/resort used by 60.9 % of the tourists, (2) Guest-house used in average by 24.2 % of the tourists, (3) Rented house/Apartment used in average by 10.2 % of the tourists and (4) House of friends-relatives used in average by 12.6 % of the tourists (Belize Tourism Board, 2019).

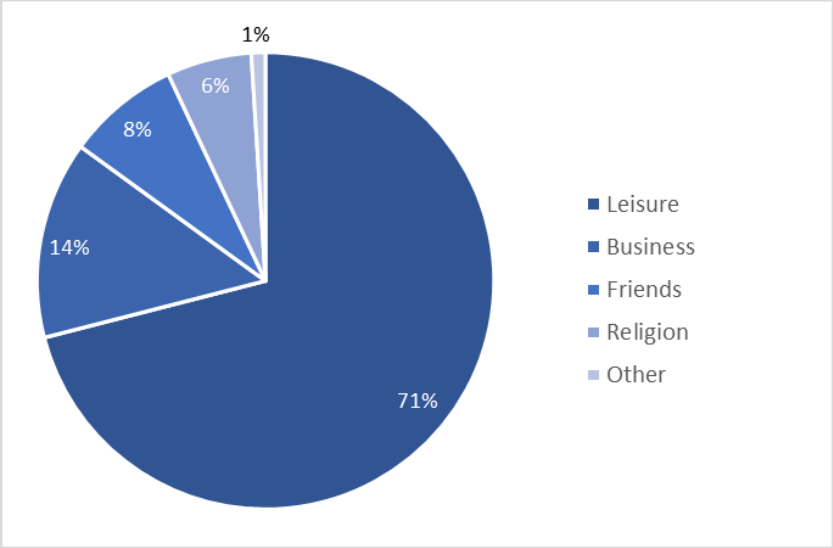
Table 7 Overnight tourist in Belize, Guatemala and Quintana Roo, Mexico 2012-2018

	Belize (a)		Guatemala (b)		Mexico (Quintana Roo)(c)	
Year	Tourist (Thousand)	Difererence	Tourist (Thousand)	Difererence	Tourist (Millions)	Difererence
2012	277,135		1,188,906		9.416	
2013	294,177	6.15%	1,213,100	2.03%	10.869	15%
2014	321,220	9.19%	1,359,855	12.10%	12.257	13%
2015	341,161	6.21%	1,473,458	8.35%	13.265	8%
2016	385,583	13.02%	1,584,727	7.55%	15.205	15%
2017	427,076	10.76%	1,659,597	4.72%	15.926	5%
2018	489,261	14.56%	1,780,775	7.30%	16.675	5%

SOURCE: (A) (BELIZE TOURISM BOARD, 2019), (B) (TURISMO, 2018), (SECRETARÍA DE TURISMO, 2019)

[2] There are small differences due the origin of the tourist. As the Tourism Digest 2018 indicates, most of the Caribbean tourist visited Belize for business purposes, while mostly of the Central America travellers came to Belize to visit friends or relatives (Belize Tourism Board, 2019).

Figure 18 Purpose of visit



SOURCE: OWN ELABORATION WITH DATA FROM *TABLE 2.8 PURPOSE OF VISIT BY COUNTRY/REGION OF ORIGIN.* (BELIZE TOURISM BOARD, 2019)

In regard to recreational activities, less than 10 % of the tourist did not participate in any activity while visiting Belize. The rest of visitors participated in some of the 13 outdoor activities such as diving, fishing, kayaking, birding, caving that are shown in the Table 8. The coastal zone activities were the most popular sites for visitors (Table 8).

Table 8 Participation in activities by country region of origin

2018	USA	CANADA	EUROPE	CARIBBEAN	CENTRAL AMERICA	OTHER	TOTAL
DIVING	18.1%	18.7%	20.3%	20.0%	20.0%	20.1%	18.7%
SNORKELING	69.8%	74.9%	76.2%	46.7%	35.6%	61.3%	70.4%
ISLAND TOUR	27.5%	25.9%	28.9%	53.3%	22.2%	24.4%	27.5%
CAVING	31.9%	33.7%	24.0%	26.7%	8.9%	19.7%	29.8%
BIRDING	7.4%	7.8%	7.5%	0.0%	4.4%	1.8%	7.0%
GAMING	1.2%	1.9%	1.1%	0.0%	11.1%	2.5%	1.4%
OTHER	12.7%	9.6%	6.1%	13.3%	6.7%	6.5%	11.0%
FISHING	21.6%	14.2%	6.1%	0.0%	4.4%	5.7%	17.3%
SAILING	12.2%	15.0%	11.0%	6.7%	4.4%	10.0%	12.0%
CANOE/KAYAKING	20.6%	23.0%	16.3%	0.0%	4.4%	8.6%	19.1%
JUNGLE TREKKING	29.9%	29.1%	22.8%	20.0%	2.2%	12.5%	27.4%
CULTURAL EVENT	13.4%	12.6%	11.5%	13.3%	4.4%	7.5%	12.6%
NONE	6.3%	7.2%	6.7%	20.0%	33.3%	16.1%	7.3%
DK/NS	0.5%	1.1%	1.1%	0.0%	4.4%	1.8%	0.7%

SOURCE: TABLE 2.19 (BELIZE TOURISM BOARD, 2019)

Table 9 Places of interest visited by country/region of origin

2018	USA	CANADA	EUROPE	CARIBBEAN	CENTRAL AMERICA	OTHER	TOTAL
OFFSHORE ISLANDS	49.40%	43.60%	33.70%	73.30%	11.10%	29.00%	45.00%
BARRIER REEF	57.30%	61.50%	64.10%	33.30%	13.30%	49.80%	57.80%
BLUE HOLE	7.60%	9.40%	12.60%	20.00%	11.10%	14.00%	9.00%
ARCHAEOLOGICAL SITES	41.30%	43.60%	36.20%	26.70%	13.30%	24.00%	39.30%
OTHER	3.00%	3.20%	1.60%	6.70%	4.40%	2.50%	2.80%
MARINE PROTECTED AREAS	46.20%	51.30%	50.30%	13.30%	28.90%	39.80%	46.60%
NATIONAL PARK / RESERVE	46.00%	40.90%	33.70%	26.70%	15.60%	19.40%	41.70%
MUSEUM /HISTORICAL SITE	18.30%	19.30%	15.20%	6.70%	4.40%	10.00%	17.20%
NONE	9.50%	10.40%	8.80%	26.70%	44.40%	18.60%	10.40%
DK/NS	0.70%	1.90%	3.00%	0.00%	4.40%	2.90%	1.30%

Source: (Belize Tourism Board, 2019)

As per list of places shown in the table above, it is clear that a great portion of tourists in Belize use the coastal zone during their stay in the country. That explain why from the perspective of supply and demand, a great portion of the tourism infrastructure is located into the coastal zone (Figure 17).

Main resorts along of the coast

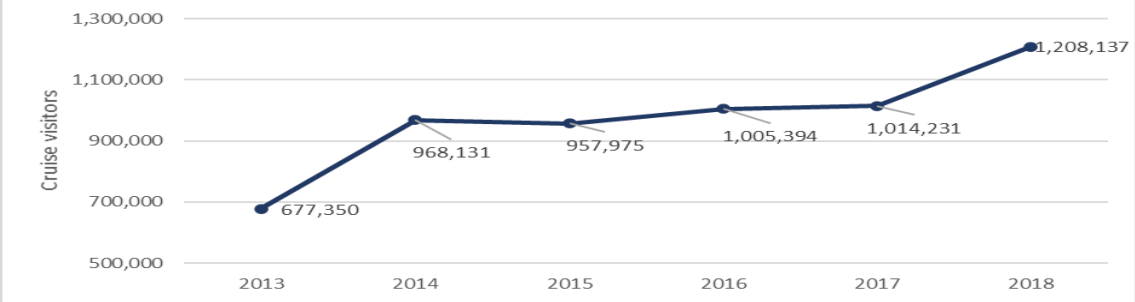
As shown in the Table 10, between 2014-2018, the number of hotels increased by 9.69% and most of the increase was located in the coastal zone. In contrast, the number of hotel rooms available grew in the same period by 14.54% which indicates that the new hotels are bigger in comparison with the previous ones as measured by the average number of rooms per hotel. In addition to overnight tourists, Belize received an increasing number of visitors that arrived by cruise ship (Figure 19). In 2018, 56% of the 1,208,137 passengers disembarked in Belize and from those, 66 % participated in inland activities. The top 11 tours preferred by passengers were: visit to Mayan temples, cave tubing, city tour, snorkelling, other wildlife watching, swimming, airboat ride, horseback riding, kayaking and museum visit (Belize Tourism Board, 2019).

Table 10 Number of hotels and rooms by area

Location	2013		2014		2015		2016		2017		2018	
	Hotels	Rooms	Hotels	Rooms	Hotels	Rooms	Hotels	Rooms	Hotels	Rooms	Hotels	Rooms
Belize District	58	1,107	57	931	58	930	62	917	62	933	60	925
Caye Caulker	90	680	105	713	108	726	118	851	125	882	127	909
Cayo	118	1,107	122	1,143	125	1,174	139	1,256	137	1,275	144	1,333
Corozal	34	334	33	368	33	371	29	346	30	371	31	363
Orange Walk	20	258	23	289	23	291	21	264	22	287	21	268
Placencia	121	764	135	764	156	842	155	961	153	993	161	994
Ambergirs Caye	163	1,841	166	1,833	172	1,898	170	2,231	169	2,086	172	2,253
Stann Creek	69	562	81	608	91	649	92	685	86	645	89	669
Toledo	39	324	40	323	40	323	36	291	38	327	36	312
Other Islands	45	400	43	392	44	415	39	410	34	378	42	409
TOTAL	**757**	**7,377**	**805**	**7,364**	**850**	**7,619**	**861**	**8,212**	**856**	**8,177**	**883**	**8,435**

SOURCE: (BELIZE TOURISM BOARD, 2019)

Figure 19 Cruise visitors are Belize in 2014-2018



SOURCE: (BELIZE TOURISM BOARD, 2019)

Economic benefits of the tourism and recreation activities

Despite the tourism industry still being an emerging sector, it is the economic base for Belize. According with the data from the Central Bank of Belize, while the national economy in the period 2014-2018 grew at an average of 1.9% per year (Table 11), the tourism inflows growths were an average of 3.6 % for the same period. By 2017, the tourism inflows represented 10.45 % of the national gross domestic product (GDP). Since Belize does not have a tourism satellite account, the total tourism contribution to the economy is unknown. The World Travel and Tourism Council (WTTC) estimated that the direct tourism contribution rose to 14.5 % of the GDP in 2014 and when the indirect and induced effects were included, it was around 41 %. WTTC also estimated that this contribution will increase in the years to come at an average rate of 4.5 % until reaches 19.0% of the GDP by 2028 (World Tourism and Travel Council, 2019).

Table 11 Tourism contribution to the economy

Economic indicator	Year					
	2013	2014	2015	2016	2017	2018
GDP (US $ Mn)	3,225.10	3,407.90	3,557.10	3,640.30	3,727.70	N.D
Tourism (inflows) US $ Mn	299	351	373.8	371.3	390.4	N.D
Tourism contribution to the GDP	9.27%	10.30%	10.51%	10.20%	10.47%	N.D
Real GDP increase (in %)	0.7	4	3.8	-0.5	1.2	N.D
Increase on inflows from Hotels and restaurant sector (in %)	8.6	9.9	-3.3	-0.9	3.5	12.9

SOURCE: CENTRAL BANK OF BELIZE

In addition, the tourism investment (measured as the capital investment in tourism infrastructure) has been estimated to grow from $187.5 Million BZ Dollars in the 2014 to $287.4 Million BZ Dollars in 2018, which represented around the 28 % and 25.9 % of the total national investment respectively (World Tourism and Travel Council, 2019).

Another economic indicator is employment related to the tourism industry. In 2018, tourism provided 20,680 jobs which represented 13.3% of the employed persons in the country or approximately 1 in every 8 persons employed in Belize works in the tourism industry (Belize Tourism Board, 2019). Also, as tourism expands, employment will increase in the sector. It has been forecasted that it will reach 31,000 jobs (around the 14.1 % of total employment) by 2028 (World Tourism and Travel Council, 2019).

An economic study on tourism in Belize published in 2017 by the Inter-American Development Bank, found that at the macroeconomic level "the increase in government tourism-related investment had, in the medium-long term, a positive impact on tourism. On the hand, the inflow of foreign resources slowed non-tourism (goods and services) export growth and increased import growth, both of which were influenced by an appreciation of regional real time exchange rate. In turn, the expansion of tourism demand tends to expand domestic consumption more rapidly than it expands GDP, also causing deterioration in the non-tourism trade balance. In other words, the increase in "tourism exports" also generates an appreciation of the real exchange rate that hurts the other tradable sectors (mainly goods)" (Cicowiez, Banerjee, & Morris, 2017).

At the sectoral level, the study found that in a scenario of growing tourist numbers, the services related industries catering directly to tourists, including hotels and restaurants, were strongly stimulated and the upward increase in prices and the real time exchange rate lead to reduced competitiveness of traditional (non-tourism) export sectors.

Main impacts on coastal zone

As was indicated before, there is a relationship between urban development and tourism development that increases the pressure on water, energy and food provision on the coastal zone; on the another, hand, this urban development associated with tourism increases the solid waste generation and the sewage discharges. Additionally, increasing of tourism infrastructure and its

associated urban development, increase the pressures on critically fragile ecosystems such as mangroves, littoral forest and coral reefs. Several habitats are modified as direct or indirect effect of tourism development. Nesting areas for sea turtles and birds, are modified, as well, feeding areas in the marine ecosystems are impacted due the human presence, ship traffic and pollutions from wastewater. There is also a modification of animal behaviour as result of human presence (for instance the lights on the beaches that disturb the nesting behaviour on sea turtles and even there are some records of boats accidents on manatees).

e. Energy and Resource Extraction

Despite concerns over the environmental impact of industrial mining and the contribution that fossil fuels make to global warming, resource extraction continues to be a major source of revenue for both developing countries and wealthier nations alike. New data shows that the amount of resources being pulled from the earth has tripled since 1970, though the global population has only doubled during that time (Worldpoliticsreview.com). In many countries, most of their carbon fossil extraction is within the coastal zone where the impacts of energy and resource extraction are greater and more difficult to address.

Impact of energy and resource extraction result from two sources: the first one is due infrastructural development, expansion and maintenance of ports to accommodate importation and exportation of products and the second one of the pollutions caused by power plants especially those that use diesel and Heavy Fuel Oil (HFO) (namely, BELCOGEN IC Engines HFO, BAPCOL with its IC engines HFO and the diesel power plant in Caye Caulker owned by Belize Electricity Ltd.) .

Exploration and extraction of carbon fossil fuels in Belize is conducted using a block and sub-block system where the country has been divided into approximately blocks representing an area of 100 square kilometres. These blocks are further divided sub-block representing 4 square kilometres. Companies can apply to the Government of Belize for licenses to conduct exploration activities and in order to receive a license, prospective companies must undergo a thorough evaluation process, which is conducted by the Geology and Petroleum Department, legislative authority for petroleum products.

Threats

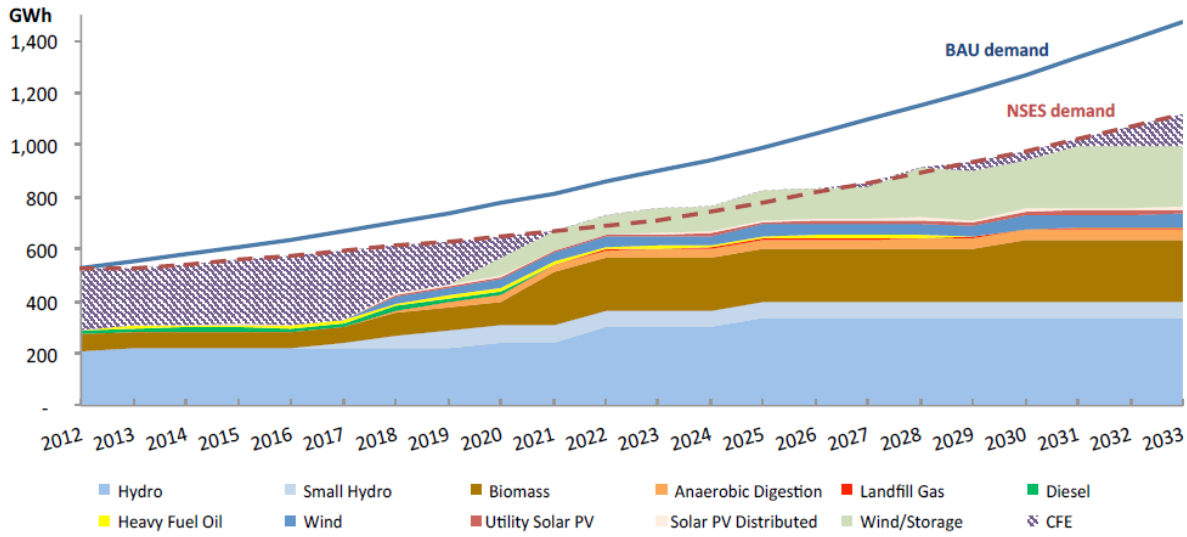
Even though there was no petroleum exploration and extraction activities on the coastal marine environment for the years in review, there is still the risk of oil spills due to the transportation of petroleum products. This is in compliance with the Petroleum Operations (Maritime Zone Moratorium) Act which imposes a moratorium on the exploration for and exploitation of petroleum and other petroleum operations in the maritime zone of Belize, to prevent pollution from installation devices and vessels used in the exploration or exploitation of petroleum resources of the seabed and subsoil of the maritime zone. Petroleum is imported through the Belize PUMA Energy terminal (Figure 20) in Belize City, and is further distributed via marine transportation to the Cayes.

Figure 20 PUMA Energy facility

The Belize Natural Energy Ltd. is the only company currently extracting oil in commercial quantities for exportation and sale. It's Spanish Lookout Oil Field, in the Cayo District, started production in 2005 but production has fallen drastically up to 2018 due to depletion of the oil field. The oil produced is exported to the United States of America and is shipped through the Big Creek Port Facility, Stann Creek District in southern Belize.

For the future demands of energy, Belize is looking for supply with renewable sources of energy. In the coast, the main sources are solar (useable though Photovoltaic Cells PVC), wind (usable though wind generators both offshore and onshore) and biomass (like sugar cane bagasse). There are expectations that those could increase their participation into the energy matrix (Figure 21).

Figure 21 Belize Electric sector and Business as usual (BAU) energy efficiency (NSES) and participation of renewable energy scenarios (2012-2033)



Source: (Gischler, Christiaan; Rodriguez, Enrique; Rojas Sánchez, Laura; Gonzalez Torres; Camila; Servetti; Gianmarco; Olson, Lars, 2014)

Conservation

On 1 December 2016, the government of Belize announced a policy intended to ban offshore oil exploration within the seven marine parks that make up the Belize Barrier Reef Reserve System World Heritage site. This resulted in a total of 2,117 km^2 being protected. However, in the October 2018 sitting of the House of Representatives, the Government of Belize passed legislation to enshrine a moratorium on offshore oil exploration in Belize. The measure was taken after heavy lobbying by the non-governmental organizations. The rationale was to protect the Belize Barrier Reef System from a possible catastrophic oil spill. Tourism generates over $200 million US dollars yearly to the Belizean economy. The Department of Environment and PUMA Energy have an oil spill response plan and the necessary equipment to contain an oil spill. This equipment includes booms for containment, oil skimmers and chemical dispersants. Other government agencies such as the Fisheries Department, Coast Guard and Port Authority assist with the provision of maritime transport. Training in response to an oil spill is always updated and simulations are held periodically to evaluate the response plan.

f. Land-Water interface

i. Origin of the coasts of Belize

Belize is tectonically located on the eastern edge of the Yucatan Block that belongs to the North American Plate. The area is characterized by the presence of left lateral faults with a predominantly North-South orientation. These are the types of faults that give rise to the approximate north-south boundary of the coast of the Yucatan peninsula.

Tectonic tearing of the area began during the Late Triassic and continued in the Cenozoic as the Caribbean Plate migrated eastward (Bishop, 1980; Salvador, 1987; Pindell, 1991). Cenozoic tectonism in Belize involved left lateral slip faults and trans tensional faults, as well as compressive lifting and folding. These events defined the main structural characteristics of the area (Dillon & Vedder, 1973; Lara, 1993; Purdy et al., 2003; Mazzull, 2006).

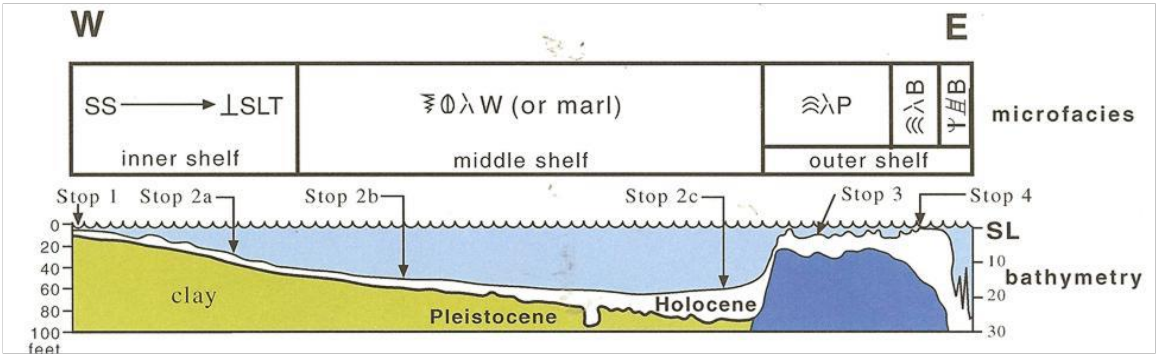
One of the consequences of left lateral shift faults in the area is the tendency of land blocks to move northward. In the terrain this phenomenon manifests itself as left faults in whose flanks there are also normal faults that cause the blocks not only to drift towards the North, but also to sink or incline towards the East.

The tectonic event described is the one that has created the solid substrate on which the Mesoamerican reef chain and its North-South alignment are based. In effect, on the tops of the relics of the submerged and semi-submerged blocks the reefs are fixed in the appropriate photic zones. The carbonate substrate of the reefs are Pleistocene limestones of the Yucatan Block.

Tectonic activity persists to this day, although with less intensity after Oligocene (Bishop, 1980). The coastal zone of Belize can be classified geologically and sedimentologically as a carbonate platform, in which its continental zones appear, as well as its internal, middle and external platforms; in the

latter, reef development occurs (Figure 22).

Figure 22 Geological profile of the Belize continental shelf and its termination at the reef edge.



SOURCE: JORDAN (2002).

Reefs and atolls also have an easterly sinking and inclination dynamic, so reefs must progressively replace areas that sink or incline. This marks a dynamic of constant growth of the reef and its permanent vertical renewal (Torres and Bolongaro, 2019).

The current morphology of the coasts of Belize is a consequence of the tectonic events described. In fact, they follow the approximate North-South orientation and show abundant karstic formations developed by dissolution of fractured limestones forming the so-called "pocket bays" (Figure 23).

Figure 23 General shape of Belize's coast and location of the main reefs and atolls.

SOURCE: ANIDE, 2019.

ii. Sea-level rise

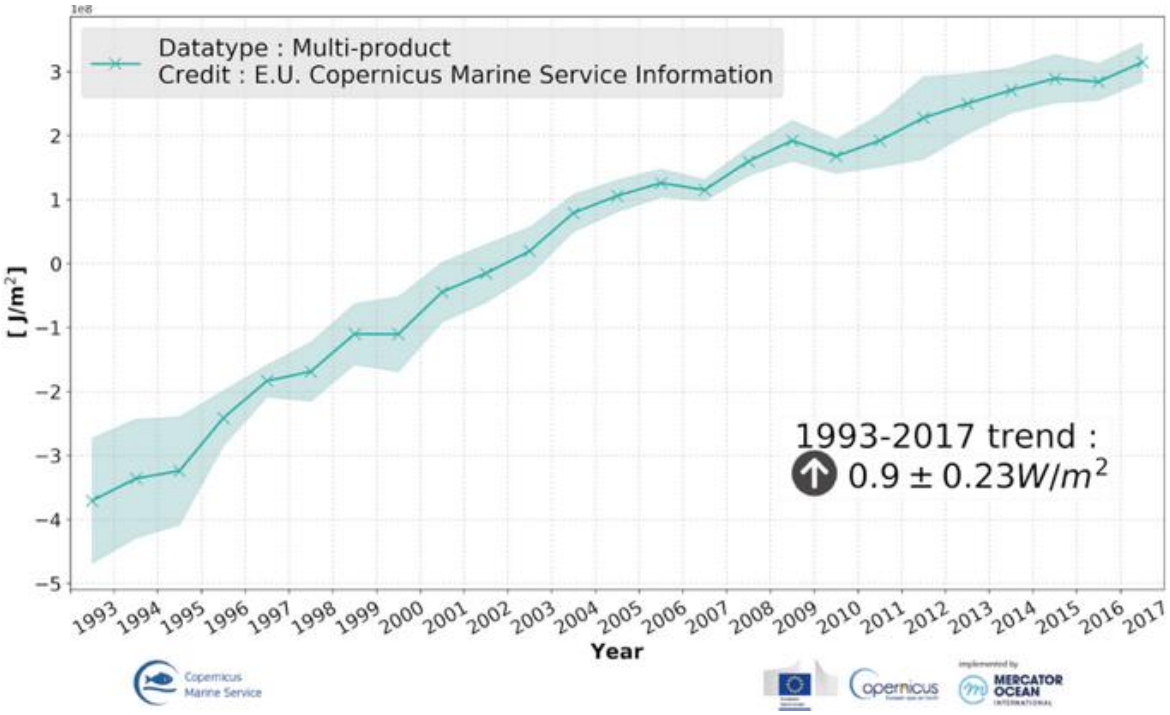
Principal coastal habitats, cities and activities affected by sea level rise in 2030

Mean sea level rise is a worldwide phenomenon. Its main origin is the melting of glaciers in the poles and mountain ranges of the continents, bringing new volumes of liquid water to the ocean, as well as the thermospheric effect (warming of shallow and deep sea water, 0-700 m deep) that brings, in turn, the increase in the volume of ocean water by thermal expansion (Torres and Bolongaro, 2019).

As a result, the cumulative effect of melting and thermospheric effect gives a rate of 3.2 mm/year for the period 1993-2018 (ESA, 2019). The most alarming thing is that this rate has risen in recent years to 4.8 mm/year today (2019).

It is worth mentioning that the thermospheric effect alone contributes 1.4 mm/year to the global phenomenon of sea level rise, i.e. more than 40% (Figure 24). Both phenomena are of anthropogenic origin. By 2030, the global sea level rise is expected to be 0.59 m (1990-2030 period). For the Caribbean region, the rate of increase is 2.7 mm/year according to satellite measurements (IPCC, 2013).

Figure 24 Global ocean heat content (0-700 m).



SOURCE: COPERNICUS MARINE SERVICE OCEAN MONITORING INDICATOR (OMI), THERMOSTERIC SEA LEVEL (0-700 M) TREND FROM 1993-2017.

The main manifestation of the rise in sea level is the advance of the coastline towards the continent appearing as coastal erosion. The average sea level rise is affected by local and regional tectonic phenomena such as the emersion, sinking and displacement of blocks of coastal land. All these phenomena occur on all the Caribbean coast of the Yucatan peninsula, including Belize.

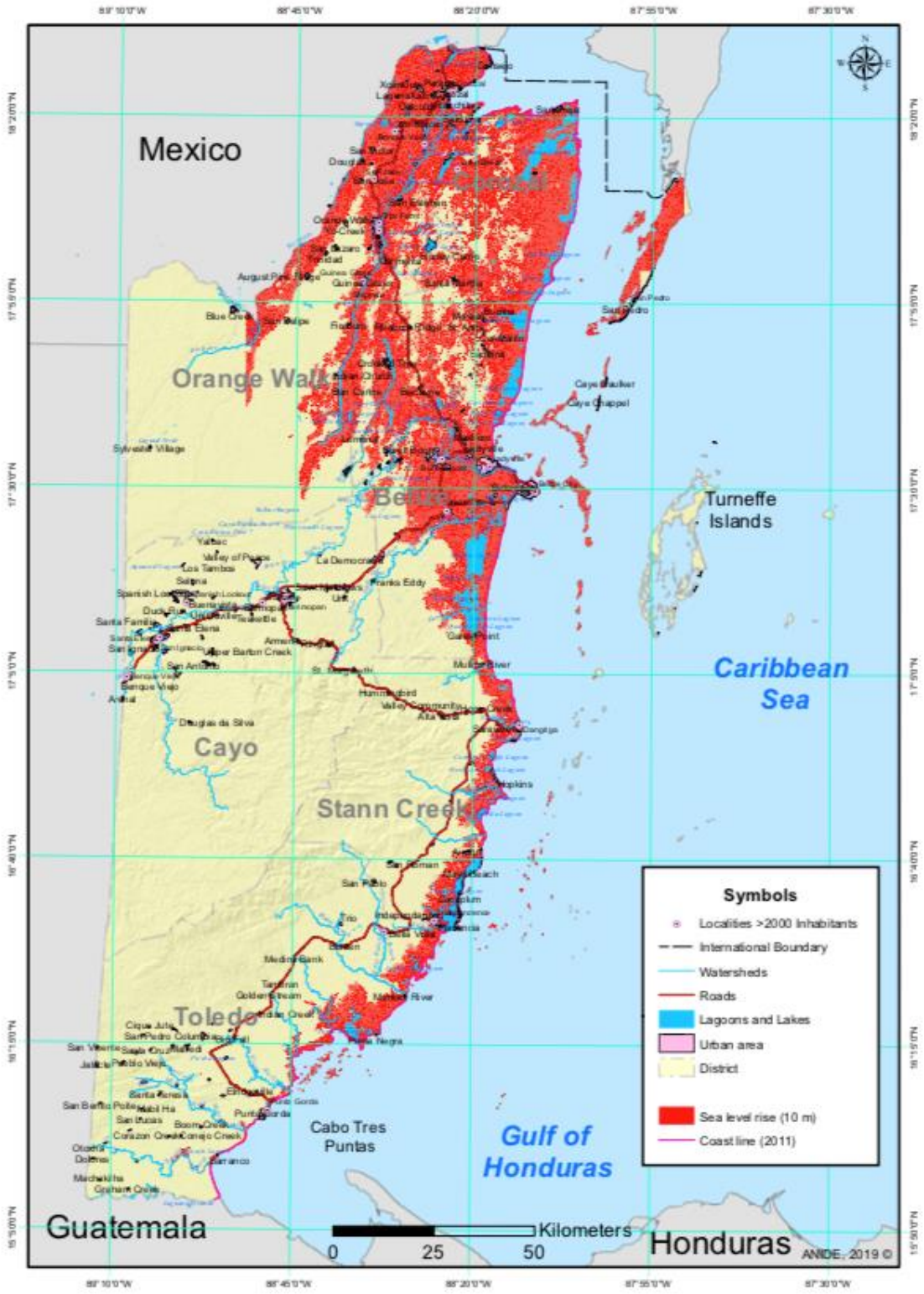
In order to know the effect of sea level rise on the coasts of Belize, a Digital Elevation Model (DEM) must be obtained. As this is a phenomenon of the order of mm/year, it is necessary to have a DEM of high resolution (mm) if you want to map the effect of sea level rise within the continent. Unfortunately, there is no information on this resolution. As a reference, the SUTRM DEM (US Geological Service) has a resolution of 10 m in the vertical and 90 m in the horizontal, which is insufficient to study sea level rise phenomena.

ANIDE (2017) constructed a DEM for the coastal zone of the Yucatan Peninsula in the Caribbean Sea from satellite images of the 2011 Palsat radar. These images have a spatial resolution of 12 m in the horizontal, and one meter in the vertical. With this model, the heights were obtained at each meter. Populations with more than 200 inhabitants were located. Although the maximum resolution of ANIDE DEM is 1 meter, this exercise provides a fairly close idea of the effect of sea level rise on the first meter of sea level rise.

In the case of Belize, Figure 25 and Figure 26 illustrate the possible flooded areas for sea level rise of 10 and 1 meter respectively. Since the most realistic case is that of an elevation of one meter, a description of the localities that could be affected is given below (Table 12). Of the 323 localities with more than 200 inhabitants, 37 localities (11% of the total) are located below a height of 1 meter which makes them vulnerable to the phenomenon of rising sea level in the region.

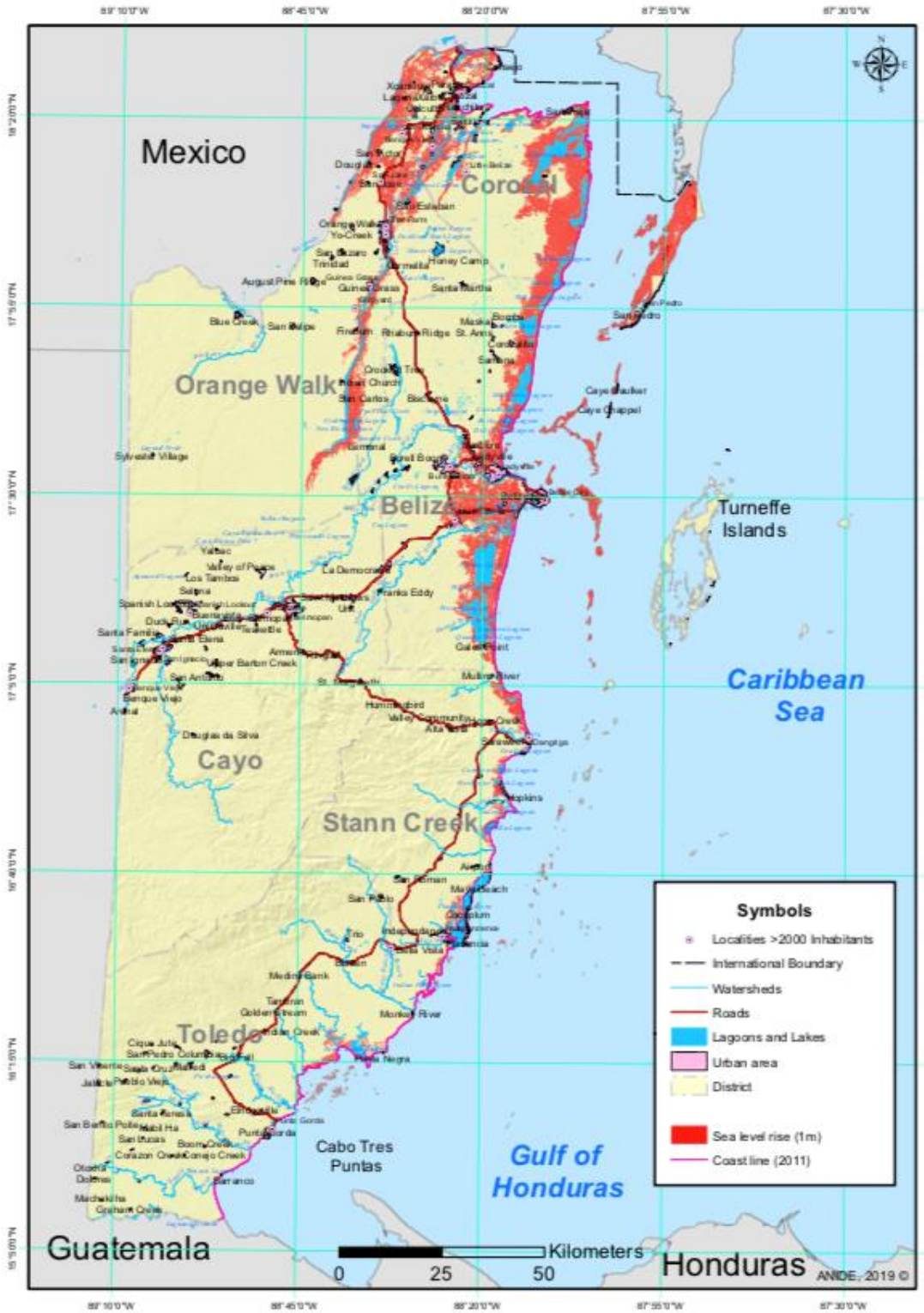
The maps obtained for sea level rise scenarios of 1 and 10 meters, also give an approximate idea of the effects of the storm surge, associated with tropical storms and hurricanes of levels 1 to 5. Studies of sea level rise by storm surges in the neighboring locality of Mexico in Chetumal Bay, shows extreme values of up to 5.25 meters of over-elevation (Torres et al, 2018). In this locality the greatest effects appeared at the entrance of Chetumal Bay with large inputs of seawater towards the south towards Belize.

Figure 25 Sea level rise (10 m) in Belize.



SOURCE: ANIDE, 2019.

Figure 26 Sea level rise (1 m) in Belize.



*

SOURCE: ANIDE, 2019.

Table 12 Locations exposed to sea level rise in the case of 1 m.

COUNT	SETTLEMENT NAME	DISTRICT	TYPE	UTM (E) (m)	UTM (N) (m)
1	Belize City	Belize	City	373687	1934478
2	Caye Caulker	Belize	Village	390983	1963964
3	Freetown Sibun	Belize	Village	356794	1927451
4	Gales Point	Belize	Village	358116	1901188
5	Ladyville	Belize	Village	362274	1940849
6	Lord's Bank	Belize	Village	359920	1940681
7	Western Paradise	Belize	Village	362064	1932351
8	Altamira	Corozal	Community	352829	2034048
9	Benque Viejo	Corozal	Community	346422	2020868
10	Caledonia	Corozal	Village	344207	2015744
11	Chunox	Corozal	Village	356336	2023552
12	Consejo	Corozal	Village	362862	2041044
13	Copper Bank	Corozal	Village	356942	2026164
14	Corozal	Corozal	Town	353403	2033829
15	Estero	Corozal	Community	341541	2036438
16	Estrella	Corozal	Community	346322	2022869
17	Hill Bank	Corozal	Community	352643	2017354
18	Laguna	Corozal	Community	339750	2032854
19	Libertad	Corozal	Village	346272	2024434
20	Progresso	Corozal	Village	351097	2015858
21	Ranchito	Corozal	Village	351104	2032334
22	San Maximo	Corozal	Community	349153	2028976
23	Santa Cruz	Corozal	Community	346144	2018237
24	Santa Elena	Corozal	Community	352596	2044433
25	Santa Rita	Corozal	Community	352898	2034507
26	Sarteneja	Corozal	Village	378948	2029540
27	Douglas	Orange Walk	Village	330701	2016852
28	San Estevan	Orange Walk	Village	340020	2007663
29	San Pablo	Orange Walk	Village	334479	2013781
30	San Roman	Orange Walk	Village	326344	2011922
31	Big Creek	Stann Creek	Community	350239	1826185
32	Dangriga	Stann Creek	Town	369916	1876495
33	Tropical Park	Belize	Community	352569	1931474
34	Los Lagos	Belize	Community	357491	1943221
35	Tower Hill Bridge	Orange Walk	Site	335261	1993829
36	Ramon's Village	Belize	Community	363255	1940370
37	Vista Del Mar	Belize	Community	365411	1940102

SOURCE: ANIDE (2019).

ii. Sediment Transport

Description of the main littoral cells along of the coast

The stability of beaches depends mainly on the availability of sediments. The Belizean coast has two main sources of sediments on its coastline: those from river discharges from incident hydrological basins, and sediments from reefs.

Terrigenous sediments come from the northern, central, southeastern, and southern hydrological regions of Belize (Table 13). Sediments are derived from continental rocks and transported by river currents to their discharge into the Caribbean Sea. Four sediment dispersion zones have been identified based on satellite imagery, each providing similar amounts of sediment; the largest is the northern region with 532 km^2 of dispersion surface area. The zone with the greatest amplitude occurs in the southern zone of Bahía Amatique (Toledo) (Figure 27).

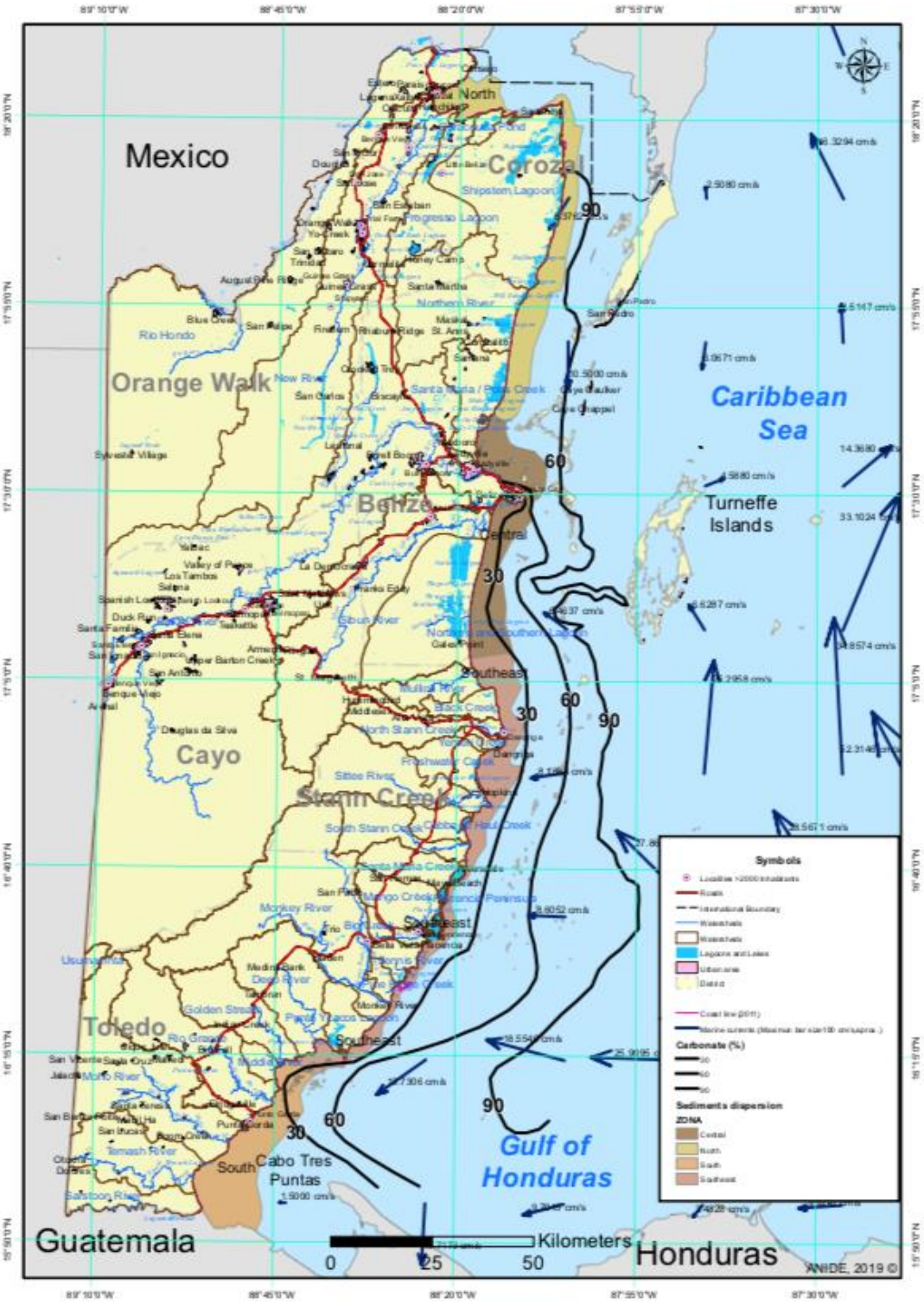
Table 13 Ocean dispersion sediment areas in Belize.

Dispersion sediment area	Hydrologic region	Creeks and Rivers	Ocean dispersion area (km^2)
1	North	Río Hondo, Blue Creek, Chan Chich River, Booth River, New River, Fresh Water Creek, Northern River.	532
2	Central	Belize River, Mopan River, Macal River, Cha Stream, Barton Creek, Sibun River, Manatee River.	495
3	Southeast	Mullins River, Big Creek North, North Stann Creek, Fresh Water Creek, Sittee River, Cabbage Haul Creek, South Stann Creek, Big Creek South, Mango Creek, Plantation Creek, Sennis River, Monkey River, Deep River.	521
4	South	Golden Stream, Middle River, Rio Grande, Joe Taylor Creek, Moho River, Temas River, Sarstoon River	466

SOURCE: ANIDE, 2019.

Carbonate sediments come from the destruction of reefs and atolls by waves and from the organisms that develop on the bottom of the carbonate continental shelf. As expected, the highest concentration is in the pre-reef zone (the one facing the open seaside), where more than 90% of the sediment is detritic carbonate. The amount of detritus decreases towards the post-reef zone (60%) reaching 30% in the interior lagoons, where the preponderance of the terrigenous sediments already described begins (Figure 27).

Figure 27 Dispersion of terrigenous sediments (ANIDE, 2019) and per cent of carbonated sediments (Jones, 2002) in the Caribbean Sea, Belize.



SEE ALSO DIRECTION AND VELOCITY OF OCEAN CURRENTS (CM/SEC, YEAR 2019).

SOURCE: ANIDE, 2019A.

Impacts on littoral transport by coastal infrastructure

Terrigenous sediments are retained in the continental zone by infrastructure works, especially roads and water storage dams. Table 14 lists the main crossings of roads with rivers that could affect the retention of sediments impeding their arrival at the ocean.

Table 14 Major road and river crossings in Belize, which retain terrain sediments.

River Name	Roads Name	District
Belize River	Hattieville Boom Phillip S.W. Goldson Highway	Belize
Burdon Canal	George Price Highway	Belize
Belize River	George Price Highway	Cayo
Macal	George Price Highway	Cayo
Belize River	George Price Highway	Cayo
Mopan	George Price Highway	Cayo
Mopan	George Price Highway	Cayo
Belize River	George Price Highway	Cayo
Belize River	Phillip S.W. Goldson Highway	Cayo
Mopan	George Price Highway	Cayo
Sibun	Hummingbird Highway	Cayo
Belize River	George Price Highway	Cayo
New River	Phillip S.W. Goldson Highway	Orange Walk
New River	Orange Walk Bypass	Orange Walk
New River	Orange Walk Bypass	Orange Walk
Sittee River	Southern Highway	Stann Creek
South Stann Creek	Southern Highway	Stann Creek
Big Creek	Southern Highway	Stann Creek
Rio Grande	Southern Highway	Toledo
Golden Stream	Southern Highway	Toledo
Deep River	Southern Highway	Toledo
Swasey Branch	Southern Highway	Toledo
Joe Taylor Creek	Southern Highway	Toledo
Bladen Branch	Southern Highway	Toledo

On the other hand, the retention of sediments from the South-North coastal current (not illustrated) is produced by ports, piers, jetties and other coastal works that retain sediments in the southern zone and

erode in the northern zone of each work. For example, in the Port of Belize, the port area has conditions of sediment accretion, while the adjacent area in the direction of the coastal current is under erosion. The erosion zone is caused by the presence and construction of the port. (Figure 28).

Figure 28 Erosion and accretion zones due to the construction of the Port of Belize

SOURCE: ANIDE, 2019A. COPERNICOUS IMAGE IN GOOGLE (2019).

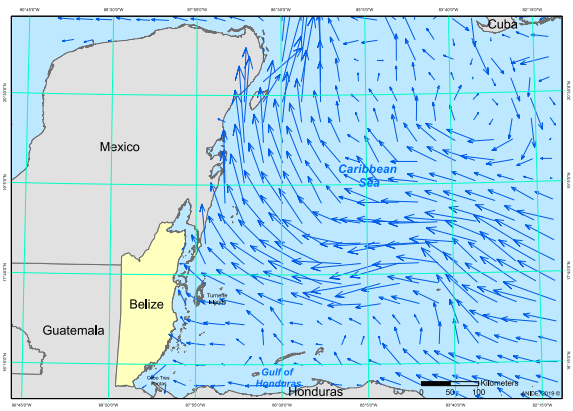
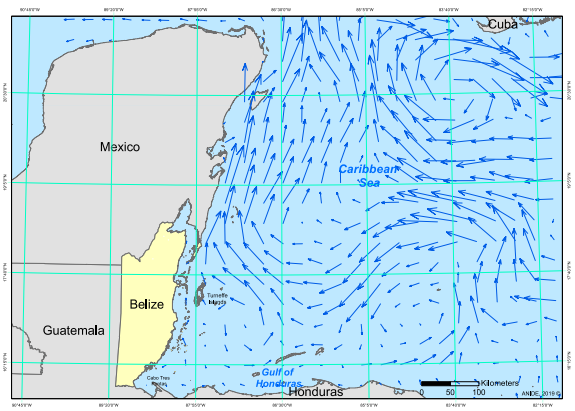
Seasonal variation of littoral transport along of the coast

Sediment distribution dynamics in the Caribbean Sea of Belize depend on the Caribbean Current and the coastal current. Depending on the time of year and the sediment load carried by the rivers, various erosion and deposition scenarios occur. No information is available on the seasonality of sediment discharges or their sediment content.

On the other hand, considering the dispersion of sediments by ocean currents, from the studies of the University of South Florida (2019), it is observed that the Caribbean Current approaches from the East to the coasts of Belize with velocities between 25 and 75 cm/s; when approaching the bottom of the platform in the vicinity of the coasts, the current reduces its velocity to about 8 cm/sec. Near the reefs, atolls and in the interior lagoon the speed is less than 4 cm/s. The drastic diminution of the currents behind the reef areas and in the interior lagoon generates what has been called "shadows" and their effect is the attenuation of the currents and the discharge of sediments.

The Caribbean Current rotates progressively until it reaches the predominant North direction, which it will conserve along the eastern coast of Yucatan. In the southern zone (Bahía Amatique), the current decreases its speed drastically and its direction is erratic, configuring a restricted zone. In this zone, the accumulation of sediments is higher. Figure 29 shows several satellite determinations of the speed and direction of the Caribbean Current in four different months in 2019.

Figure 29 Major ocean currents in Yucatan Peninsula border. Bar size 100 cm/s (approx.).

<table>
<tr><td> 
</td><td> 
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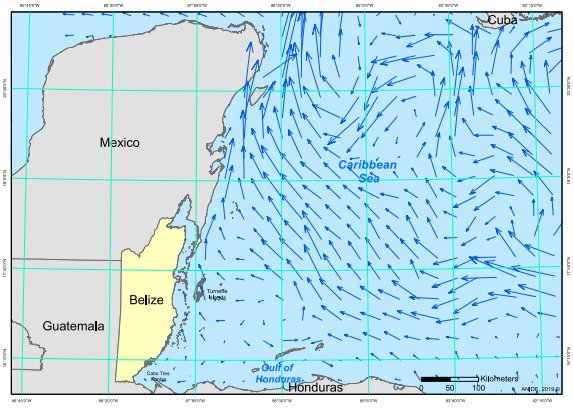
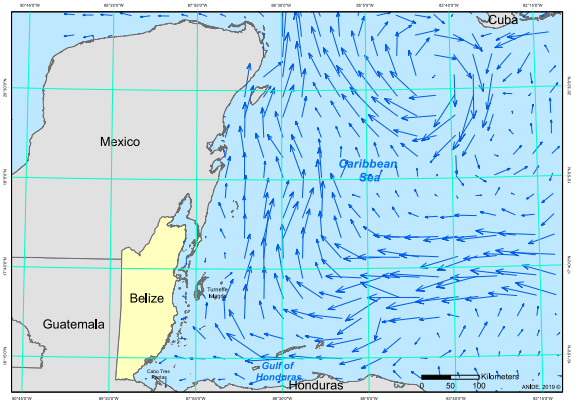
<tr><td>January 2019</td><td>April 2019</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>July 2019</td><td>October 2019</td></tr>
</table>

SOURCE: UNIVERSITY OF SOUTH FLORIDA (2019). PROCESSED BY ANIDE (2019A).

Finally, the combined effect of river discharges and ocean currents is to distribute sediments mostly at the northern edge of each discharge, contrary to what is described when an obstacle is located in the coastal current (case of coastal Infrastructure). In areas adjacent to fluvial discharges, beaches will have new materials for stabilization and/or growth, while areas on the southern edge of river mouths will have less sediment and possible intensification of erosion processes (Figure 30).

Figure 30 Dispersion of sediments flowing from rivers into the Inner Lagoon. Note the effect of the coastal current heading north.

SOURCE: ESA COPERNICOUS IMAGE ON GOOGLE PLATFORM, 2019. PROCESSED BY ANIDE, 2019.

iii. Erosion

Coastal erosion is a phenomenon of loss of continental zone by the advance of the sea inside the continent, regardless of the origin of this phenomenon. The opposite process is called accretion and consists of the natural or artificial growth of the coastline by the contribution of sediments and materials. All beaches have erosion/accretion dynamics at different times of the year. Long-term studies (minimum 50 years) define the dominant process and it can be determined whether the beaches are in erosion, accretion or equilibrium.

The study methodology was initially proposed by US Geological Service (2009), and modified and expanded by Torres et al., 2010 and ANIDE (2013). This methodology consists of the analysis of spatial images of the highest available resolution and aerial photographs, all of which are georeferenced with the same control points. Coastlines are obtained following the criterion of maximum high tide and spatially analyzed to obtain erosion rates and surfaces.

Table 15 presents an unpublished ANIDE study (2019), where the magnitudes of net displacement of the Belize coast and erosion rates for the period 1969-2017 were determined. It can be observed that there are severe erosion problems along the entire coast of Belize, with rates of up to -2.61 m/year and beach losses of 113 meters in 50 years. Such is the case of the District of Corozal. Beach growth zones of up to 80.55 m were also recorded in the Stann Creek district.

Table 15 Erosion and accretion rates in the municipalities of Belize in the period 1969-2017.

COASTAL EROTION/ACRETION RATE IN BELIZE (1969-2017)
Source: Anide, 2019

Municipality	Sites studied	Period	Years	Parameter	Erosion rate (m/y) (1969-2017)	Accretion rate (m/y) (1969-2017)	Net displacement (m) (1969-2017)
COROZAL	33	1969-2019	50	MEAN	-1.05	0.41	-38.39
				MAX	-0.20	0.66	29.91
				MIN	-2.61	0.18	-109.50
BELIZE	79	1969-2019	50	MEAN	-0.49	0.52	-5.41
				MAX	-0.02	1.26	62.93
				MIN	-2.28	0.02	-113.88
STANN CREEK	42	1969-2019	50	MEAN	-0.47	0.56	12.81
				MAX	-0.07	1.64	80.55
				MIN	-0.71	0.05	-35.60
TOLEDO	45	1969-2017	48	MEAN	-0.47	0.14	-14.59
				MAX	-0.01	0.31	15.07
				MIN	-1.33	0.01	-63.81

Negative values: Erosion processes.
Positive values: Accretion processes.

SOURCE ANIDE (2019), UNPUBLISHED DATA

Main causes of erosion in some sites along of Belize´s coast

Coastal erosion/accretion may be due to anthropogenic effects such as sea-level rise from global warming, thermospheric effects, intensification of extreme hydrometeorological events, and mismanagement and administration of the coastal zone and incident basins. They can also occur from natural phenomena such as sinking and lifting of portions of the land by tectonic and volcanic phenomena, or extraordinary events such as storm surges (hurricanes) and tsunamis.

All beaches have coastal dynamics with seasons of accumulation and loss of sediments, closely related to the marine and continental climate. Over time the beaches stabilize and preserve. The stability of beaches is due to phenomena of continuous supply of sediments mainly from rivers, which can be diminished by civil constructions in the coastal zone, such as roads, railways, bridges, as well as by the damming of river flows in hydraulic works, retaining sediments.

It is pertinent to clarify that the phenomenon of accretion (growth of beaches) in the first instance seems beneficial (preservation and increase of the land gained to the sea), it takes concomitant that in another nearby place (or adjacent) the opposite effect is produced: erosion. What one zone won was lost by another. So, any change that is intended to induce in the coastal zone must carry out a study of hydrodynamic modelling in order to anticipate the positive and negative effects of the same. Coastal dynamics will always seek to return beaches to equilibrium condition, resulting in erosion and accretion effects.

In the areas most affected by coastal erosion in Belize, the following were identified as probable causes of erosion:

1. Coastal roads.
2. Blockage of river sediment input by storage dams.
3. Inadequate coastal structures (piers, breakwaters, etc.) or carried out without studies of coastal dynamics. The result is that a beach is protected, and the problem is passed on to the neighbor.

iv. Saline intrusion

Freshwater reservoirs affected by saline intrusion

Saline intrusion is the phenomenon that occurs in coastal areas due to the formation of a "saltwater wedge" from the oceanic water that penetrates the continent and is located below the freshwater aquifer. It is a phenomenon of difference in water density, where the saltier water finds the lower of the less dense water, the freshwater, which explains the frequent stratification of the aquifer.

The groundwater of Belize is found in a carbonate aquifer karstic types with stratification of freshwater and saline. These aquifers tend to contain hard water in Ca-Mg. The depth at the static level is small, with the freshwater layer found a few meters deep (2-10 m). The thickness of the freshwater layer varies from 10 to 70 meters from which the salty and/or saline water layer begins.

The phenomenon of saline intrusion is known throughout the Yucatan peninsula, which is formed by intensely dissolved carbonate rocks and the formation of karst which are characterized by a very high permeability. In Belize, the characteristic of coastal aquifers is that they are stratified, where the usable fresh water is located at shallow depths and under which a layer of saline water is located.

The penetration of the so-called saline wedge can be up to 100 km inland as occurs in the area adjacent to Mexico, and the tendency is to go even further as the sea level rises, as it boosts the water pressure of seawater under fresh water.

Mainland uses affected by saline intrusion

Inside the continent, the effect of the seawater wedge is the deterioration of the quality of the groundwater used by the population. The extraction of water by means of wells and handcrafted structures modifies the stratified state of the aquifer, producing the ascent of progressively saltier water, salting the aquifer.

In karst aquifers in the area, another common phenomenon is the contamination of groundwater by leachate from urban solid waste, waste of special management, and even hazardous residues.

Aquifers are also exposed to the entry of untreated wastewater and by the construction of latrines and sewage injection facilities, without complying with regulations.

The leachate produced by rainwater and by the waste fluids themselves and untreated wastewater easily reach the aquifer due to the high permeability of the carbonated rocks, affecting the chemical and bacteriological quality of the water.

g. Coastal Waters

i. Nutrient Pollution

Source of Pollution

A problem that has become frequent due to the presence of human settlements and productive activities adjacent to the coast are the high concentrations of nutrients such as nitrogen (N) and phosphorus (P) in coastal waters. These two elements are essential for the biogeochemical processes that occur in the coastal zone, but in high concentrations, it has harmful effects on habitats. In the case of Belize, although there are no recent estimates of the concentrations present in coastal lagoons, bays or shallow waters adjacent to the coast, it is known that organic waste from urban areas, together with agricultural, livestock and aquaculture activities contribute significant amounts of nutrients (Department of the Environment. Ministry of Natural Resources and the Environment, 2008, p. 58).

Nutrients on the coastal and marine area

The presence of nutrients (phosphorus and nitrogen) in coastal waters is due to the transport of these elements from the land through streams, rivers and drains so that the highest concentrations can be located at the sites of the mouths or discharges. The constant introduction of nutrients and their accumulation in coastal waters causes eutrophication processes (decreased oxygen in the water column) that negatively impact the habitats in the area (Department of the Environment. Ministry of Natural Resources and the Environment, 2008, p. 60; Oelsner and Stets, 2019, p. 1226).

In a study conducted by Townsend et al. (2016), the impact of *Siderastrea sideidea* samples (a specie that forms part of the reef barrier) was laboratory analysed. The study contemplated a sudden increase in nutrient concentrations, decrease in salinity and decrease in water temperature. These conditions occur in the coastal zone when there are a higher frequency and intensity of runoff from Belize and Honduras. Laboratory analyses showed that there is a loss of bleaching resistance and resilience (Townsend et al., 2016), and although the results are inconclusive, it is crucial that nitrate concentrations not continue to increase for that the irrigation does not increase in the reefs near the coast, due to the combination of the mentioned variables.

One of the most vulnerable habitats to the effects of eutrophication are coastal lagoons because they are shallow areas where water circulation is slow, which prevents adequate dispersion of nutrients and other contaminants accumulated there. On the other hand, the concentration of nutrients in the sediments allows the eutrophication processes to continue even without water contributions from the terrestrial area (Cabral et al., 2019). During the dry season, the effects of increasing the temperature of the water column and increasing salinity are combined with the eutrophication process, worsening the conditions for the development of aquaculture activities or the maintenance of various species such as molluscs and bivalves.

The main causes of the increase in nutrients in the water column are not only due to the expansion of activities such as livestock, agriculture or urban discharges. The absence or inefficiency of waste water treatment systems makes urgent the need to improve the service, but the costs for the design,

construction, operation and maintenance of the infrastructure often exceed the government budgets or only a part is a better possibility of the treatment system.

In the case of Belize, one of the sanitary projects for the treatment of wastewater is that of the coastal town of Placencia in the Placencia Peninsula, which is located at the tip of the sandy bar of the coastal lagoon of Placencia. Specifically, the project seeks to increase access to wastewater treatment through the development of a new collection system and a treatment system (Belize Water Service, 2019a). According to the Belize Water Service (2019a), the estimated cost of the design and construction of the collection and treatment systems was US $ 10 million, without considering the operation and maintenance costs. With such a high investment, it is necessary to ensure that the quality of the water treatment service is efficient.

Also, a comprehensive model is being developed that allows to know the fate of nutrients and faecal bacteria that enter the lagoon and the sea in front of the peninsula, to be able to choose the locations of the waste water treatment plant and the final disposal of effluents (Belize Water Service, 2019b, p16) and not negatively impact coastal habitats.

The investment made and the cost of the studies to determine the fate of the pollutants show the complexity involved in a project of this nature and the challenges that similar projects will imply in other coastal cities of Belize, when the wastewater treatment needs increase, due to the increase in population and industrial activities.

ii. Marine Pollution

Type of pollution

Pollution to the marine and coastal environment comes in many different forms, such as toxic chemicals (organic compounds, DDT, PCBs, heavy metals, pharmaceuticals and gas), solid wastes (plastics, metal objects and glass objects), increase of nutrients (nitrates and phosphates) and sediment contribution due to human activities (industry, agriculture, deforestation, wastewater discharge, aquaculture), radioactivity, oil spills and discarded fishing nets.

The pollutants that can cause the most damage are the persistent, bioaccumulate and toxic substances, which change the physical, chemical and biological characteristics of the oceans and coastal areas. In areas where these pollutants occur, measures must be established to control their discharge and sanitation programs that mainly allow the recovery of the ecosystems closest to the coastline, where they tend to accumulate more easily.

Main source of pollution in the marine area

Pollution is an anthropogenic process that derives from human activities such as industrialisation or population density that pollute the marine and coastal environment. Pollutants flow through processes such as direct discharges of effluents or solid wastes that come from land or human activities in the sea, and runoff that comes from rivers and rains. The relative contribution of each of these pathways to marine pollution varies greatly depending on the substance and its concentration, which coupled with the lack of

data and the complexity of natural processes, especially in the boundaries of land, atmosphere and the sea, make quantitative estimates of these processes difficult and uncertain.

Other marine pollution processes that occur suddenly are oil spills that occur due to accidents of tankers or oil rigs (Vikas and Dwarakishb, 2015) and radiation leaks from nuclear plants. The magnitude of the impacts produced by these accidents can become a severe risk to marine and coastal ecosystems, which are within the area of influence of the disaster, which sometimes covers hundreds of kilometres and where the quantification of environmental damage becomes impossible.

Main impacts of marine pollution in Belize

The wastewater generated in Belize is domestic and industrial, and the treatment service is only offered in the most populated cities of the country such as Belize City (secondary treatment), San Pedro Island (secondary treatment) and the city of Belmopan (primary treatment) (Grau et al. 2013, p.11; Silva, 2013, p. 38). For industries, hotels and in housing in some villages, packet plants, septic tanks, latrines and lagoons are used (Silva, 2013, p. 102).

In theory, effluent regulations can control any type of domestic or industrial pollution (Silva, 2013, p. 102), but the lack of adequate infrastructure and technology for wastewater management remains a problem that causes impacts such as groundwater, streams, rivers and soil pollution.

The use of chemicals in the agricultural industry is a requirement to maintain production, but the detection of its effects in the marine area is not easy. In an analysis conducted to know the effect of agriculture in the protected area of Maya Mountain, Kaiser (2011) found the presence of pesticides in the area, although the impact they have on the fauna of the protected area is unknown.

In another analysis, whose objective was to know the quality of water in the Port Honduras Marine Reserve (Sweetman et al., 2019), it was shown that the relative stability of water quality is due to factors such as the absence of beaches, the limited coastal development and the low population density of the Toledo District. These conditions benefit the sportfishing activities that are performed in the protected area.

The effects of substances on the marine zone such as detergents and pesticides that are used in villages and agricultural areas or the presence of faecal coliforms, are well known, but the lack of data only allows partial conclusions about the state of different habitats and species that use them, as well as possible sources of impact.

iii. Dredging

Dredging activities are sometimes necessary to extract sand used for beach nourishment or to fill flooded areas where permanent infrastructure can be established (CZMAI, 2016). The way in which these deposits are exploited, how the sand is transported and the places where the material is deposited, can have immediate effects on nearby ecosystems such as mangroves, coral reefs, seaweed beds. That is why in

many tropical countries dredging activities and landfills have been responsible for extensive degradation of coastal resources and the decline of fisheries (Price at al., 1992).

Dredging activities are used in ports and coastal lagoons to create and maintain channels for navigation. Another reason for marine dredging is to use the white calcareous sand for landscaping.

The key factor for fill flood zones and beaches is the existence of sand deposits in the marine area and the availability of dredging equipment. Additionally, coastal engineering measures are required that minimize give the number of dredges needed for the maintenance of beach fillings. There is the need for mitigation measures that compensate for the impacts of the loss of vegetation cover in flood areas.

Landfills

Due to the low elevation above the average sea level along the coastline, there is the presence of coastal lagoons and estuaries. These geological characteristics make it necessary to carry out landfill activities that allow the construction of new infrastructure near the coastline (CZMAI, 2016), through dredging systems that extract the sand found in the marine area. Dredging activities increase costs depending on the location and depth of the sand deposit, as well as the distance of the landfill. These conditions limit the use of this extraction procedure to those companies that have the budgets to cover the costs.

The lack of budget to extract the sand from the marine zone, as well as the absence of other deposits of material on land and coastal dunes or the sand that is deposited at the mouths of the rivers, have forced the local population of Ambergris Caye to use different materials such as wood, cardboard, vehicle wreckage, sargassum, etc., to reclaim flood land. In several areas near the coastline, it is possible to find the accumulation of the described materials, and according to the restrictions of use for coastal development, this activity is prohibited (CZMAI, 2016).

Beach fill

Similarly, in order to have more recreation area for tourists or as a measure of protection against storm events, there have been landfill activities in front of the hotels, condominiums or houses that are located in the beach area to along the Caribbean coastline. Filling activities are carried out in short sections of the waterfront, by building a deep wall at the bottom, which is filled with sand to a height similar to that of the existing berm.

Landfill actions increase the width of the beach and solve the need for space and protection for a hotel, condominium or houses; yet, it is inefficient if the construction of similar infrastructure that requires wider beaches is contemplated. However, the decision to use other engineering methods to increase the width of the beach will depend mainly on the impact that this measure may cause on the reef barrier and the costs involved in technical studies, the design and construction of the structures.

On the other hand, the impacts caused by the construction of the walls for beach fillings can be concentrated in a small space, but the long-term effects of the construction of several walls can have similar impacts to those of other structures such as breakwaters, which are also used to increase the width of the beach. Another particular problem that arises from dredging activities is that the demand for sand that is needed for landfills can exceed the volumes (Demir et al., 2004) provided by the barrier reef, which

is the only source of sediment in the Caribbean coast of Ambergris Caye. The recovery speed of material deposits that have already been exploited will require the search of new sand deposits that have the volume necessary to cover the demand for landfills and possibly in the future, to cover the demand for infrastructure construction.

The challenge in the following years will consist of the adequate balance between the investment that is desired to be made to increase the tourism, the impacts resulting from the construction of infrastructure on the coastline, the protection of the barrier reef and significant information for understand the evolution of the Caribbean coastline, especially in tourist destinations such as Ambergris Caye, to identify and quantify sediment deposits for extraction in the marine zone without affecting the natural supply of the coastline..

iv. Fishing

Main coastal and marine fisheries

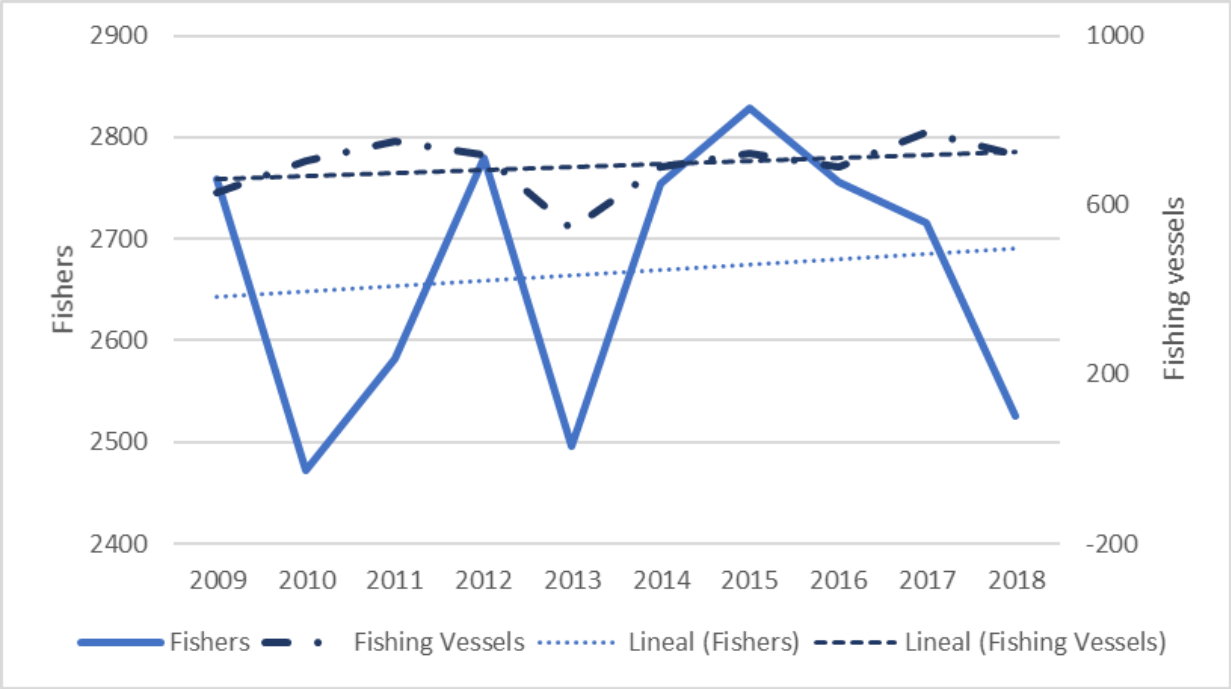
The national artisanal commercial fishery export-oriented and has been dominated by Caribbean spiny lobster (*Panulirus argus*) and the queen conch (*Strombus gigas*) even though there are small fisheries for sea cucumber, sharks and finfish. In the 1960's the fishing industry transformed from a small-scale domestic fishery to the commercialization of lobster, conch and finfish to lucrative markets for the United States Americas and the Caribbean.

The fishing fleet consists of wooden sailing vessels equipped with outboard motors. The vessels conduct fishing trips during the open seasons for the various species which last between 6 to 12 days. Each sailboat carries between 8-10 wooden canoes which are used to fish by individual fishers. The fishing fleet also includes fiberglass or wooden skiffs that are equipped with outboard motors (Figure 31). Fishing trips for these vessels last between 1 and 2 days.

Figure 31 Fishing vessels in Belize

Fishers – The number of fishers shows an overall trend of ranges from 2,000 to 2,500 over the past five years, while the number of vessels has remained fairly stable during the same period (Figure 32). Two thousand two hundred and fifty-three fishermen were licensed in 2018.

Figure 32 Number of Fishers and Fishing Vessels for the past 10 years



Management

The Belize Fisheries Department, under the Ministry of Agriculture, Fisheries, Forestry, Environment, Sustainable Development and Immigration, is responsible for the conservation and sustainable use of fishery resources through registration and licensing of fishers and vessels, conducting fisheries research, surveillance and enforcement, marine reserve management, fisheries law and policy formulation and issuing export and research permits. The Department is headed by the Fisheries Administrator who is assisted by officials from the Department's four technical units – the Administrative Unit, the Policy and Planning Unit, the Fisheries Capture Unit and the Ecosystem Management Unit.

Since the first pilot test in 2011 at Glover's Reef Marine Reserve, the Managed Access Program prove to be a tool that balance the economic needs for fisher persons, the certainty on the access to the fisheries resources and the conservation of its stocks and the ecosystems. The program aim is to protect the rights of customary fishers by giving them exclusive access to fish certain areas, this is achieved by issuing licenses annually to fishers according to criteria developed in consultation with fisher representatives. Licenses allow fishers access to specific areas and require them to comply with regulations and report their catch. Since 2011, the Fisheries Department and allies, including fishing organizations have been working towards a national roll out of managed access to all marine areas. The national expansion of Manage Access took effect on 13 June 2016.

Fisheries

The major fisheries in Belize can be described as being fully exploited but with stringent monitoring and evaluation in order to guarantee the sustainability of the resources.

Lobster

The Caribbean spiny lobster *(Panulirus argus)* fishery is artisanal and commercial but is the most important with 1,786,226 pounds of lobster products exported in 2018 (Figure 33) contributing more than US $11.9 million to the economy (Figure 34). In 2016, a managed access program was implemented at the national level with fishers choosing two fishing areas to fish. The Fisheries Department is determining the yields for the fishing areas to adjust the number of fishers to the resources. Manage access reduces the rush to fish as only a given number of fishers operate in their designated areas. It also decreases illegal fishing and promote ownership of the marine resources. Other regulations include closed season, minimum size and weight, no dicing of tails, no taking of berried or molting specimen and the prohibition to use SCUBA gear. Lobster fishing is conducted by free diving using hook sticks and by using lobster shades and lobster traps.

Head meat production and export has always been minimal while tails have always been the bulk of the lobster exports. For the years in review, the highest tail exports were in 2014 (569,250 pounds), with slight decrease in 2015 and 2016 only to have an increase in 2017 (494,881 pounds). Figure 34 depicts the export earnings which follow the same pattern with the exports. Whole lobster exports were the lowest in 2014 and has been increasing yearly. The sale of whole lobster started a few years ago due to changing market demands.

Figure 33 Lobster production and export for the years in review

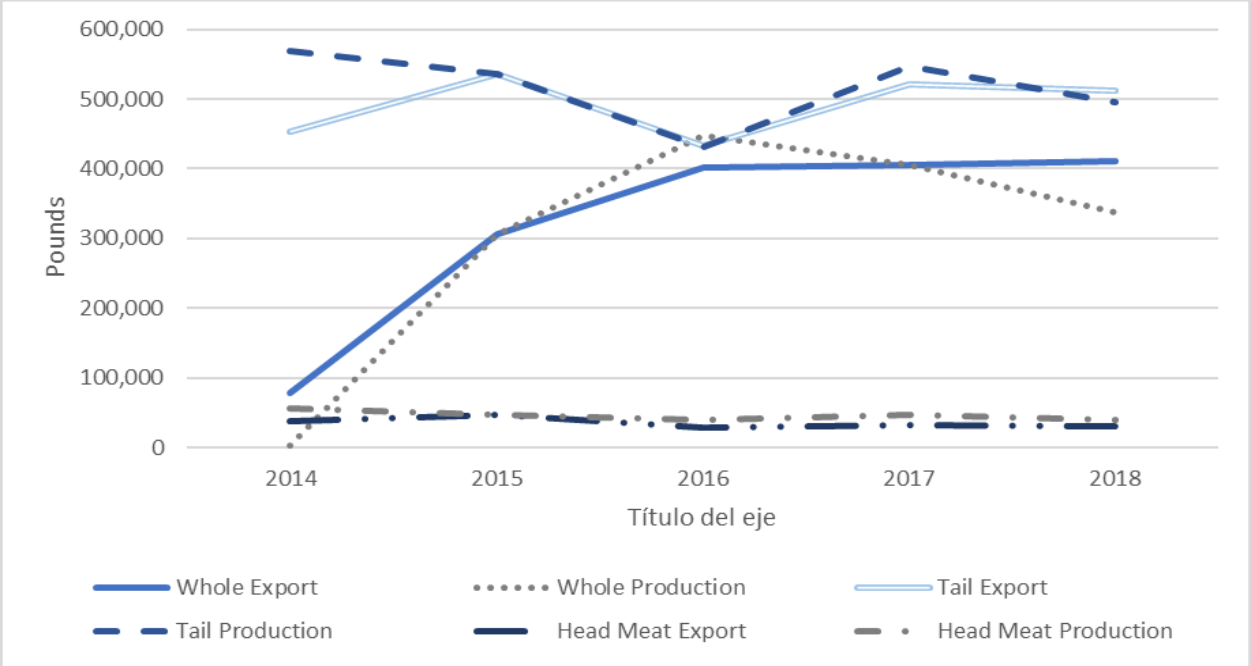
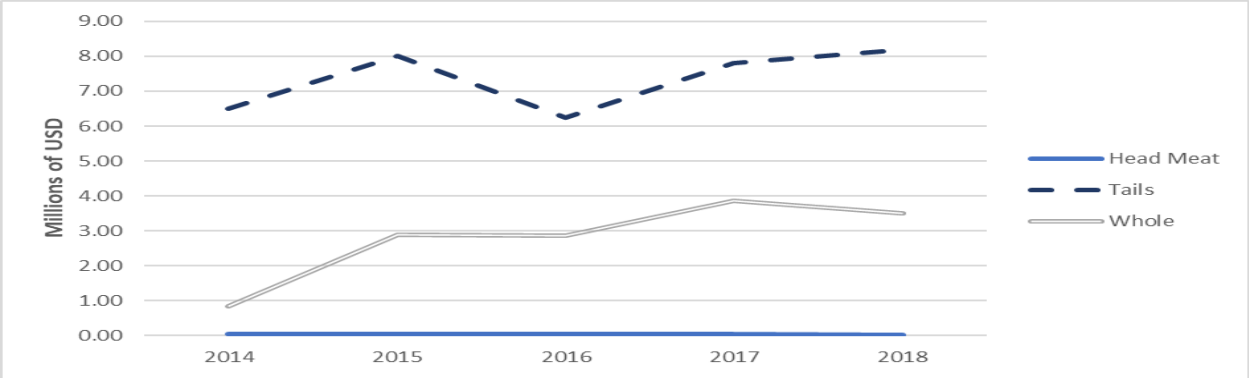


Figure 34 Lobster earnings for the years in review



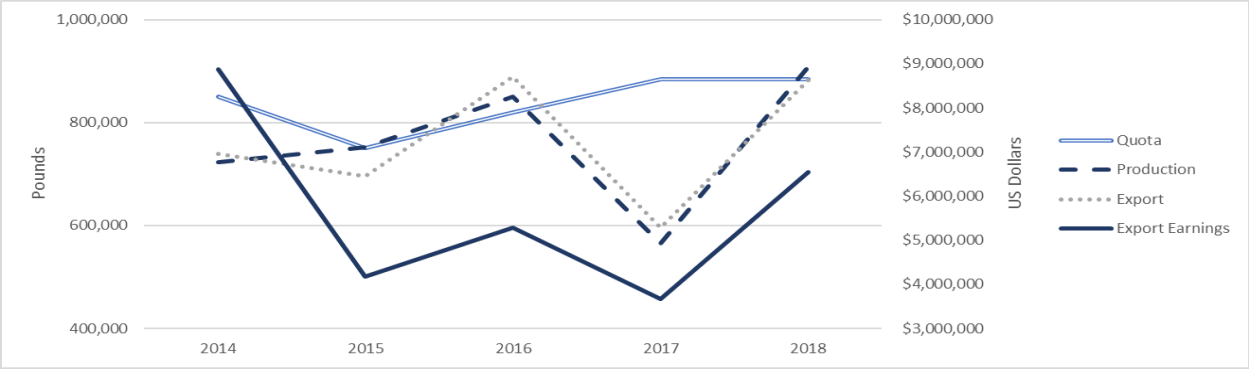
Conch

Uncontrolled harvesting and increased demand for Queen Conch resulted in its overfishing, illegal landings and a rapid decline in numbers. Seventy percent of all internationally traded meat is consumed in the United States. Queen Conch was included in CITES in November 1992. The inclusion of queen conch in CITES has prompted numerous collaborative initiatives to promote its recovery, reduce overfishing and ensure legal, sustainable trade.

The Queen conch *(Strombus gigas*) fishery is the second largest in the country which exports generates more than $3.6 million US in earnings (**Error! Reference source not found.**). An annual quota is generated which is 70% of the maximum sustainable yield. There is a closed season from 1 July to 30 September but fishing closes earlier if the allocated quota is met before. Conch is harvested by free diving along coral reefs and seagrass meadows ranging from 5 to 60 feet deep.

The Fisheries Department conducts comprehensive population assessments every two (2) years since 2004. Every year a quick sampling is conducted in order to generate the annual catch quota. Figure 35 shows quotas and productions and exports and values for the years in review. Conch production after increasing slightly in 2016 declined by 33.5% in 2017 to slightly surpass the quota of 884,092 pounds. However, it increased again in 2018. The reason for the decrease in 2016 could be a reflection on the state of the population or an over-calculation of the annual quota.

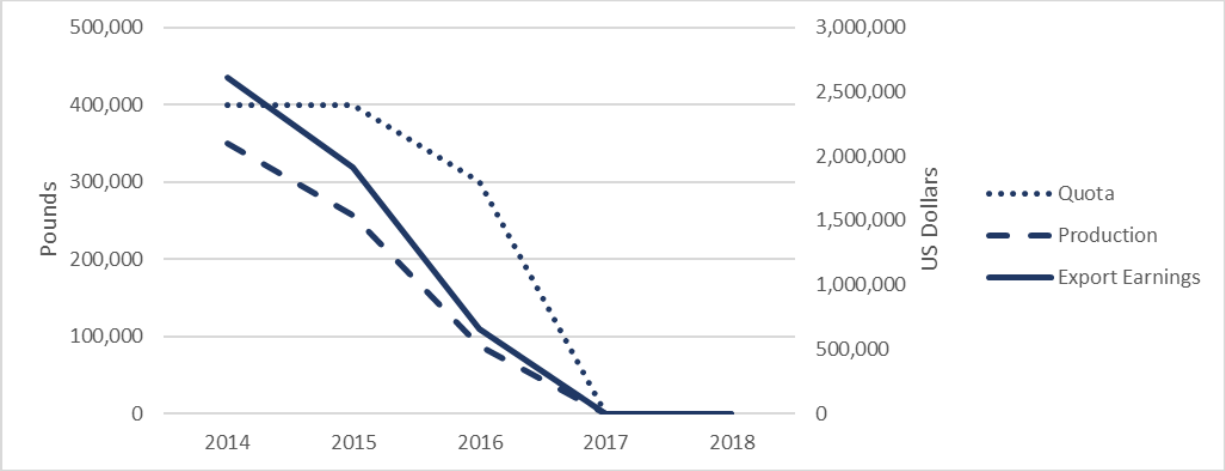
Figure 35 Conch quotas, production, export and earnings 2014-2018



Sea cucumber

After a brief population study in the south of the country, the sea cucumber fishery began in 2009. Two species, Donkey Dung (*Holothuria mexicana)* and Three-Rowed *(Isostichopus badionotus)* sea cucumber compose the catches that oscillate between 180,000 to 400,000 pounds. The regulations of 2009 and 2012 grant the Fisheries Department the power to set annual quotas and monitor the fisheries in order to make informed management decisions. Quotas are generated by sampling in sea cucumber habitats in the territorial waters. 2016 was the last year in which fishing was allowed with a quota of 300,000 pounds but the production was only 87, 407 pounds. This shows a decline in production of 66% compared to 2015 (36). Reason for the decrease could be reflection of the state of the population or an over-calculation of the annual quota. This important commodity is exported to the USA, Hong Kong, Mexico and Taiwan.

Figure 36 Quota, exports and earnings for sea cucumber 2014 - 2018

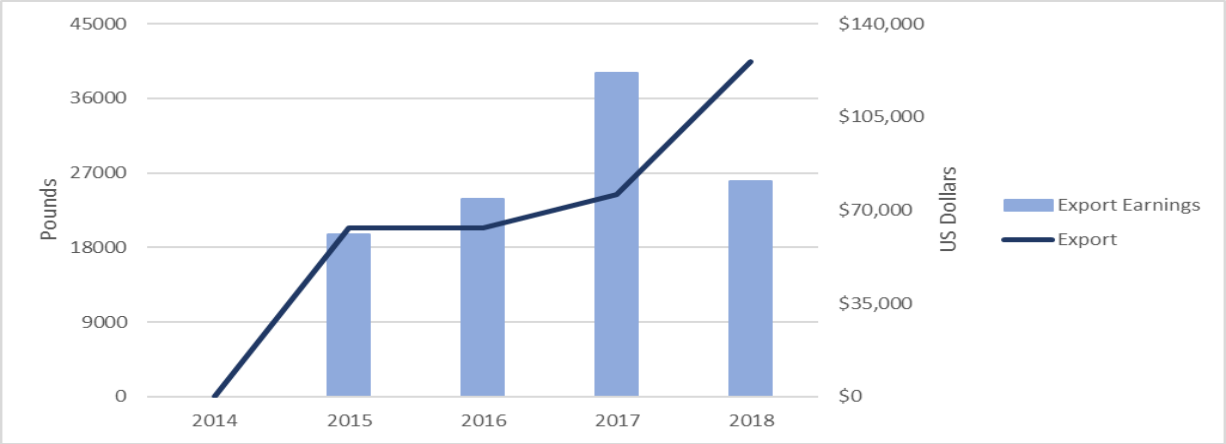


Sharks

The shark fishery in Belize is guided by regulations instituted under the Statutory Instrument 78 of 2011. The regulations have a closed season (August 1 to October 31), disallow wanton waste, bans fining and mandate fishers to report catches. Belize also adheres to the Central American Fisheries & Aquaculture Organization Regulation OSP-05-11 which prohibits shark finning at the regional level. The Whale Shark, *Rhincodon typus,* and the Nurse shark, *Ginglysmostoma cirratum*, are completely protected.

The National Action Plan for the Conservation and Management of Sharks 2017-2022 was developed in collaboration with the Belize Shark Working Group, which is composed of governmental authorities, non-governmental organizations and fishers (cooperative and independent). The plan embodies the principles of the FAO's International Action Plan for the Conservation and Management of Sharks and Regulation OSP 05 11 which are in line with the precautionary approach, the need to minimize catches, discards, and guarantees responsible fishing practices.

Figure 37 Shark exports and earnings 2014 – 2018



Shark production and exports were considered the same as the shark fishery is geared to the export market in the neighbouring countries of Guatemala and Honduras. Production increased sharply from 2017 to 2018. However, the earnings decreased by 33.4%.

Benefits of principal coastal and marine fisheries

Belize relies on subsistence and commercial fishing for food and income generation for a large portion of the population especially in coastal communities. The demand for fishery products has increased in a fast-growing and nationally important marine-based tourism industry. Fifteen thousand Belizeans directly benefit from the fishing industry. An additional 1,200 are employed in processing and marketing services. The fishing industry ranks fifth in the national economy and Coastal communities such as Corozal, Sarteneja, Chunox, Copper Bank, Caye Caulker, Belize City, Dangriga, Hopkins, Seine Bight, Placencia, Mango Creek, Monkey River and Punta Gorda are highly dependent for income generation.

Impacts of coastal and marine fisheries on Belize's coastal zone

The impacts of coastal and marine fisheries on Belize's coastal zone is minimal. Belize has made much progress in policy and legislation for the sustainable management of aquatic resources through consultations with key stakeholders, especially the fishers. Fishers and fishing vessels need to be licensed in order to fish. Through this legislative tool and with the assistance of its various units, the Fisheries Department collects data on the various fishing activities to make informed management interventions in relation to the resources. There are several regulations for different commercial and non-commercial species. There are several regulations for different arts and fishing methods. Fishing officers are legally authorized to stop, board and search vessels, vehicles or aircraft and to detain fishermen or anyone else they specifically suspect have violated fishing law and its regulations. The Fisheries Department is promoting new approaches that use conventional and unconventional data for adaptive management measures.

There can be impacts on the coastal zone through illegal, undeclared and unregulated (IUU) fishing[3] which has increased substantially in the past 20 years by the demand for seafood and high economic benefits. It is estimated that in the western Caribbean alone, IUU fishing comprised of 30% of marine products landings with an estimated value between US $700 million and US $930 million USA dollars per year (FAO Circular No. 1193).

The Department of Fisheries could be considered to have good control of the fisheries with limited available resources especially the lack of personnel, obsolete equipment and an inadequate operational budget. The draft lobster and conch management plans, which were developed with the support of OSPESCA, should be adopted. The Department needs to continue to work closely with the non-governmental organizations with clear working terms of reference in the implementation of innovative tools and management measures.

v. Shipping

The liberalization of the markets, the numerous bilateral or multilateral agreements in force in the world, and the growth of several emerging economies have caused a considerable boom in international exchanges, particularly in merchandise exchanges favoured by the improvement of transport techniques (ACS, 2019a).

It is currently estimated that 90% of the goods that circulate the world travel by sea, which makes maritime trade one of the biggest challenges for economic growth. The Greater Caribbean does not escape the process of globalization, and the development of maritime transport is a fundamental challenge for the growth of the region (ACS, 2019a).

The Caribbean Sea is classified as one of the main transit areas in the world and hosts more than 90,000 calls to the port per year (Singh, 2015). Due to the heavy maritime traffic, the risk of pollution caused by oil, chemicals, garbage, sewage and food waste that is thrown into the ocean, negatively affects fishing and tourism marine habitats (ACS, 2019b). In the case of the coastal area of Belize, water taxi routes, shipping routes, and cruises cross almost the entire extent of the country's coastal waters. These maritime transport activities sometimes overlap with other activities or cause effects on wildlife, such as collisions between manatees and vessels (CZMAI,2016).

Effect on marine habitats

Maritime and port transport activities have adverse effects on the terrestrial habitat and the marine ecosystem in several ways. The rapid growth of maritime trade and the increase in the size of the vessel cause the expansion or construction of new ports that require new areas for unloading and storing containers, which causes the loss of terrestrial habitat and the effects on the ecosystem marine (Waker et al., 2017).

[3] IUU fishing is defined as fishing that is carried out contradictory to the legal conservation and management measures that exist around the world. IUU fishing depletes populations of aquatic species, destroys habitats, distorts competition, threatens food security, harms honest fishers, robs governments of income and weakens coastal communities, especially in developing countries like Belize.

Belizean Marine Zone is characterized by its low depth and the presence of the barrier reef and other habitats of ecological importance whose state of health depends mainly on the impacts that can be generated by human activities. The type of vessels that transit the coastal waters of Belize can be classified as cargo transport ships and tourist cruises; smaller vessels that carry passengers, fuel, and merchandise; as well as boats dedicated to fishing or recreational activities. Larger vessels such as cargo ships and cruises have routes that are established considering the time, depth, presence of sensitive habitats and the safety of the passengers, crew or cargo they carry.

On the other hand, the presence of human activities in several islands and cayes that are in shallow waters, require marine transport and the means of safety for the transit of vessels remain the same as those used for large vessels. However, the number of vessels and the frequency in which particular areas transit increases the possibility of environmental impacts. The effects of frequent boat traffic in certain areas are difficult to detect. The collision of species and the changes in habits of certain species generated by the noise of the boats are a sign of the impact it can generate.

Although international maritime policies and regulations are established primarily by the United Nations International Maritime Organization (IMO), marine transport activities in "local waters" must be regulated by the national government through policies or strategies. These strategies represent a significant challenge due to the number of capacities that should be available for their application. To increase the efficiency of policies or strategies, several authors have discussed the role of self-regulation and voluntary actions, such as corporate social responsibility (CSR) practices in the maritime transport industry (Parviainen et al., 2018). In many Latin American countries, there are self-regulation schemes, as in the case of responsible fishing, but with severe limitations to achieve the sustainability objectives required by the activity. In the case of maritime transport, it is necessary to introduce the CSR concept gradually and strengthen the collaboration between actors to make the application of marine traffic control means more efficient and reduce the effects on the marine area.

vi. Aquaculture & Mariculture

Aquaculture

The aquaculture industry in Belize started in 1982 and together with fisheries, they contribute 3.2% of the gross domestic product. The currently cultivated species are the Pacific white shrimp (*Litopenaeus vanammei*) and Nile tilapia (*Oreochromis niloticus*) in sites such as Dangriga Town, Riversdale, Monkey River, Ladyville and south of Belize City. The Pacific white shrimp remains the most lucrative product, and in 2016 represented 97% of the value generated by aquaculture, despite the collapse of its production in 2015 (Fugazza et al., N.D.). Historically, shrimp production has been approximately 10 tons per year, but production declined dramatically in 2015 and 2016 due to Early Mortality Syndrome (EMS). Consequently, the production value fell from $ 28.6 million in 2014 to $ 3.6 million in 2016 (Fugazza et al., N.D.).

The aquaculture industry has benefited from the climatic conditions of the country which have favoured the reproduction and growth of the species described above. However, the industry is very vulnerable to disease outbreaks, increasingly non-seasonally adjusted weather patterns, the risk of tropical storms or hurricanes, droughts and floods that are increasingly affecting the production and export of products (NBSAP, 2016, p: 16).

Belize is the first developing country in the world to earn (in 2015) the Aquaculture Stewardship Council (ASC) certification for demonstrating that production was obtained with minimal impact on the environment and the communities where the shrimp farms are located (Fugazza et al. ND). Other alternatives, better aeration systems and zero water exchange, to reduce the discharges of nutrients and solids suspended in the water column have been used by companies such as Belize Aquaculture Ltd., to reduce the effect on water quality in ponds and increase shrimp production levels (Burford et al. N.D.).

One of the most concerning issues in the production of economically valuable species in ponds has been the discharge of water with high concentrations of nutrients and other elements into the marine environment, but in the case of the land area, the size of the ponds is an issue that should be considered in planning strategies. The construction of ponds can cause significant modifications to the coastal landscape and reduce the coverage of different species of flora. Currently, the Guidelines for Coastal Zone Management prepared by the CZMAI, establish areas, production volumes and marine areas that should be monitored based on changes in the aquaculture industry and the state of terrestrial ecosystems in order to improve the performance measures (CZMAI, 2016). On the other hand, the presence of agricultural activity also produces significant changes in the original coverage and when combined with aquaculture activity, they generate synergistic impacts that can be difficult to prevent or mitigate if there is no adequate planning.

Other factors for the cultivation of commercially valuable species in ponds are the quality and quantity of freshwater that is required to achieve optimum production. In the case of Nile tilapia, the use of fresh water used together with the volumes required for the supply of urban areas and irrigation of agricultural areas can be of concern. If there are no estimates of the quantity and quality of surface or groundwater available for different activities, this situation may become a problem in the future.

Mariculture

The interest to diversify the aquaculture sector in Belize included the commercial production of species in marine cages whose rapid growth, quality and market price offers advantages to invest in their cultivation. In addition, the country offers attractive competitive advantages due to its location in the Caribbean region which allows seawater temperatures off the coast to range between 26.9 ° C and 30.5 ° C (Beltraide, 2019) while the presence of the barrier reef offers protection to the systems of culture in marine cages in case of events of storm of low intensity.

Marine Farms Belize Limited (MFB) started in 2006 a marine farm at Robinson Point, in the waters adjacent to the coast, eight nautical miles southeast of Belize City (FAO, N. D; MFB, 2019). The species selected for cultivation was Cobia (*Rachycentron canadum*) and the first harvest was obtained in 2007 with an average fish weight between 10 and 12 pounds. At the end of 2007, volumes of 9 thousand to 10 thousand pounds of product per harvest were exported biweekly to the city of Miami, USA (MFB, 2019).

According to Gillett and Myvette (2008, p: 56), despite the possible advantages that exist and the gains that could be obtained by the production of Cobia, the expected increase in the frequency and intensity of hurricanes and other derived storms from climate variability and change could affect all aspects of aquaculture in Belize. Most susceptible would be cultivation in cages and other breeding systems at sea which could experience cage damages, cultivation losses and damages to supporting infrastructure on

land. Hurricanes and tropical storms have caused severe impacts in the fisheries and aquaculture sector. Storms forced the private industry to stop Cobia production by not being able to recover from the losses caused by their impacts (Table 16). There are scarce possibilities of establishing feasible adaptation measures in the marine area in the face of adverse weather conditions which ensure these activities to continue.

Table 16 Impact of natural disasters on fisheries and aquaculture

Name of the Event	Date & Year	Fisheries sector damage / Cost (BZD)
Hurricane Dean	August 21, 2007	Fisheries: $1.32 million
Tropical Storm Arthur	May 31, 2008	Fisheries: $5.4 million Aquaculture: $7.8 million
Hurrican Earl	August 2016	Aquaculture/ Capture Fisheries: $ 15.8 million (3)

SOURCE: MODIFIED FROM GILLETT AND MYVETTE (2008) IN: DANA, NEMO (3) DANA, NEMO 2016.

vii. Invasive Species

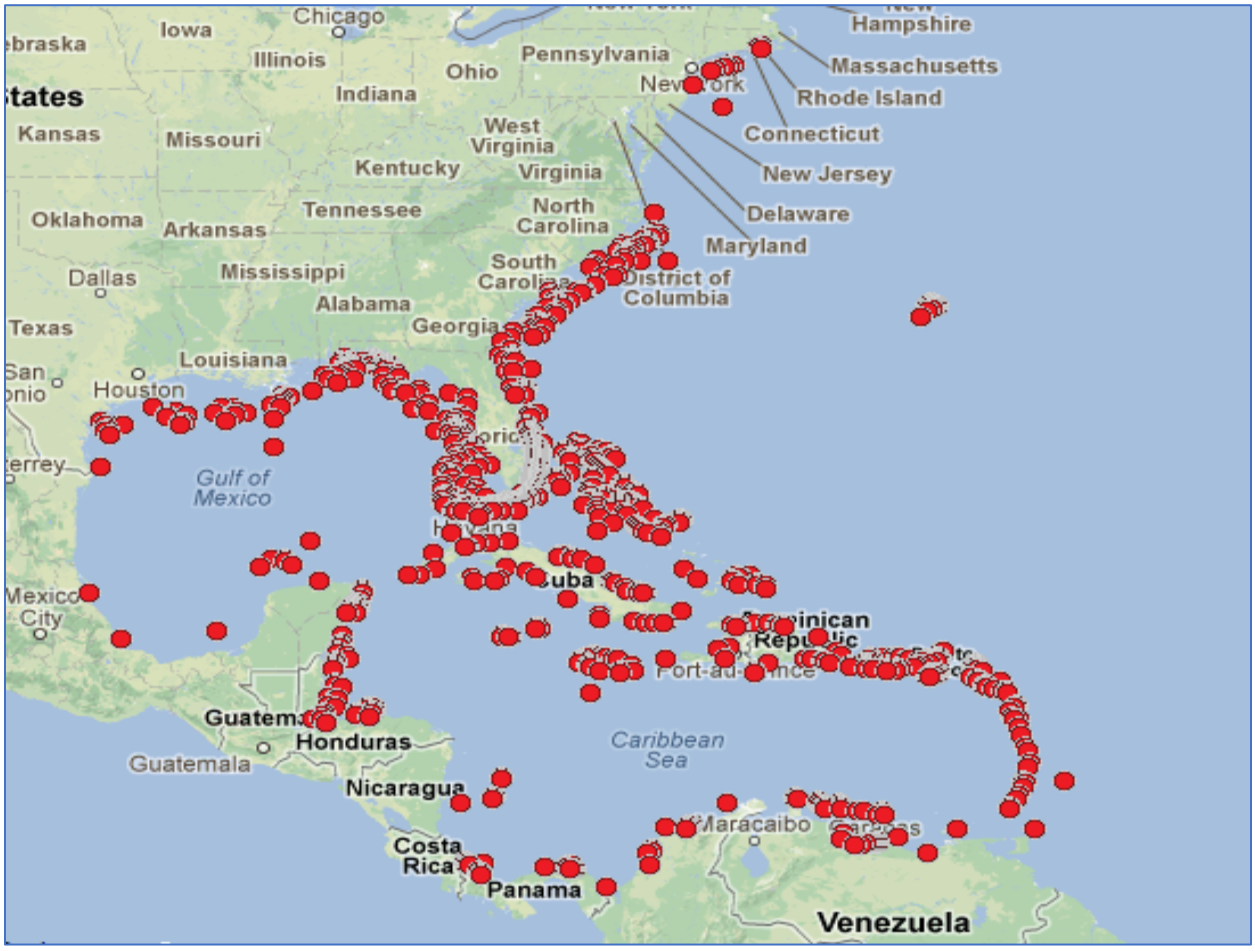
An exotic species is a species introduced outside of its past or present natural distribution and it is called an invasive exotic species (IES) when it becomes problematic (IUCN, 2019) because of the impacts that it can cause, such as the loss of economically important species, the threat to the survival of endemic species, as well as the affects to the functions of the ecosystem, the cultural and economic resources of the local communities (Gómez-Lozano, 2013).

Lionfish

Lionfish are native to the Indo-Pacific. The invasion of lionfish is responsible for threats to various fisheries in the region. It is believed that they were first introduced in the waters of south-eastern Florida where they were being held as ornamental fish. Lionfish were first observed along the coast of Florida in 1985 and has spread to the Gulf of Mexico, Caribbean Sea and the Atlantic Ocean (Figure 38).

The invasion was possible because the lionfish have no native predators in the Atlantic and Caribbean region. They are voracious hunters, known to consume more than 60 other species of marine organisms, including their own in the region. Lionfish has very high fecundity as a single female spawns more than two million eggs per year and can live in multiple coastal habitats such as coral reefs, seagrass beds and mangroves. They have been found at 300 meters depths.

Figure 38 Lionfish invasion.



SOURCE NOAA

Management strategy

The lionfish invasion in Belize is extensive. As a result, implementation of control efforts is a priority. A number of control measures are utilized, including culling, promotion of commercial and recreational fishing of lionfish, design and implementation of marketing schemes, establishment of cooperation schemes between fishers, restaurants and hotels to encourage consumption of the species, removal of lionfish from MPAs by fisheries managers and promotion of spear fishing for the species (CRFM Implementation Report 2015). Belize has a National Lionfish Response and Management Plan that needs updating. The current Fisheries Legislation authorizes the Fisheries Administrator to issue permits for SCUBA divers to engage in culling of lionfish. However, the spears used need to be approved by the administrator. Many lionfish derbies are held annually where thousands are removed and consumed.

The range of lionfish distribution requires different collaboration and coordination mechanisms for its control, such as the Regional Strategy for the Control of Invasive Lionfish in the Wider Caribbean (Gómez-Lozano, 2013) and the Regional Strategy for the Control of Lionfish in the Mesoamerican Reef (Rodríguez, 2014), where different governments, non-governmental organizations, international agencies,

fishermen's groups, tourism associations, research institutions and other groups affected by the presence of the invasive species are involved.

The most important tasks for these mechanisms are to know the different impacts caused by the invasive species and the way to control their abundance and distribution. This represents a considerable challenge and tests the capacities of each government to contribute to a solution for the problem. In the case of Belize, the Belize National Lionfish Management Strategy (2009-2015) sets the objectives for the control of these species in national waters (Chapman et al., 2019). The implementation of this strategy will require the participation of different actors and their actions will allow reducing the impacts on the barrier reef and other species that are being affected by the lionfish. Additionally, it will contribute to the fulfilment of sub regional and regional strategies. It is important to note that there is a need to gradually strengthen monitoring capacities to know the results of the strategy implementation and the experience acquired by various groups and government areas responsible for monitoring the marine environment in Belize.

viii. Sargassum

Brown algae of the genus *Sargassum* form dense floating populations on the surface of the ocean, and their presence has been frequenting for a long time in the Caribbean Basin and the Atlantic Ocean. These algae can be considered a nuisance when they reach the beaches. However, it is important to note that the sargassian mantles are home to many endemic species and provide protection or food to a wide range of species, such as invertebrates, important commercial fish and turtles (UNEP, ND).

Since 2011, the proliferation of sargassum populations (*Sargassum natans* and *Sargassum fluitans*) around the Greater Caribbean Region has been observed, even in places where, until recently, they were absent or were extremely rare. The potential impacts identified by the arrival of Sargassum in the shallow areas of the coastline and the beach are economic (tourism, fishing, nautical activities), environmental (disturbance of marine species, erosion of beaches, effects on mangroves, corals and seagrasses) and sanitary (algae decomposition and H_2S release) (UNEP, ND).

Due to the dependence of the Caribbean territories on their marine and coastal areas, the arrival of sargassum in shallow areas near the coastline and beaches has had an economic impact, mainly in the tourism sector which was severely affected by the unprecedented levels of sargassum that reached the beaches of the Caribbean in 2018 and that resulted in estimated cleaning costs of US $ 120 million. Besides, the region is the most dependent on tourism in the world, where it is the primary economic sector in 16 of the 18 Caribbean states and holds about 3 million jobs (CND, 2019).

Management Strategy

In order to improve coordination and help affected countries facing the arrival of sargassum in the Greater Caribbean Region, the Activity Center for the Protocol concerning Specially Protected Areas and Wildlife for the WCR (SPAW-RAC) and the SPAW Secretariat of United Nations Environment Program - Caribbean Environment Program have been working together since 2015 to improve regional cooperation through 1) Data exchange across the region, with the launch of an active exchange platform, 2) Networking and 3) Support for research on the origins, impacts and ways of controlling the arrival of sargassum (UNEP, ND).

In the case of Belize, among the most important actions that have been carried out, were 1) the support to the municipalities in the cleaning of beaches with an investment of BZ $ 1.5 million dollars through the Belize Tourism Board, 2) the formation of a Sargasso Working Group, 3) a tax relief for properties severely affected by sargassum, 4) ease of duty exemption for imported machinery and equipment to support cleaning efforts, 5) municipal assistance support that includes disposal, collection - disposal and storage sites, 6) launching of social media awareness campaigns so that tourists and interest groups know what is being done and what are the best practices when it comes to getting rid of Sargassum, and 7) forecast , where a system has been developed to help predict the influx of sargassum on the coast of Belize. The reports are published every Wednesday, Thursday and Friday along with the weather forecasts (BTB, 2019).

These 7 actions show the interest of the public and private sector to collect the sargassum in the emerged and submerged part of the beaches, but it is necessary to establish an action plan to attend the arrival of the sargassum to habitats such as the barrier reef, the coastal lagoons, areas of seagrass, mangroves and flood areas, since efforts have been concentrated on cleaning recreational beaches.

Many questions arise about the effects of the continuous arrival of sargassum and the impacts that occur in the long term by removing the sargassum that floats on the surface of the water and with which it has been deposited at the bottom or in some sensitive habitat. The actions proposed to maintain the health of the habitats must establish ways to measure the effects produced by the sargassum and its cleaning, to prevent the gradual loss of the different environmental services that these areas provide.

In the case of the tourism sector, there are estimates of losses and the investment made to clean the sargassum, but in the case of critical habitats the costs for the loss of environmental services are often immeasurable and difficult to restore, so It is crucial to establish actions that reduce the effects of the continuous arrival of sargassum.

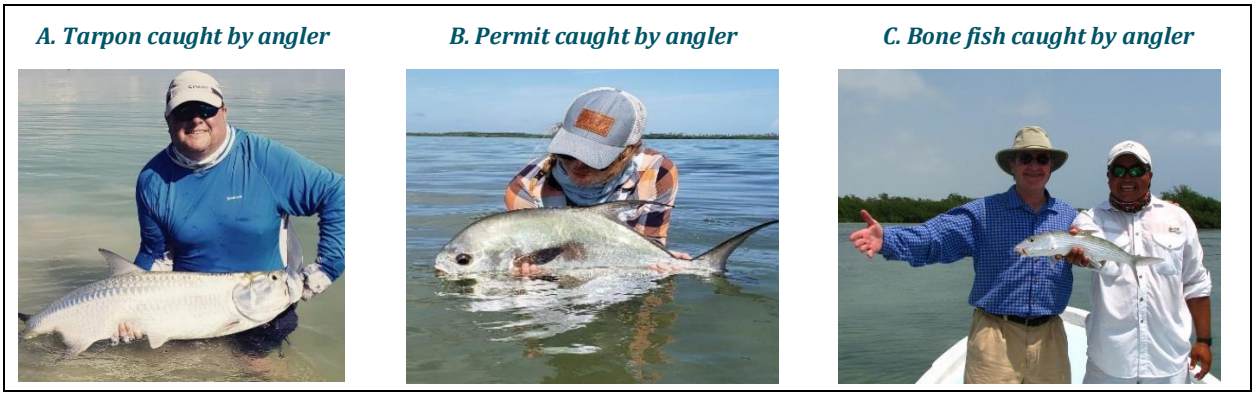
ix. Sportfishing

Worldwide, sportfishing is defined as fishing with a rod and reel for sport from a motor craft and is synonymous with recreational fishing as it is fishing for pleasure or competition contrasting with commercial fishing which is for-profit and subsistence fishing which is for survival. In Belize, it is more specifically defined as *“sports fishing” means fishing for recreational purposes only without the intention of selling the fish (CZM-Act)*. Sportfishing has become a major global economic driver generating billions of dollars for large and small nations. Sportfishing provides employment for tour guides and other personnel from marinas, tackle shops, restaurants, hotels and gas stations that cater to anglers. In large countries like the USA, it is a US$40 million industry. Statutory Instrument 115 of the Coastal Zone Act defines sport fishing as recreational fishing. It is estimated that sportfishing contributes, directly and indirectly, $100 million BZ to the economy.

Belize is known worldwide for its excellent sport fishing (reef, deep water and fly). It is most famous for its fly fishing around Bonefish, Permit and Tarpon (39). Fishing for these three species is primarily conducted on shallows or back reef flats throughout the country, from Northern Ambergris Caye, along the coastline and up to Punta Gorda. Tarpon is caught in channels, creeks and rivers. Reef fishing is mainly

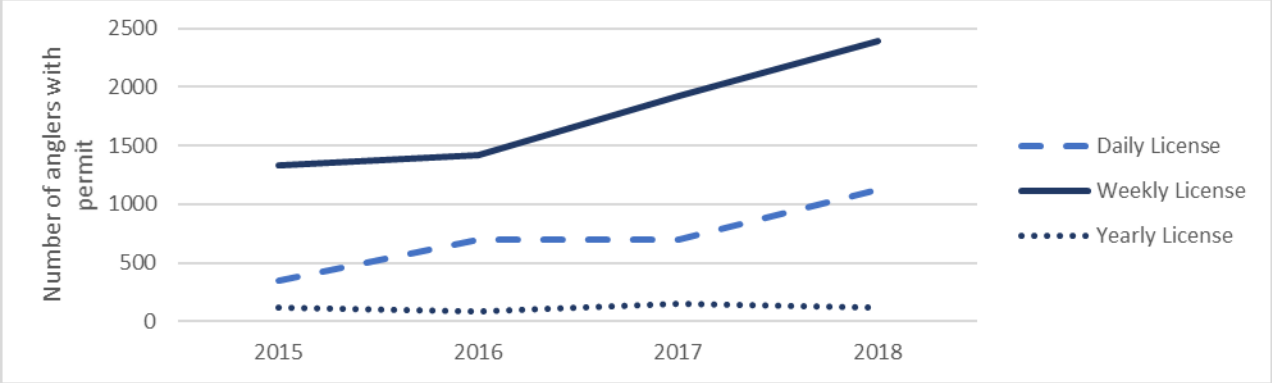
conducted inside the barrier reef and its channels. Most common catches will include snapper, barracuda, grouper and jacks. Sportfishing for billfish and other pelagic is starting to increase in popularity as up to four major fishing tournaments are held yearly. Tuna, blue marlin, dorado, king mackerel, wahoo, amberjack and kingfish are the most common catches.

Figure 39 Sportfishing target species



Belize is attracting North American tourist as it is the only English-speaking country in Central America and is just under two-hour flights from the USA. The Coastal Zone Management Authority and Institute (CZMAI) has the legislative authority to manage sport fishing in Belize. Tourists and nationals need a sport fishing license which can be obtained on-line through the CZMAI Website or purchased from tour operators. Figure 40 shows the total number of anglers permitted to sports fish in Belize, which has been increasing, for 2015 – 2018 (CZMA/I Data). The Belize Fisheries Department protected the Bonefish, Permit and Tarpon for catch and released only for the sportfishing industry.

Figure 40 Anglers permitted in Belize to Sport fish 2015-2018



Threats

Sportfishing species are under constant threat due to illegal fishing, usage of detrimental gear such as gillnets and harvesting for commercial purposes during sport fishing activities. Bonefish, before it became fully protected, was an eating delicacy resulting in many local different dishes. Some fishers still illegally fish Bonefish and sell it on the black market. Unattended gillnets are further decimating Bonefish and Permit populations especially when they are set along the coastline right into migrating routes. Reef fish and deep water pelagic are being caught and sold for commercial purposes by tour guides to supplement

their income. There is little data on the species and quantities caught by the sportfishing industry especially the pelagic species.

The consistent decline in stock abundance for billfish species within the Atlantic Ocean, the Caribbean Sea and the Gulf of Mexico, is a concern for the International Commission for the Conservation of Atlantic Tunas (ICCAT) which is responsible for the management of tuna and tuna-like species in the Atlantic Ocean and adjacent areas. The status of billfish stocks would be worse if it were not for the efforts of the various regional fisheries management organizations. There is a movement in Belize to protect billfish even though various species have been designated for sport fishing, and there is no requirement for catch and release. The CZMAI intends to work closely with the Belize High Seas Fishing Unit, Ministry of Finance to report incidental billfish catches so that this can be included in Belize's annual report to ICCAT.

Conservation

Belize has taken the extraordinary step to protect the three main species (Bonefish, Permit and Tarpon) of Belize's fly-fishing sector once again demonstrating its ability to be a world leader in conservation. Anglers have recognized the value of sailfish species and have started to encourage catch and release fishing when targeting these species in Belizean waters. The CZMAI has prioritized its focused on three main areas of management as it relates to sport fishing in Belize:

Education and Outreach – CZMAI recognizes the need to educate the general public on the importance of the sport fishing sector to Belize's economy by increasing foreign exchange and through job creation. Additionally, CZMAI understands the need to increase the knowledge of the general public on CZMAI's work in the sport fishing sector and the management of Belize's coastal zone at large. To this end CZMAI, participates in media visits; attends sportfishing tournaments; and host booths at science expositions and informational fairs (i.e. University of Belize's Earth day fair, OCEANA's Reef Week and Coastal Awareness Week Fair). To further bolster its efforts in the realm of education and outreach, in 2018 CZMAI launched a sport fishing sign campaign. This campaign resulted in the construction of signs at all the local fish markets along within Belize. The aim of this initiative was to inform the general public about the protected status of the Bonefish, Tarpon and Permit.

Planning and Management - Engaged stakeholders to Identify key sport fishing areas that will in the future be used to develop zoning recommendations within CZMAI's Integrated Coastal Zone Management Plan. CZMAI led efforts with stakeholders from north, central and southern Belize to form a national sport fishing association.

Sector Development - Co-sponsored major sport fishing tournaments within Belize:

- Tackle Box Wahoo Fishing Tournament
- Frenchies Offshore Fishing Tournament
- Placencia Lobster Fest Fishing Tournament
- San Pedro Fishing Tournament
- Tres Pescado Salm Fishing Tournaments
- Placencia Yamaha Marelco Saltwater Fishing Tournament
- Blue Water Classic

- TIDE Fish Festival Fishing Tournament.

The CZMAI is working closely with stakeholders to develop: an enforcement and compliance policy; strategic partnerships with local and international entities; and training of staff in conflict management negotiation and mediation.

Assessment summary

The following charts show summaries of the major pressures described above in the report on the terrestrial (Figure 41) and marine areas (Figure 42) in the coastal zone. Each row in the charts shows assessment of a coastal zone pressure using a scale that ranges from *very low* impact to *very high* impact. In each case, a trend scale is used to indicate if the pressure is increasing its impacts (deteriorating), reducing its impacts (getting better) or has no change (trend is not clear). These charts were constructed with individual responses from an online survey (which represented individual perceptions), then those responses were aggregated (to configure a collective perception) and were analysed and validated at a national expert workshop (See Methodology section and Annex 1 and Annex 4). Finally, the charts indicate the grade of confidence that the national experts had on the assessments. The grades ranges from *very confident* (because there is high quality of evidence and strong consensus regarding the level of pressure) towards *low* which means that the evidence and consensus are too low to make any assessment.

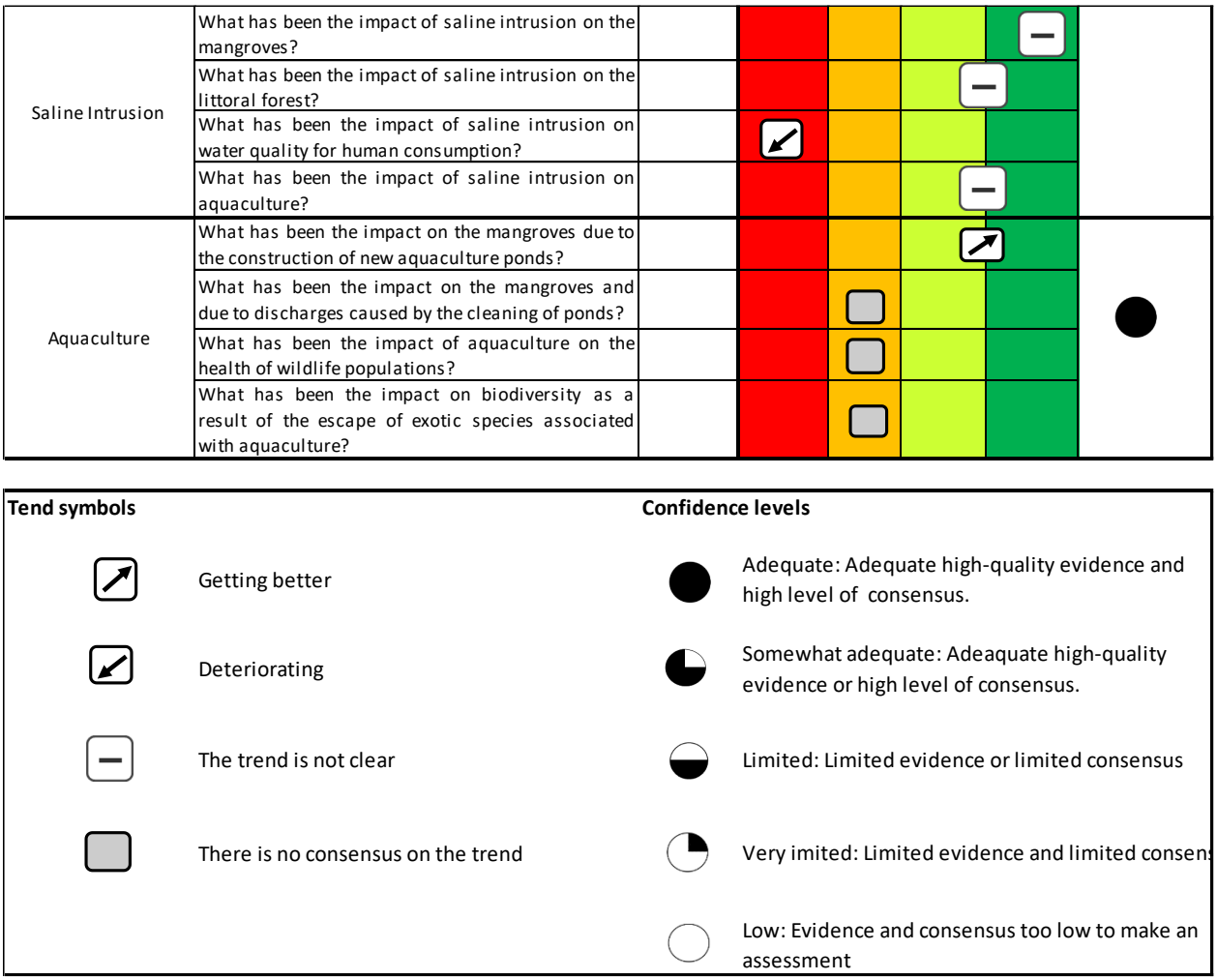
It is confident to says that urban development, tourism development, sediment transport and beach erosion are causing high or very high impacts on several elements of the terrestrial portion of the coastal zone and that most of those impacts are deteriorating. In contrast, energy, saline intrusion and sea level rise have low or very low impacts on the terrestrial portion of the coastal zone.

It should be noted that the collective perspective suggests that more evidence or consensus is needed to properly assess the impacts on tourism development, resources extraction, sea rise level, sediment transport and beach erosion.

Figure 41 Pressures on the terrestrial environment

Pressures	Questions	No consensus	Very high impact	High impact	Low impact	Very low impact	Confidence of the pressures
Climate, weather and climate change	What has been the impact of climate change on mangroves and littoral forest?				↙		●
Coastal development and land use	What has been the impact of urban development on mangroves and littoral forest?		↙				●
Tourism	What has been the impact of construction of new tourism development and recreational activities on mangroves and littoral forest?		↙				◔
	What has been the impact of disposing untreated water in the mangrove areas?	↙					
	What is the impact of pollution generated by garbage in the mangrove areas?		↙				
	What is the impact of coastal infrastructure associated with tourism development and recreational activities on the beach?		↙				
	What is the impact on wildlife species populations as a result of tourism development and recreational activities?		↙				
Energy	What has been the impact by the construction of new power plants in the mangrove and littoral forest areas?					–	●
	What has been the impact by the operation of new power plants on the bays?					–	
	What has been the impact by the operation of new power plants on the coastal lagoons?						
	What have been the impacts by ground discharges of polluting substances used in the operation of power generation plants?				↗		
Resources extraction (sand and pebbles for the construction industry)	What has been the impact of mangrove by the extraction of resources?			↗			◔
	What has been the impact on the littoral forest by the extraction of resources?			–			
	What has been the impact on the coastline caused by the extraction of resources?		–				
	What has been the impact on the soil due to the spillage of toxic substances used in the extraction of resources?					–	
Sea-level rise	What has been the impact of mangroves due to sea-level rise?					↙	◔
	What has been the impact on the littoral forest due to sea-level rise?				↙		
	What has been the impact on tourist development due to sea-level rise?			↙			
Sediment transport	What has been the impact on sediment extraction for the construction of coastal protection infrastructure?			↙			◔
	What has been the impact on sediment transport, due to the lack of sediment replenishment on the coast?		↙				
Erosion	What has been the impact of storm surge on the beach?		↙				◔
	What has been the impact of coastal protection infrastructure on the beach?			↙			
	What has been the impact of beach erosion on urban development?		↙				
	What has been the impact of beach erosion on the tourism development?			↙			

Figure 41 Pressures on the terrestrial environment (continuation)

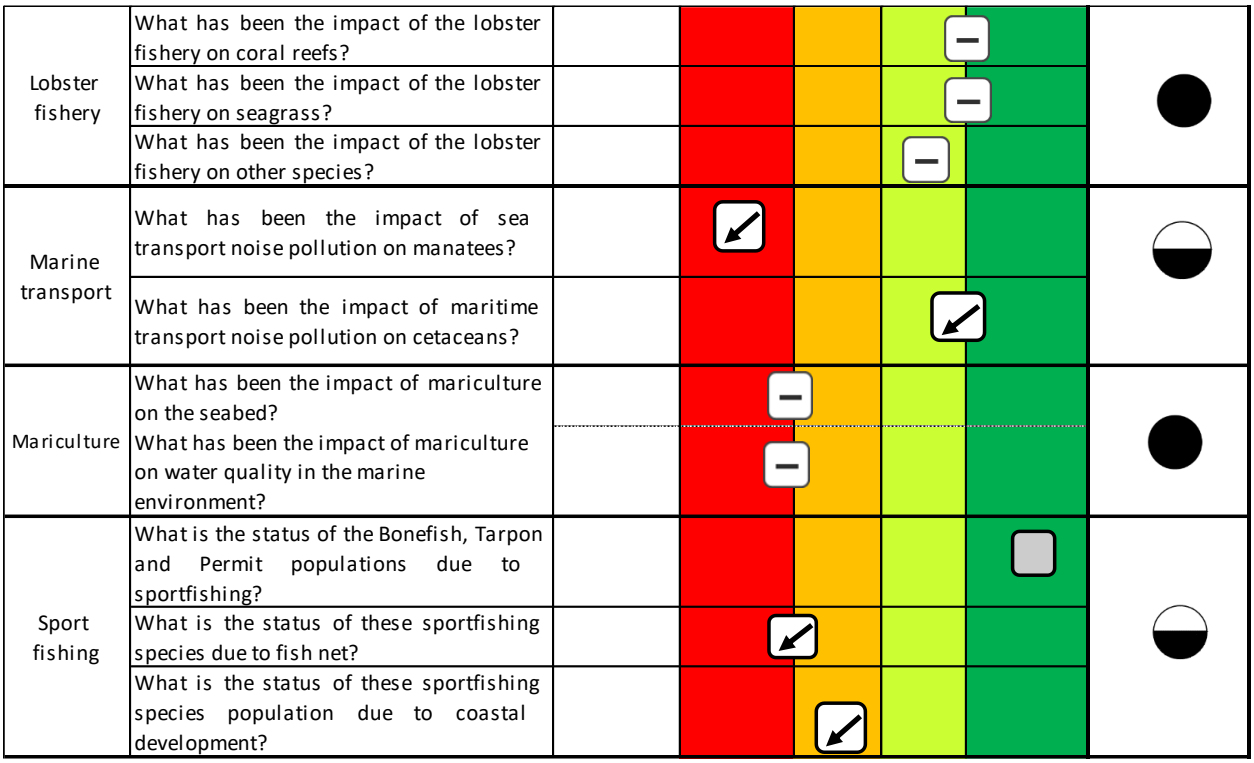


In regard to the marine area of the coastal zone (Figure 42), the main pressures that cause very high impact on elements of the marine ecosystems are: pollution by nutrients, dredging, sargassum, tourism, marine transport, mariculture and invasive species. A second tier of pressures with less impacts are from general marine pollution and sport fishing. Lobster fishing is the only pressure that overall causes very low or no impact. There are adequate confidence on the assessments for invasive species, sargassum, tourism, spiny lobster fishery and mariculture, for the rest of the mentioned threat more evidence though data is needed to conduct proper assessments.

Figure 42 Pressures affecting the marine environment

Pressures	Questions	No consensus	Very high impact	High impact	Low impact	Very low impact	Confidence of the pressures
Marine Pollution	What has been the impact on water quality due to marine pollution?			↙			
	What has been the impact on seagrasses due to marine pollution?			↙			
	What has been the impact on reefs due to marine pollution?			↙			
	What has been the impact on the various fisheries due to marine pollution?			↙			
Pollution by nutrients	What has been the impact on water quality due to nutrient pollution?			↙			
	What has been the impact on seagrasses due to nutrient pollution?		↙				
	What has been the impact on reefs due to nutrient pollution?		↙				
	What has been the impact on the various fisheries due to nutrient pollution?			↙			
Dredging	What has been the impact on the mangroves by dredging activities?		↙				
	What has been the impact on coastal lagoons by dredging activities?				↙		
	What has been the impact on the reefs by dredging activities?		↙				
	What has been the impact on seagrasses by dredging activities?			↙			
	What has been the impact on the various fisheries by dredging activities?				↙		
Invasive species	What has been the impact of invasive species on the reefs? No consensus, very high impact and high impact.		↙				
	What has been the impact of invasive species on seagrass?				▢		
	What has been the impact of invasive species on the various fisheries?			↙			
Sargassum	What has been the impact of sargassum on coral reefs?	▢					
	What has been the impact of sargassum on seagrasses		↙				
	What has been the impact of sargassum on the various fisheries?		↙				
	What has been the impact of sargassum on tourism activities?		↙				
Tourism	What has been the impact of tourism on coral reefs?			↙			
	What has been the impact of tourism on seagrass?			↙			
	What has been the impact of tourism on the various fisheries?				↙		
	What has been the impact of tourism on sandy beaches?		↙				
	What has been the impact of tourism on water quality in the marine environment?		↙				
	What has been the impact of tourism on biodiversity e.g. manatees, dolphins etc.		↙				

Figure 44. Pressures affecting the marine environment (continuation)



Recommendations

Reducing the impacts on the pressures analysed is a critical goal to achieve some milestones in the short (2-4 years), medium (5– 8 years) and large term (more than 9 years). Some suggested actions are as follows:

1. A beach erosion risk assessment is completed/updated. This will increase village, districts and

national capabilities to adapt or mitigate the impacts of urban development along the coast.

2. Coastal construction guidelines aligned with the principles of green infrastructure, are created, published and implemented in every single settlement along the coast.
3. Centralized systems for garbage collection and disposal are operational for the northern and southern portions of the coastal zone.
4. Programs for solid waste generation recycling and reducing are implemented at the country level by passing regulations and integrating value chains for collecting and processing cardboard and plastics.
5. Master plans for tourism destinations with densities and sustainable criteria are approved and implemented.
6. Cycles for development opportunities and construction moratorium for tourism at each destination are assessed and defined.

II. State of the Coastal Zone

a. Water quality

i. Water quality for mariculture activities

A fundamental characteristic of seawater is the chlorophyll (phytoplankton) content that starts the trophic chain. Studies carried out by ANIDE, using the MODIS satellite, for the period 2010-2015 shows that the average content of alpha chlorophyll increases towards the offshore with values of 0.080 µg / L for coastal areas and up to 0.21µg/ L sea indoors (Figure 43). For the 2014-2018 period, the average values were higher. Maximum values of up to 2.45 µg / L were detected in the Amatique Bay (Figure 44). Also, high values of alpha chlorophyll were detected in the inner lagoon with values of 0.53 and 2.29 µg / L (points 2 and 3), contrasting with the minimum offshore values of 0.19 and 0.181 µg / L (points 5 and 7) (Table 17).

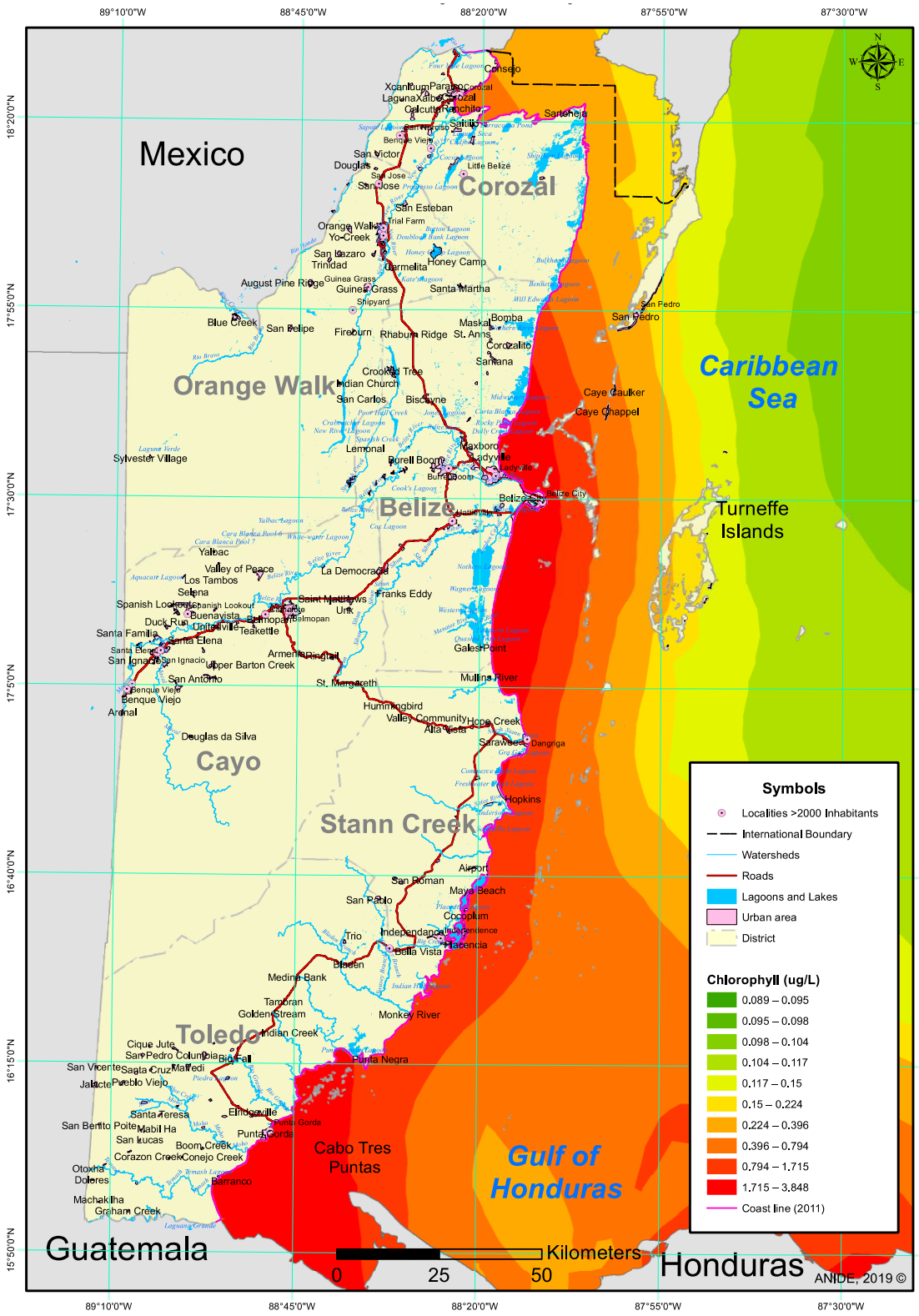
In general, there is an increase in the chlorophyll content in seawater in the reported periods. Explanations are raised from the increase in average sea temperature to increase in nutrients from wastewater discharges. The chlorophyll alfa data are also consistent with those of brown macroalgae (sargassum).

Table 17 Chlorophyll-a MODIS (µg/L. 2014-2018)

ID point	Latitude	longitude	Max	Min	Average
Point 1	18.2468	-87.4083	0.235	0.055	0.098
Point 2	17.5673	-88.0236	0.503	0.072	0.159
Point 3	16.6959	-88.2048	2.259	0.379	0.88
Point 4	16.0424	-88.691	2.45	0.394	1.288
Point 5	18.1372	-87.0787	0.194	0.044	0.096
Point 6	17.4625	-87.0238	0.202	0.05	0.096
Point 7	16.7906	-87.1447	0.181	0.054	0.095
Point 8	16.2007	-87.315	1.627	0.073	0.162
		Mean	0.956	0.14	0.35925

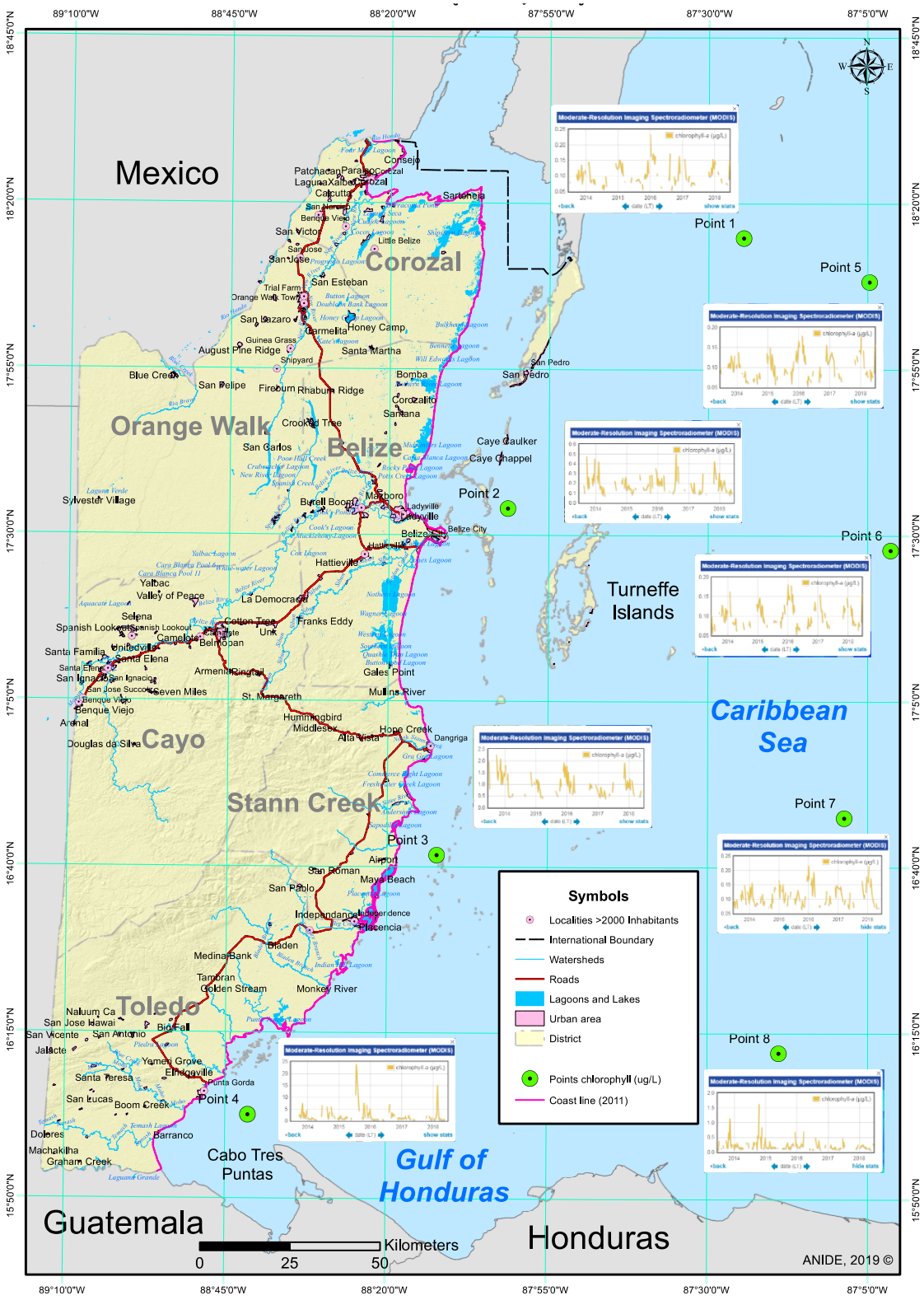
SOURCE: DATA: PACIOOS VOYAGER, 2019.
PROCCED BY ANIDE (2019).

Figure 43 Average content of alpha chlorophyll (µg/L) in the Belizean Caribbean Sea for the 2010-2015 period.



SOURCE: ANIDE, 2019. DATA FROM: MODIS AND PACIOOS VOYAGER.

Figure 44 Average content of alpha chlorophyll (µg/L) in the Belizean Caribbean Sea for the 2014-2018 period.

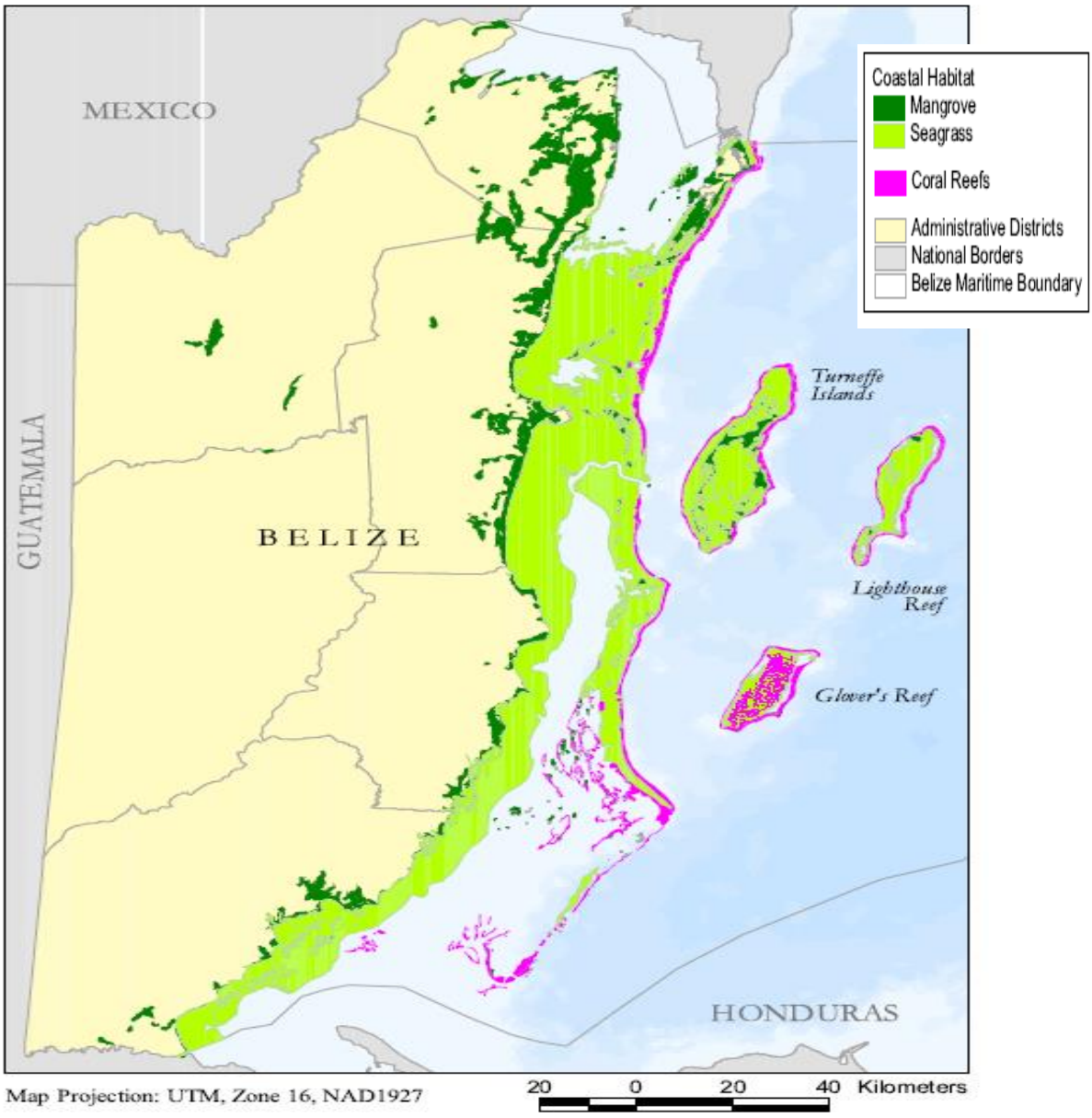


SOURCE: ANIDE, 2019. DATA FROM: MODIS AND PACIOOS VOYAGER.

b. Coastal Habitats

Tropical coastal habitats are mainly composed of deep waters, coral reefs, seagrass beds, and mangroves with estuaries and lagoons which are high-diversity systems (Karlson and Cornell 1998) providing important ecological and economic goods and services, such as seafood production, shoreline protection and tourism attractions.

Figure 45 Coastal Habitats



SOURCE: WRI 2005

The coastal zone of Belize consists of the largest barrier reef in the northern hemisphere, hundreds of Cayes, three offshore atolls, open deep waters, mangrove forests, littoral forests, coastal lagoons and

estuaries (Figure 45). These habitats provide refuge and feeding areas for hundreds of faunas as well as threatened and endangered species such as the manatee, marine turtles and Morelet crocodile. The eastern part of Belize beyond the barrier reef consists of open deep waters (down to 15,000 feet) where three of the four Caribbean atolls are found (Glovers Reef, Lighthouse Reef and Turneffe). The deep waters support phytoplankton which is consumed by zooplankton. The latter is consumed by small fish which are preyed upon by larger fish and marine mammals. At the top of the food chain, there are large pelagic fish including sharks.

i. Mangrove

There are four types of mangroves in Belize: Red mangrove (*Rhizophora mangle*), Black mangrove (*Avicennia germinans*), White mangrove (*Laguncularia racemosa*) and Buttonwood (*Conocarpus erectus*). The Red mangrove is found along the Cayes, coastline and waterways and is identified by the long prop roots that support the plant from the waterlogged environment. The black mangrove is found more inland from the water's edge and is recognized by small protrusions called pneumatophores that encircle the base of the plant. These pneumatophores facilitate gas exchange. The White mangrove and Buttonwood species are located further inland away from the water.

According to a 2018 report (Cherrington), Belize lost 2% of its mangroves since 2010. Land clearing for urban development was the main cause of mangrove deforestation. In contrast a recent report indicates that the losses in between 2014 and 2019 was 0.13 % and an average annual loss of mangroves and littoral forest cover off 15.84 ha. / year for the period of January 2014 through 30 November 2019 (Table 18)

Table 18 Annual net loss in Belize's mangrove and littoral forest cover, 2014-2018

Year	Area (ha.)	% loss	% remaining
2014	31.59	0.04%	99.96%
2015	19.89	0.03%	99.93%
2016	8.91	0.01%	99.92%
2017	5.94	0.01%	99.91%
2018	10.89	0.01%	99.90%
Total	**93.78**	**0.13%**	-

SOURCE: GRIFFING AND CHERRINGTON 2019.

Associated with the mangroves are coastal lagoons and estuaries. Lagoons run along the shoreline and are shallow bodies of water that provide access to the sea. The salt content of the water is altered by tidal exchange and the inflow of freshwater. Estuaries are points where rivers and the sea meet; the saltwater is brought into the estuary by tides where it mixes with the freshwater diluting the seawater. Both coastal and lagoons in Belize are covered with mangroves contributing to a higher diversity of fauna.

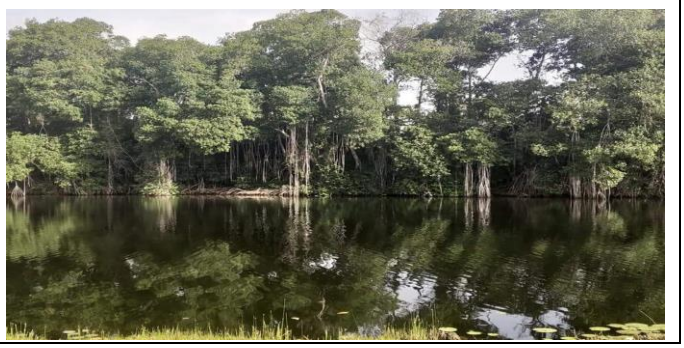
Approximately 78 species of fish and 180 of birds (Figure 46) feed and nurse on mangroves in Belize. Mangroves also provide habitat for 11 species of amphibians, 30 reptile and 40 mammals. Crabs and insects feed on the leaves while the decomposers such as microbes and fungi consume the decaying leaves and other detritus. In this process, nutrients like nitrogen, phosphorus, sulphur and iron are recycled. Underwater species such as sponges, snails, worms, anemones, barnacles, and oysters cling to the roots. Many aquatic species feeds between the roots and find shelter from predators. Various species of fish, crabs and shrimp spend the early life stages within the mangrove roots before migrating to the reef as adults.

In Belize mangroves are used for building traps, marking fishing grounds, construction materials for fishing camps and for cooking. Many years ago, mangroves were used for its dye for tanning clothes. Today, due to the increase in tourism, mangroves are used for building palapas. Mangroves along the coastline minimize erosion and protect against strong winds and wave action during storms. Environmental services provided by mangroves in Belize is estimated upwards of US$900,000 per hectare per year according to a 2006 UNEP report. Mangrove forests also absorb and store carbon from the atmosphere. As the trees grow, they take the carbon from carbon dioxide and use it as the building blocks for leaves, roots and branches. Mangroves constitute less than 2% of the coastal environment but account for about 15% of the carbon sequestration.

Figure 46 Mangroves environmental services

A. Various species of birds feeding and nesting on a mangrove island

B. Healthy Red Mangrove forest along the Belize River



Threats

Apart from the positive importance of mangroves, as a tourist and urban development demands continue, they are being cleared at an alarming rate.

Mangroves are cleared for coastal development (Figure 47) and most of the time illegally. In order to clear mangroves, a permit is necessary from the Forest Department, Ministry of Agriculture, Fisheries, Forest, Environment, Sustainable Development and Immigration. Regulations are not sufficiently enforced to stop illegal mangrove cutting.

Figure 47 Pressures on mangrove forest

Mangrove Clearing for Urban Development (Belize City)

Mangrove cutting and filling with sand for development

The shrimp industry that started in the 1980's has contributed significant revenue to the Belizean economy. In 2014, a total of 14.38 million pounds were exported to a value of US$44.23 million (SIB 2016 Report). However, the industry has been plagued with setbacks due to disease outbreaks with the most recent being the Acute Hepatopancreatic Necrosis Disease in March 2015. The shrimp farms have been constructed mostly behind the mangrove formations thus minimizing their destruction (Figure 48).

Figure 48 Shrimp Farm

PHOTO COURTESY OF ROYAL MAYAN SHRIMP FARMS LTD.

As sea level rises due to higher global temperatures causing the polar ice to melt, mangroves move to higher ground inland. However, a human settlement will impede migration. Mud accumulation, on which mangroves rely to migrate inland, does not match the sea level rise rate.

Conservation

Cooper et al. (2009) found that mangroves contribute up to US$249 million to the Belizean economy through their environmental services. According to Cherrington et al. (2010) in 1998, mangroves covered

3.5% of the land surface in Belize. In 2010, there was still 96.7% of the original mangrove cover (99.90% according with the lasts report); this means that the loss of mangroves is slow. New mangroves regulations have been enacted that are better address the cutting of mangroves due to development. The Minister of Agriculture, Fisheries, Forestry, Environment, Sustainable Development and Immigration signed the Protection of Mangroves Regulations in June 2018. The revised regulations emphasized on the management and conservation of mangroves along the coast, rivers and Cayes. The regulations also have an improved application process for mangrove cutting permits along with new fees and strengthened the fines and penalties to deter illegal mangrove alteration.

ii. Littoral Forest

Coastal littoral forests are defined as a narrow band of trees which grow along the sandy beaches bordering the coastlines. Coastal littoral forests are severely threatened and can become globally extinct. These forests are highly specialised ecosystems that apart from protecting the soil from erosion, also provide nesting grounds for turtles, feeding and roosting for indigenous and migratory birds and homes for small mammals and reptiles. Littoral forests in Belize cover the smallest land area (25 square Km or 0.11% of the landmass).

In Belize, littoral forests are found on the high sandy ground of coastal mainland and Cayes. Plant species found in the littoral forests are coconut (*Coco nucifera*), cocoplum (*Chrysobalanus icaco*), mata palo (Fiscus glabrata), Sapodilla (*Manilkara zapota*), Zericote (*Cordia dedecandra*), Gumbolimbo (*Burseva simaruba*), Copal (*Protium copal*), buttonwood (*Conocarpus erectus*), saltwater palmetto (*Thrinax radiata*), sea grape (*Cocoloba uvifera*) (Figure 49), poisonwood (*Metopium toxiferum*), wild black pepper (*Pimienta dioica*) and various types of palm trees and grasses. Some plants have a seasonal succession of fruits and berries that attracts different fauna.

Threats

The littoral forests are most threatened on the Cayes due to heavy urban development both planned and unplanned. On Ambergris Caye, which is the largest Caye in Belize, the native vegetation is being cleared rapidly. The fauna also disappears as a result of the loss of littoral forest.

Conservation

There is no legislation regulating littoral forests in Belize. The Government of Belize has protected some littoral forests under some protected areas status. In northern Ambergris Caye, 12,000 acres were protected in the Bacalar Chico National Park. Some owners of private land have also left portions of their littoral forests to minimise erosion and attract wildlife for tourist attractions. There is an urgent need to address the rapid loss of littoral forest before they are extinct in Belize.

Figure 49 Wild Sea Grape

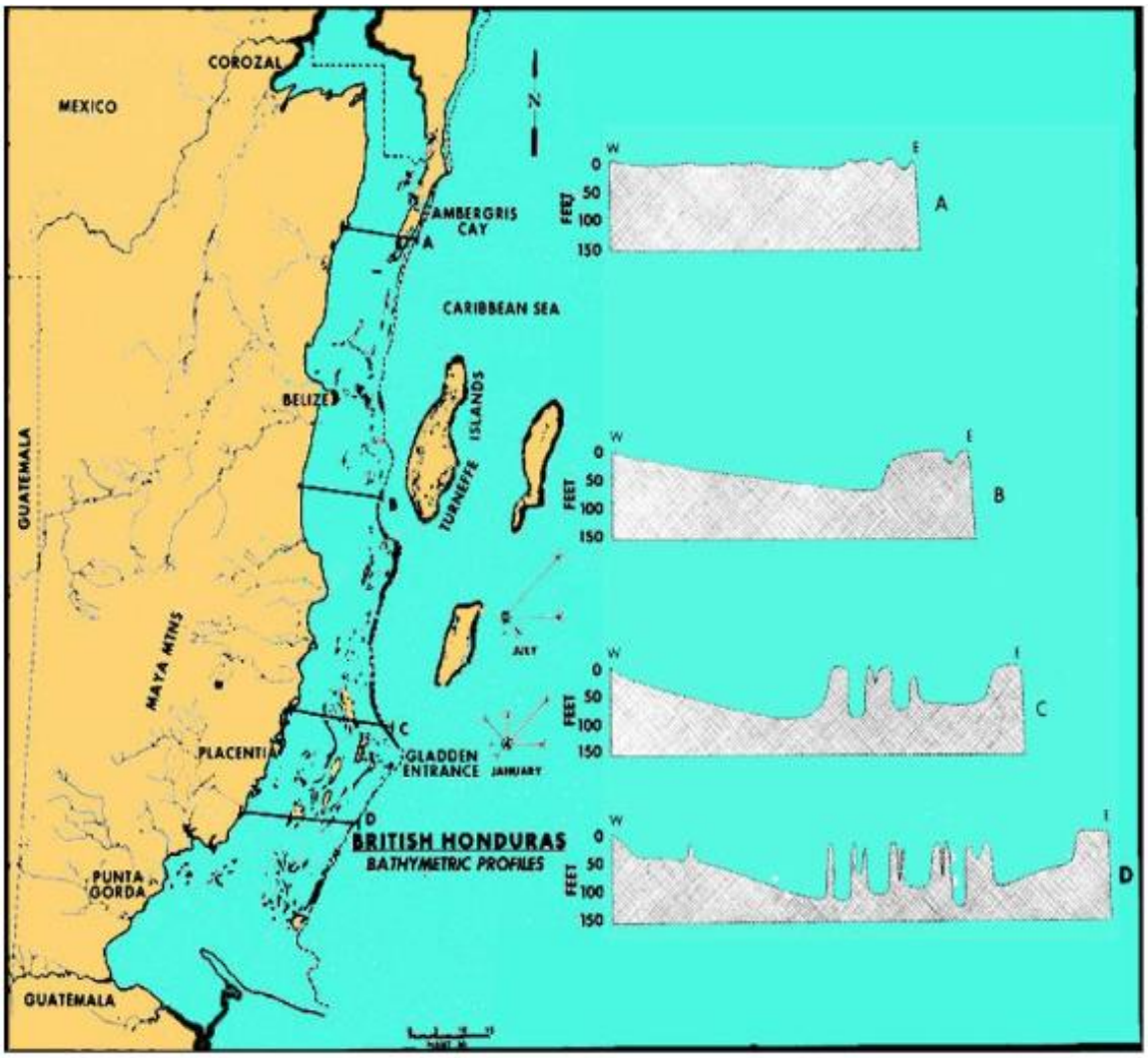
iii. Coral Reefs

Distribution of coral reefs along the coast

The Belize Barrier Reef is the most prominent feature in the marine environment consisting of hard and soft corals, sponges, crustaceans, molluscs, worms, fish and mammals. Fringing, barrier and platform reefs can be found along with the atoll reefs. Fringing reefs are found near the land while platform reefs are found between the barrier reef and the mainland (Figure 45). The barrier reef touches the mainland at Rocky Point, northern Ambergris Caye and runs parallel to the mainland extending twenty-five miles outwards.

The Belize submarine shelf is 170 miles long and its reefs represent the largest reef complex in the Atlantic-Caribbean area. Belize has three offshore atolls which along with the barrier reef, have high complexity and variety of corals and associated species. The Belize shelf is divided into distinct northern and southern halves. Its edge is characterized by a series of five discontinuous ridges that trend northeast and which are thought to be fault controlled. The Belize shelf is the drowned expression of a low-relief karst surface, on which are locally developed sinkholes and incised river channels (Mazzullo and Reid, 1985). The reef structures occupy a narrow strip on the seaward edge of the shelf. This reef meets the mainland on northern Ambergris Caye, Belize District, and runs southwards where it is thirty miles east of Punta Gorda Town, Toledo District (Figure 50 and Figure 51). Westward is the reef lagoon with coarse, slightly muddy skeletal sand, which is stabilized by beds of seagrass *Thalassia*, *Syringodium* and *Halimeda*.

Figure 50 Continental Shelf with the Belize Barrier Reef



The **Fore Reef** is found immediately outside the reef crest and has a flat rocky area of five meters depth with numerous soft corals, including *Gorgonia Ventalina, Plexurella sp.* and *Pseudopterogorgia sp*. The outer reef crest is subject to constant wave action and *Acropora palmata* is abundant. Moving eastward, the water depth increases gradually and at nine meters there are numerous East-West ridges. Going deeper, the coral configuration changes to *Montastrea sp*. and *Porites astreoides* along with large specimens of Verongia and *Xestospongia*. At this depth, the spur and grooves are more evenly separated and continuous. The reef wall `drop-off' occurs at approximately three fourth of a mile seaward of the reef crest.

The **Reef Crest** has a foundation of dead *Acropora palmata* and *Montastrea annularis* underlying it which provide support for the live corals, *Acropora palmata*, *Porities porites* and *Agaricia agaricites*. The dead corals are often extensively eroded, bored and covered by micro and macroalgal turfs. Small channels running perpendicular to the reef crest are found at various locations along the reef allowing water

exchange between the open sea and the lagoon. These channels are mostly extremely shallow and lined with outcrops of the hydrocoral *Millepora complanata*.

Figure 51 Belize Barrier Reef with Channel

The **Back Reef** is the area extending west of the reef crest containing many patch reefs situated in the midst of coral rubble often covered with an algal turf. Coarse sand and gravel make up the rubble in this shallow wave swept region. Patch reefs occur in this area due to coral fragmentation by intense wave action. Encrusting corals such as *Porites asteroids* and *Diploria sp.,* often grow on dead coral formations, building patch reefs closer to the surface of the water, the corals *Agaricia agaricites* and *Siderastrea siderea* also appear consistently on patch reefs in the back reef. The back reef is a nursery area for many of the smaller reef fish especially the herbivores.

The **Central Reef** is found in the reef lagoon mainly in the south range where the shelf topology reaches its maximum complexity with a narrow outer platform and a maze of patch reefs, faros, and pinnacles. This complexity originates with an eroded limestone (karst) under-surface covered by unusually steep coral reefs known as faros or rhomboid reefs (Figure 50).

State of coral reefs along the coast

Despite its enormous contribution to the overall Belizean economy, this climate range dependent fragile ecosystem is still threatened by a variety of anthropogenic sources such as coastal and tourism development; pollution from point and non-point sources, such as from excess nutrients, pesticides and agricultural run-off; coastal aquaculture and domestic waste on the reef; over-fishing; increased tourism activities such as boating and sedimentation caused by dredging, landfill and inland deforestation. It is additionally subjected to periodic natural phenomena including episodes of warmer temperature, flooding, bleaching, outbreaks of disease, storms and hurricanes. Some of the human activities may be

aggravating the impacts of these natural events, resulting in an inability of the ecosystems to recover as rapidly as they might have done under natural circumstances.

In 2015 the Healthy Reefs Report stated that the overall reef health in Belize remained in 'poor' condition with a reef health indicator (RHI) score of 2.5. The coral cover was scored as 'fair' (15%) but had declined slightly from 18% since the last report of 2012 likely related to an increase in macroalgal cover and declining water clarity.

In 2018 the Healthy Reefs Report stated that the overall reef health in Belize was in fair condition with an RHI score of 2.8. The coral cover was still fair (average of 16%) compared to 2015 even though some areas such as Lighthouse Reef had 19% coral cover. In Belize, parrotfish biomass continued to increase after protection in 2009 with the first indication of a slight decline in fleshy macroalgae.

It is illegal to remove corals from Belizean waters except for Black Coral (*Antipatharia sp.*) with special permission from the Fisheries Administrator.

Coral reef monitoring is conducted by government agencies, private researchers and NGOs to track changes. With scientific data including from climate change, informed decisions can be made to better manage the Belize Barrier Reef Complex which is included as part of the Mesoamerican Barrier Reef System. Belize has an active National Coral Reef Monitoring Group that has been very active since the mid-1990s. The group meets every three months to update on the status of the barrier reef and associated habitats and springs into action immediately to deal with coral bleaching, storm impacts or shipwrecks.

Economic activities that affect coral reefs

The Belize Barrier Reef complex provides protection to the coastline against hydrometrological events such as storms and hurricanes. The reef along with its associated habitats, seagrass beds and mangroves, support two of the largest industries: tourism and fishing. There are also other economic activities in Belize that affect coral reefs either directly or indirectly.

Tourism in Belize in the coastal zone environment offers a wide variety of recreational activities ranging from sports fishing, SCUBA diving, snorkelling, birding, and manatee watching. Sportfishing, dive and snorkel shops, hotels, restaurants, and bars line the oceanfront of the major tourist destinations such as San Pedro Town, Ambergris Caye, Caye Caulker Village and Placencia Village, Stann Creek District (Table 8). Tourism through visitation to the various sites along the reef system causes physical damage from humans destroying coral formations, anchor and shipwreck damage and habitat loss due to dredging and pollution. Due to the popularity of diving and snorkelling sites, the number of vessels and tourists sometimes leads to over-crowding resulting in environmental degradation and conflicts among operators (Figure 52).

Figure 52 Heavy visitation at the Hol Chan Marine Reserve

As indicated before, the national artisanal commercial fishery export-oriented and has been dominated by Caribbean spiny lobster (*Panulirus argus*) and the queen conch (*Strombus gigas*) even though there are small fisheries for sea cucumber, sharks and finfish. The fishery consisting of over 2,500 fishers using 750 vessels. The two largest commodities (lobster and conch) can be classified as fully exploited while others such as the sea cucumber fishery are overexploited.

Inland agriculture land use causes siltation that runoff eventually ending into the marine environment. Herbicides, pesticides and fertilizers used in agriculture also end up in the marine environment causing pollution that affects coral reefs and its inhabitants through bioaccumulation.

Governance for coral reefs conservation

Apart from the declaration of marine reserves to protect unique coral reefs and associated habitats, the Government of Belize, in 1996 got the Belize Barrier Reef System (BBRRS) inscribed as a UNESCO World Heritage site in 1996. The site is comprised of seven marine protected areas (Bacalar Chico National Park and Marine Reserve, Blue Hole Natural Monument, Half Moon Caye Natural Monument, South Water Caye Marine Reserve, Glover's Reef Marine Reserve, Laughing Bird Caye National Park and the Sapodilla Cayes Marine Reserve) representing 12% of the reef complex. The Government of Belize has also band petroleum exploration and extraction in the marine environment. This was possible through the concerted lobbying efforts of a consortium of non-governmental organizations. Since management of marine and coastal protected areas that include coral reefs is expensive, Belize has moved towards legally binding agreements between NGOs, in contractual forms clearly stipulating the roles and responsibilities of the parties, as well as provisions for withdrawal, renewal and termination of the agreements. NGOs can access especially international funding that government agencies cannot and as a result, coral reef protect is beneficial from the public and private perspectives.

The Government of Belize, in 2016 officially endorsed Belize's National Integrated Coastal Zone Management Plan. This decision reaffirms the Government's commitment to fulfilling its national agenda for sustainable development. The plan implementation will strengthen coastal zone resource governance through coordination and cross-sectoral decision making. The plan is science-based, comprehensive and informed by the various stakeholders operating in the coastal zone and addresses conservation with present and future needs in marine and coastal development. It's zoning scheme and policies will ensure economic development while minimizing environmental impacts. Under the Marine Climate Change Adaptation Project, sponsored by the World Bank and executed by the Fisheries Department, a repopulation of reefs within replenishment zones of two targeted marine reserves with temperature resilient coral varieties. Sites have been identified within the South Water Caye and Turneffe Atoll Marine Reserves for the construction of coral nurseries for coral propagation (Figure 53). Six nursery areas will be constructed within these protected areas. Coral colonies propagated will be out planted to preidentified areas within the conservation zones.

Figure 53 Coral Nursery

PHOTO COURTESY OF LISA CARNE, FRAGMENTS OF HOPE

iv. Seagrass

Seagrass are flowering plants that are found in continental water around the world. Seagrass can reproduce through sexual or asexual methods. In sexual reproduction, the plants produce flowers and transfer pollen from the male flower to the ovary of the female flower. Most seagrass species produce flowers of a single sex on each individual, so there are separate male and female plants (Segrasswatch.org). Seagrass will grow and thrive under specific environmental conditions such as depth,

substrate types, temperature, salinity and currents. The depth at which seagrass grows is where there is enough sunlight for photosynthesis.

Seagrass forms meadows with creating diverse habitats controlling nutrient cycling and filtering sediment. These diverse habitats serve as nursery areas and feeding areas fish and invertebrate. The commercially important Queen conch is found in the seagrass meadows which are also home for tarpon, hogfish, snappers, barracuda and parrotfish. Many juvenile species settle in the seagrass meadows and migrate to other habitat as adults.

Seagrass in Belize are found west of the main barrier reef and the mainland. The seagrass beds are home and nursery areas for juvenile lobsters, conch, shrimp and fish. Manatees and turtles feed on the seagrass. The seagrass beds also filter water runoff from the mainland reducing nutrients and pesticides from reaching the barrier reef system.

In Belize seagrass is important to the West Indian Manatee, *Trichecus manatus* (Figure 54).

Figure 54 West Indian Manatee

Seagrass is the most extensive ecosystem within the Belize Barrier Reef and three atolls. These seagrass meadows start immediately west of the back reef and spread through the lagoons stabilizing sediments found on the seabed and maintaining productive lobster fishing grounds. The three species of seagrass have been identified are: the turtle grass (*Thalassia testudinum*), the manatee grass (*Syringodium filiforme*), and the shoal grass (*Halodule wrightii*). Other important algal components of this ecosystem, such as Halemida and Laurencia species are found distributed throughout the seagrass beds. The latter is

known to induce settlement of the Queen conch, *Strombus gigas*, larvae where they spend the first year of their life buried in the sediments.

Threats

The seagrass ecosystem can be susceptible to degradation due to industrial, agricultural and domestic pollution as it is dependent on various factors to thrive such as temperature, salinity and turbidity. The direct impact of pollution is unknown. There is some damage to seagrass meadows from lobster fishing gears known as the "Cuban casitas" or shades. The fishing gear covers the seagrass which eventually die as there is no sunlight for photosynthesis. The extent of the impact is unknown as there is no data on the number of shades and the areas where they are deployed. A more recent threat that has predominantly increased during the years in review, is the heavy influx of pelagic sargassum. Massive strandings of sargassum, *Sargassum natans* and *Sargassum fluitans*, occur along the coastline and Cayes covering seagrass meadows for long periods of time (Figure 55). The seagrass dies due to the lack of sunlight for photosynthesis and the anaerobic conditions created by the decaying sargassum.

Figure 55 Sargassum stranding along the coast

Conservation

There is no specific legislation for protecting seagrass in Belize. However, there is some direct protection for seagrass found within marine protected areas as there is the need for removal approval from either from the Fisheries or Forest Department, depending who has the legislative authority for the protected

area. The dredging permit is issued by the Mining Unit of the Petroleum and Geology Department. A permit is only issued after a thorough evaluation that there will be no environmental damage.

Overall, seagrass meadows in Belize are in very good condition with periodic scarring in shallow areas of high boating activities and limited dredging in occasional development sites along the coast, Cayes and atolls.

c. Protected Areas

i. The marine and coastal protected areas of Belize

The concept of protected areas is not new to the Caribbean Region. Various categories have existed for over 200 years such as *nature preserves* and *natural monuments*. The categorisation depends on various criteria including management objectives, preservation of endangered species, protection of watersheds etc. The management of marine protected areas in Belize is currently under the preview of two (2) main Government Agencies viz.; the Ecosystems Management Unit of the Fisheries Department and the Conservation Division of the Forest Department, both under the Ministry of Agriculture, Fisheries, Forestry, Environment, Sustainable Development and Immigration. However, the Ministry of Education, Youth, Sports and Culture through the Archaeology Department can declare marine archaeological sites such as shipwrecks, but none has been declared up to date.

Individual countries, in an effort to protect areas within their political borders, have used the marine protected areas concept; however, it is also common to see the protection of a large area encompassing various jurisdictions. Protection of these areas has been achieved through the extension of terrestrial protection legislation, incorporation into fisheries legislation or the creation of independent legal bodies under the application of the multiple-use concept. The latter is the more progressive approach as the underlying principle is the "ecosystem management approach."

Marine protected areas' objectives vary according to countries, but the underlying management programs are designed for one or more of the following:

a) *continued welfare of local communities dependent on the sustained use of the marine resources*

b) *protection of representative coastal and marine habitats to ensure their viability and biological diversity*

c) *economic and social benefits to surrounding areas*

d) *relative importance due to scientific, aesthetic, recreational, cultural, archaeological or educational value*

e) *protection of endangered or threatened species of flora or fauna*

Under this approach, for example, the Belize Fisheries Department includes a representative section from the coral reef habitats, seagrass beds and mangrove systems since these are all ecologically related. In this scheme, varied levels of protection are accorded for particular zones which are usually accompanied by its corresponding area-specific regulations.

In Belize, management in this context is the planned activities undertaken to achieve the basic objectives of the MPA. These activities usually fall under one or more of the following:

1. Guidelines to permit, regulate and coordinate human activities compatible with objectives for example fisheries and tourism.
2. Research and monitoring (baseline data collection can be instrumental in the decision-making process).
3. Community participation in the management of the MPA.
4. Educational programs to enhance local knowledge of natural resources.
5. Restoration programs for species and habitats.
6. Enhancement of existing laws - regulations and policies.
7. Funding (it is imperative for applied management).
8. Periodic revision and evaluation processes to compensate for changes.
9. Knowledge of the political will for establishment of MPAs.

This multidisciplinary approach has a wide scope of human integration and it seems to be the most favourable approach in the international community. It should be noted that the MPA concept will be ever evolving as new technologies are applied to management strategies.

ii. Legislation

The first piece of legislation concerning resource regulation was the Crown Land Ordinance, 1924, which enabled the relevant Minister to categorize proposed protected sites on an ad hoc basis, leading to the designation of a number of terrestrial sites known as crown reserves. The Forest Ordinance of 1927, which provided for the establishment and management of forest reserves followed this. Both laws were revised in 1958. The principal protected areas legislation currently in effect is the National Protected Areas Systems Act, 2015 (No. 17 of 2015) which replaces the National Parks System Act No. 5, 1981, which provides for the declaration by the Government of National Parks and other protected areas. This Act was legislated to provide for the maintenance of coordinated management of a system of protected areas that is representative of internationally agreed categories, effectively managed, ecologically based, consistent with international law, and based on best available scientific information and the principles of sustainable development for the economic, social and environmental benefit of present and future generations of Belize. The Act repealed the National Parks System Act, Chapter 215 of the Substantive Laws of Belize, Revised Edition 2011; amended the Fisheries Act, Chapter 210 and the Forests Act, Chapter 213 of the Substantive Laws of Belize, Revised Edition 2011. The Wildlife Protection Act No. 4, 1981, provides for the conservation, restoration, development and regulation of wildlife resources.

The other habitat specific legislation relating directly to MPAs is the Fisheries Amendment Act of 1983. The Fisheries legislation is cited as Statutory Instrument No. 66 of 1977. This legislation was revised under the Fisheries Amendment Act, 1983.

The Ancient Monuments and Antiquities Act, Chapter 330, Revised Edition 2000 can be used to declare marine archaeological sites. Table 19 lists the marine and protected coastal areas in Belize.

Table 19 The marine and protected coastal areas in Belize.

Name	Management	Establishment	Area in Acres	Special Status
Bacalar Chico National Park & Marine Reserve	Fisheries Department/Forest Department	1996	15,766	WHS
Blue Hole Natural Monument	Forest Department/BAS	1996	1,020	WHS
Caye Caulker Forest Reserve and Marine Reserve	Fisheries Department/Forest Department	1998	9,670	
Corozal Bay Wildlife Sanctuary	Forest Department/ SACD	1998	180,510	
Hol Chan Marine Reserve	Fisheries Department	1987	91,429	
Gladden Spit and Silk Cayes Marine Reserve	Fisheries Department/SEA	2003	25,978	
Glover's Reef Marine Reserve	Fisheries Department	1996	86,653	WHS
Gra Gra Lagoon National Park	Forest Department/ Friends of Gra Gra	2002	1,200	
Half Moon Caye Natural Monument	Forest Department/BAS	1982	9,770	WHS
Laughing Bird Caye National Park	Forest Department/ SEA	1981	30	WHS
Port Honduras Marine Reserve	Fisheries Department/TIDE	2000	100,000	
Shipstern Wildlife Sanctuary	Private	1987	26,000	
Sapodilla Cayes Marine Reserve	Fisheries Department	1996	38,594	WHS
Sarstoon Temash National Park	Forest Department		41,850	Ramsar
South Water Caye Marine Reserve	Fisheries Department	1996	117,875	WHS
Turneffe Atoll Marine Reserve	Fisheries Department/TASA	2012	325,412	
Total Area			1,071,757	
Percentage of national marine area			21.7	
Percentage of national no-take area			4	

SOURCE: PROTECTEDAREAS.GOV.BZ

iii. Status of marine and coastal protected areas

Fisheries are collapsing worldwide due to over exploitation, bad management strategies, habitat destruction and climate change. Since mid-1980's, the Fisheries Administration decided that fisheries

management in Belize should be through the ecosystems management approach. As a result, the Fisheries Department started to declare marine reserves as fisheries management tools. Studies of marine protected areas in tropical waters indicate that they increase population size, increase average individual fish size, lead to the restoration of natural species diversity, and increase population reproductive capacity. The marine areas protected under the Forest Department, has also enhanced fisheries and increased biodiversity.

Marine Protected Areas

Belize presently has 21.6% (4,050.5 km²) of its territorial waters under protection as marine protected areas. Of the total protected areas 80.6% (3,268.2 km²) falls under the legislative management of the Fisheries Department. The total replenishment areas (no-take) compose 15% of the protected areas but only 4% of the total territorial waters. The recent expansion of the Hol Chan Marine Reserve included sensitive habitats consolidating the already long accomplishment of the AICHI Target 11 under Strategic Goal C. Annex 2 shows the protected areas in Belize. However, the map has not been updated to show the expansion of the Hol Chan Marine Reserve. Annex 3 shows the legislative authorities' framework.

iv. Future challenges for marine and coastal protected areas

Some many challenges and threats impact the integrity of marine and protected coastal areas in Belize. Included in the list are overharvesting of marine resources, tourism, industrial and coastal development as well as oil exploration. In order to minimise these impacts, there is an overarching National Protected Areas Policy guiding development while the National Protected Areas System Plan (NPASP) outlines the needed management, planning and evaluation interventions. The NPASP was updated in 2015. Each marine protect area has its specific management plan as each area has its unique physical and biological characteristics.

The Fisheries and Forest Departments have strategically approached the management challenges posed the large protected areas by establishing innovative co-management agreements with various non-governmental organizations (NGOs). This agreement helps to ensure on-the-ground supervision backed up by national legislation and guided by the official management plans. The management plans address resource protection, research and monitoring, surveillance and enforcement, community outreach and education, and financial sustainability. The Protected Areas Conservation Trust (PACT) has been one of the largest national funding agencies assisting the marine and coastal protected areas since its inception.

Coordination amongst the enforcement agencies, especially the Belize Coast Guard and Police Department enhances resource protection by enforcing the existing regulations for the marine and coastal protected areas. Close coordination with the agencies responsible for mangrove clearing and dredging also ensures further protection. Belize has also always worked closely with the neighbouring countries and is involved in many regional and international conservation initiatives that strengthen the management and conservation of the marine and coastal resources.

The strengthening of a robust network of marine protected areas can be attributed to the long vision of sustainable management of our natural resources through ecosystem-based management by the Government agencies with the legislative authorities to declare marine protected areas.

d. Species Population

i. Manatees

Manatees and dugongs are members of the order Sirenia which include four living species: West Indian manatee, West African manatee, Amazonian manatee, and the Dugong. The West Indian manatee has two subspecies: the Florida (*Trichechus manatus latirostris)* and Antillean (*Trichechus manatus manatus)* manatee (Figure 57). The Florida manatee is found along the Florida (USA) coast and the Gulf of Mexico Coast while the Antillean manatee is found in the Caribbean and the northern coasts of South America. Manatees are distantly related to the elephant as they split some 50 million years ago adapting to a marine environment with extensive underwater sea grass meadows. Their preferred habitats are inland waters and shallow areas along the coast with dense underwater vegetation as they are known herbivores.

Figure 56 West Indian manatees being observed in their natural environment

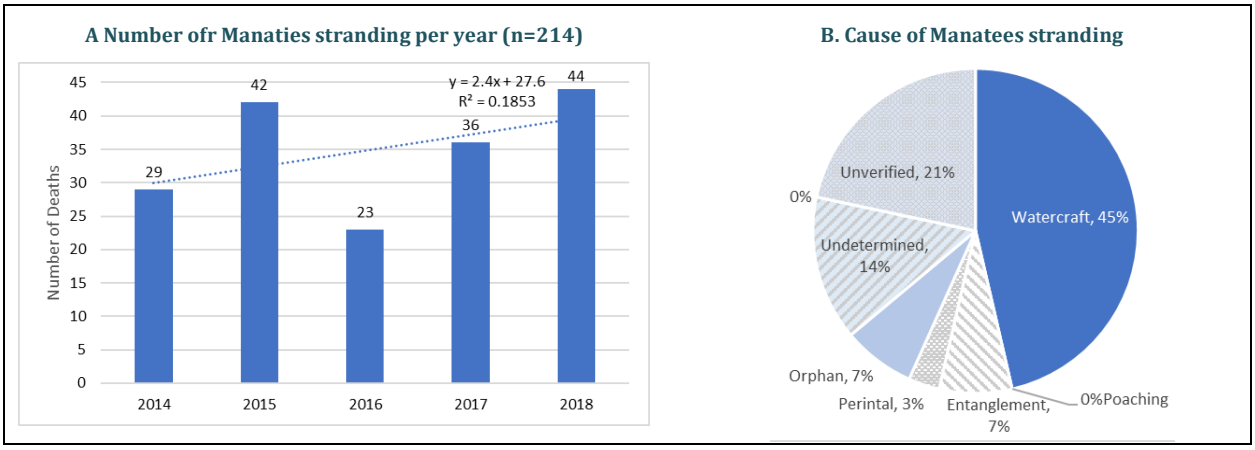
Manatees were hunted by the ancient Maya for food, their hides, and their bones for making carvings. Manatee meat was a staple food especially along coastal fishing communities. Manatees have no natural enemies and can live up to sixty years or more. An adult manatee can grow to twelve feet long and weigh between eight hundred to a thousand two hundred pounds. They prefer fresh water but are found in brackish and saltwater systems such as river mouths, estuaries, canals and lagoons. Belize has the largest population of West Indian manatee in the region mainly due to legislation and public environmental education.

Threats

Manatees have very slow reproductive. Female manatees are not sexually mature until five years old and males at around nine years. Gestation period ranges from twelve to fourteen months. The interval between births is two to five years and mothers nurse their young for up to three years. They are

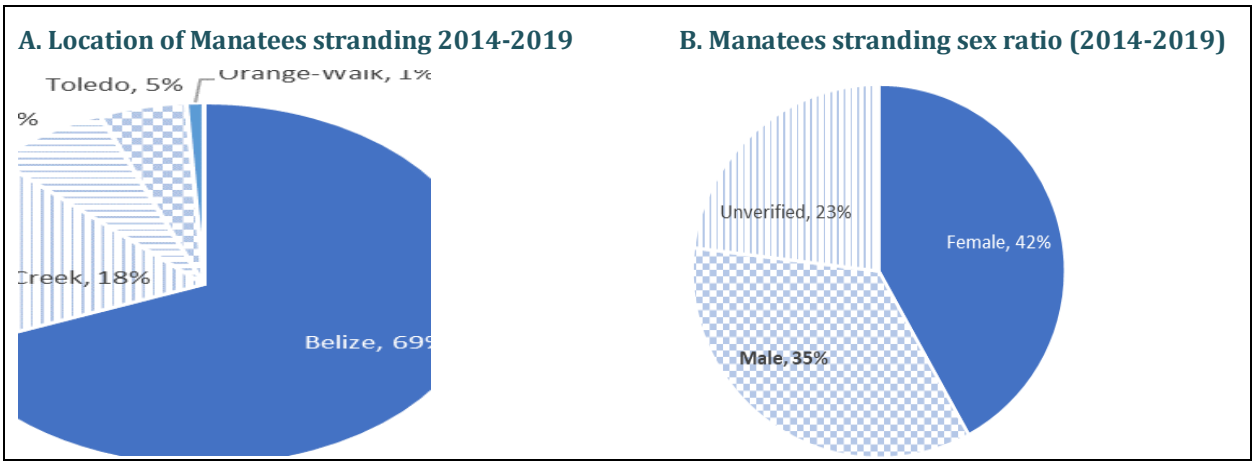
endangered throughout their range as there is loss of habitat; they are exposed to chemical pollution, climate change and injury by vessel collisions and propellers. In Belize, there is high usage of manatee habitats by vessels navigating along the coast and conducting river tours. These docile creatures are vulnerable as they rest submerged at the bottom or just below the water surface. According to the Belize Marine Mammal Stranding Network (BMMSN) and Clearwater Marine Aquarium (CMA) statistics the manatee stranding increased from 2016 (Figure 57 A)due mainly by human-induced mortalities (Figure 57 B) from collisions with watercraft (45%). Mostly of the stranding (69%) occurs in the Belize District due to heavy boat tourist traffic and water taxis and there were more females stranding than males (Figure 58 A). Many female mortalities result in orphans which if they are not immediately rescued, also perish (Figure 58 B).

Figure 57 Cases of Manatees stranding (2014-2018)



SOURCE BMNSN/CMA

Figure 58 Distribution of the Manatees stranding (2014-2018)



SOURCE BMMSN/CMA

Conservation

The Antillean Manatee is listed as endangered under Belize's Wildlife Protection Act of 1981 and is afforded total protection from hunting or having in possession any of its products. The Belize Forest Department, Ministry of Agriculture, Fisheries, Forest, Environment, Sustainable Development and Immigration, has the legislative authority to manage manatees, including permitting research, in Belize. However, due to constrains with human and equipment resources, the Department works closely with the CZMAI, the Clearwater Marine Aquarium (CMA) (previously Sea to Shore Alliance) and BMMSN to manage manatees since their very slow reproductive rate. BMMSN responds to strandings, conducts autopsies and rescues abandoned calves. The 2018 – 2022 Manatee Recovery Plan outlines the necessary working environment to further manatee conservation in Belize.

In 1997, the CZMAI along with Sea to Shore Alliance began a manatee conservation project in Belize. CMA scientists and collaborators provide data, expertise and training that are used by the Government of Belize to establish sanctuaries, speed zones, laws and regulations and other actions to safeguard manatees. The BMMSN composed of government and non-government organizations and volunteers, is very active and contributed to the success of the program. Programmed activities by the coalition include:

- Conduct countrywide community-related education and outreach programs;
- Coordinate the Belize Marine Mammal Stranding Network;
- Serve as a resource and representative on relevant government and local committees, such as the Belize Manatee working group;
- Track and monitor tagged, wild manatees;
- Create public information brochures and posters on manatees and their habitat;
- Communicate with the media and the public on manatee conservation issues; and
- Continue critical fundraising efforts for our programs and handle all aspects of managing, administering, and maintaining an active research and conservation program in Belize.

ii. Fish Spawning Aggregations

Fish spawning aggregations are commercially exploited making them vulnerable to overexploitation during predictable and geospatially identifiable mass gatherings. The aggregations are for reproduction to replenish population stocks. The aggregations are brief and concentrate mature fish which makes them easy fishing targets due to their high caloric food intake. Special management measures need to be put in place, for countries that do not yet have them, for the sustainable use and conservation of various aggregating species ensuring fish population viability and their wider functional role in the coral reef ecosystem. In Belize, fishing at the spawning aggregation sites supplemented fishers' income.

According to a Food and Agriculture Organization report (FAO 1959), over 200 metric tons of Nassau grouper (*Epinephelus striatus*) were fished at the Emily spawning aggregation site during one season. High fishing pressure continued to impact Nassau grouper populations at all spawning sites. Due to very low

numbers of Nassau grouper, in 2001 the Belize National Spawning Aggregation Working Group (BNSAWG) was established to address this decline. The working group is composed of governmental and nongovernmental organizations (NGOs). According with the BNSAWG website, the objectives of the working group are:

- To manage, monitor and patrol spawning aggregation sites including monitoring the impact of use on the sites;
- To involve the stakeholders in monitoring, research, and patrolling of spawning aggregation sites;
- To create, house, and maintain a spawning aggregation database;
- To analyse the data and provide recommendations for the conservation, protection and sustainable use of the sites;
- To disseminate information for the education of all stakeholders;
- To utilize the information to advocate for and build support for the management, conservation, protection and sustainable use of the spawning aggregation sites;
- To support other initiatives that contribute to this general goal;
- To promote alternatives for the traditional users of spawning aggregation sites.

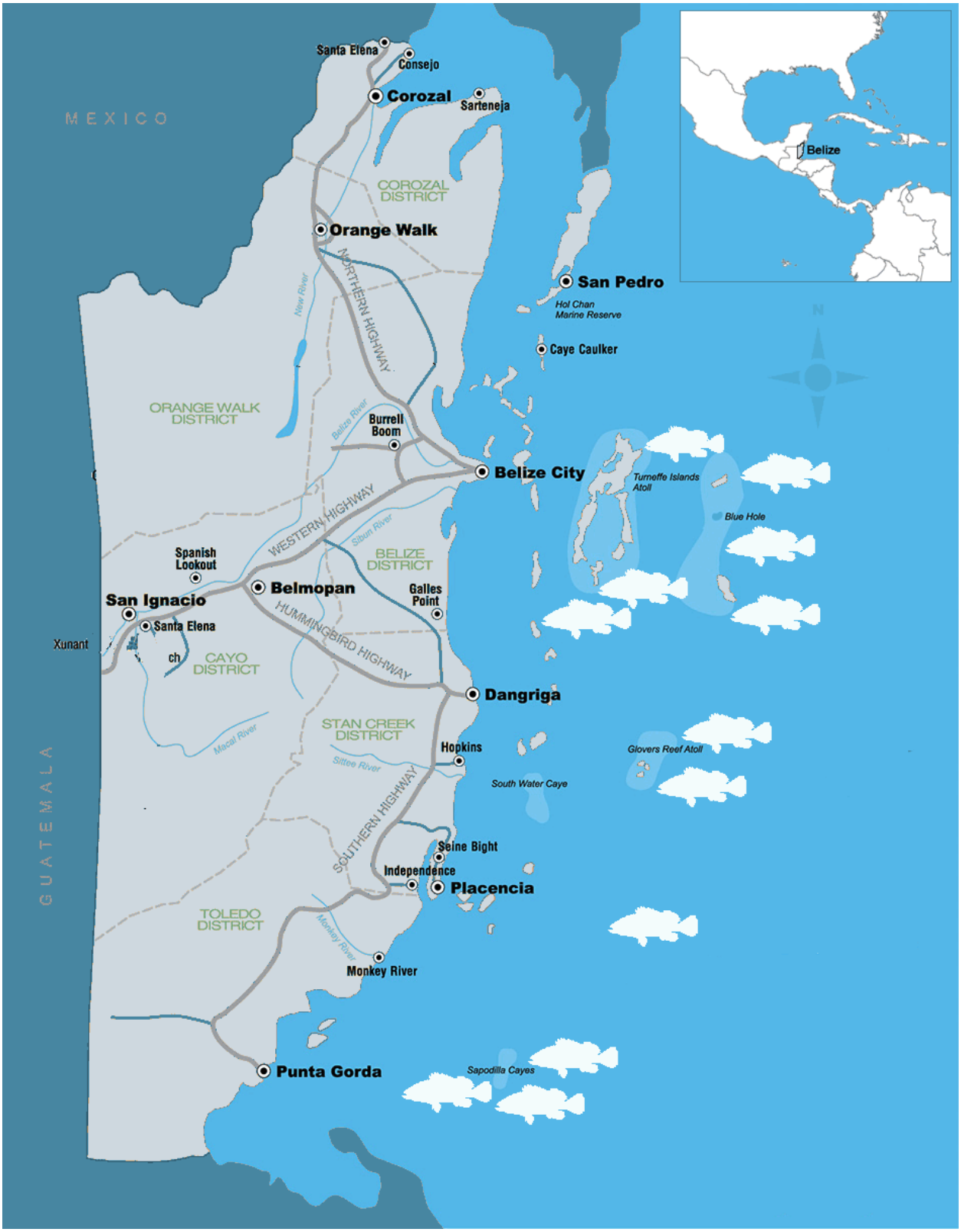
In 2002 a coalition of seven non-governmental organizations along with the BNSAWG lobbied the Government of Belize to completely protect 11 of the 13 Nassau grouper spawning sites (Figure 59A). Regulations were enacted in 2003 and introduced year-round protection for the 11 sites and a four-month closed season at the national level except for the Maugre Caye and Northern Two Caye spawning aggregations at the Turneffe Atoll and Lighthouse Reef Atoll respectively. The regulations of 2009 established fishing minimum and maximum sizes and landing of whole fish (Figure 59B). In 2014, all 13 Nassau grouper spawning aggregations were fully protected as the two sites where traditional fishers were given special fishing licences (Figure 60) were closed as landings drastically decreased and the same fishers requested that the sites be fully protected.

Figure 59 Aspects of the Nassau grouper

A. Spawning aggregation at Turneffe Atoll 2005

B. Landing of whole fish at Turneffe Atoll 2005

Figure 60 Belize Nassau Grouper Spawning Aggregation Sites



The Nassau grouper spawning aggregation sites are multi-species as they are used by various other species. These species include the mutton, cubera and yellowtail snappers (Figure 61).

Figure 61 Snappers spawning aggregation at Gladden Spit

Monitoring

It is relatively expensive to monitor all the viable Nassau grouper spawning aggregation sites during the aggregation period. The estimated yearly cost is around $100,000 Belizean Dollars. As a result, government and non-government organizations join forces to monitor the sites and are always seeking financial assistance to cover operational costs. When data is collected, it is entered in a national database hosted by ERI/UB, which can be accessed by the members of the BNSAWG; each year the data is analysed, and an annual report is generated. According to the BNSAWG Chair, data is missing from some sites as they are not monitored, or the data is not entered into the database.

Data for the Nassau grouper for the five years in review (2014 -2018) shows that Sanbore, Lighthouse Reef Atoll, is stable with around 3000 - 4000 individuals (Figure 62); North East Point, Glovers Reef Atoll, declined from 1,442 individuals in 2014 to a low of 413 in 2017 and increased to 925 in 2018. All the other spawning aggregation sites had less than 1,000 individuals (2019 interim report). The Working Group is looking into the hypothesis that fish may be moving from the spawning locations a few hundred meters along the reef or to deeper waters beyond the reach of safe SCUBA diving limits.

Monitoring of snapper spawning aggregations shows low numbers for March to June except for the Gladden Spit site (Table 20). However, dog snapper and mutton snapper counts were markedly lower in 2018 compared to 2017. Data entering into the database will ensure accurate and prompt reporting for all sites.

Figure 62 Nassau grouper monitoring results

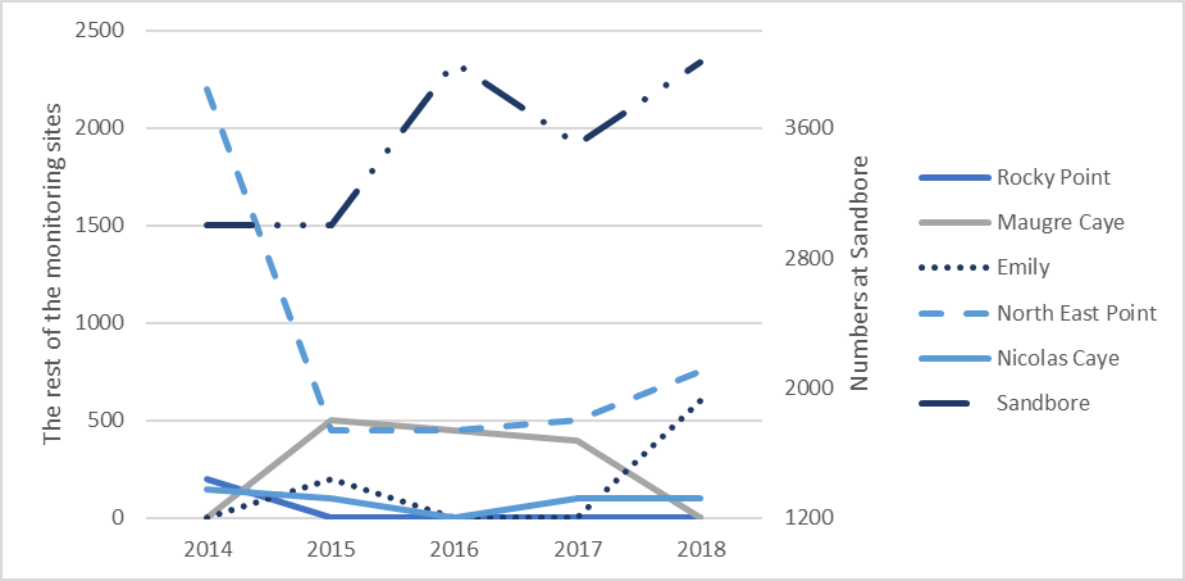


Table 20 Snapper aggregations by year and site

SPECIES	SITE	2015	2016	2017	2018
Yellowtail Snapper	Caye Bokel	-	-	-	48 (±23)
	Emily	-	-	23 (±16)	-
Dog Snapper	Emily	-	-	-	-
	Gladden Spit	1358	138 (±24)	2593 (±2111)	135 (±230)
Mutton Snapper	Gladden Spit	116	-	6000 (±2828)	1400 (±1039)
Cubera Snapper	Gladden Spit	1400	-	-	2023 (±887)

Enforcement

Enforcement is conducted during the monitoring trips as it is expensive to patrol the protected spawning aggregation sites during other times of the year except for those eight sites that fall within a marine protected area. Anecdotal information from fishers and from the large number of hooks and line in the mouths of individuals observed during monitoring indicates that there is heavy fishing in the North East Point, Glovers Reef Atoll. Reports point to heavy poaching of the spawning aggregation sites by fishers from neighbouring Honduras especially during the night hours. Unless adequate resources are allocated by the government to enforce the regulations, at the spawning aggregations in Belize, and particularly to conduct armed patrols at night in ocean-going vessels, the numbers of Nassau groupers and snappers will continue to decline.

iii. Marine Turtles

Marine turtles have existed in the oceans for over 200 million years. Five of the seven existing marine turtle species are found in Belize; these are the green (*Chelonia mydas)*, hawksbill, (*Eretmochelys imbricata)*, and loggerhead (*Caretta caretta)*, leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*). Due to their long-range for foraging and reproducing, these turtles travel vast distances creating a challenge for their protection and conservation.

In 1977, the Belize Fisheries Department enacted the first regulations to protect marine turtles. The protection included juveniles, eggs and nesting females. Turtle harvest was only allowed from June 1 to August 31 each year. Exportation of turtles and their products was also prohibited. Fishery regulations were amended in 1993 to protect green and loggerhead turtles greater than 60 cm and the hawksbill turtle was completely protected. In 2002, all turtles became fully protected making it illegal to buy, sell or have in possession any turtles and related products.

WIDECAST (Wider Caribbean Sea Turtle Conservation Network) published in 19992 the *Belize Sea Turtle Recovery Action Plan* (Smith, Eckert, Gibson 1992) which summarizes marine turtle threats, nesting locations (Figure 63) and fishery legislation. It remains a comprehensive source of information on marine turtles in Belize. Belize has members which participate in the annual general meetings to learn about and share information on marine turtle opportunities and programs occurring in the Wider Caribbean.

The Belize Sea Turtle Conservation Network was formed after a regional turtle meeting in 1996 and is one of the oldest working groups meeting in Belize. The Mission is to improve the conservation status of marine turtles in Belize through research, monitoring, protection, political lobbying, planning, training and public awareness. Its objectives are:

- To recuperate and stabilize the marine turtle nesting populations on the coast and cayes of Belize.
- To standardize outreach, conservation and research programs with the aim of unifying criteria and activities for the management of the sea turtles nationwide.
- To have more involvement in decision making at the political level, in management, enforcement and use of marine turtles.
- The communities will have alternative livelihoods and shall participate in the conservation of marine turtles.
- The Turtle Network plays a key role in the conservation of marine turtles.

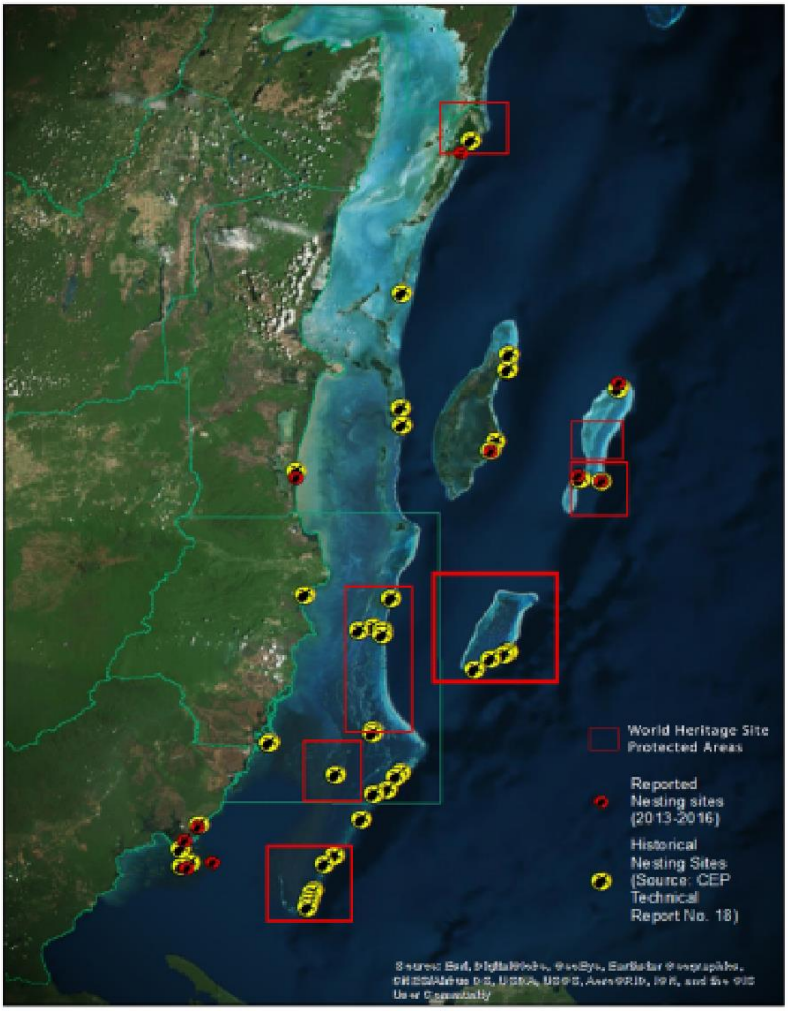
Roles & Responsibilities:

- Ensure that relevant commitments by the regional sea turtle networks are carried through in country.
- Provide feedback to the regional sea turtle networks on the activities of the BSTCN.
- To be informed of proposed development, tourism activities, or research projects that may affect sea turtles or their habitat and provide recommendations to the appropriate permitting Department or Ministry.
- Review legislation concerning sea turtles and provide recommendations for amendments to the Ministry of Agriculture and Fisheries (MAF).

- Ensure sound management plans for protected areas include protection of sea turtles by reviewing draft plans.
- Ensure that the activities included in the Belize Sea Turtle Recovery Action Plan (STRAP) are completed and that the STRAP is updated every five years.
- Ensure standardization of outreach programs, conservation, and research and monitoring protocols within Belize.
- To share data gathered on sea turtle research activities with network members.

Belize is a member of the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) which is an intergovernmental treaty which provides the legal framework for countries to take actions in benefit of these species. The IAC entered into force in May of 2001 and currently has sixteen contracting parties. Belize signed the convention on December 1998 and ratified it on February 2003. The Convention promotes the protection, conservation, and recovery of the populations of sea turtles and those habitats on which they depend, on the basis of the best available data and taking into consideration the environmental, socioeconomic and cultural characteristics of the Parties (IAC Website).

Figure 63 Marine turtle nesting sites (BSTCN 2017).



Threats

In the 1700-1800s, marine turtles were extensively harvested in Belize for the local and export markets. Considered at one point as inexhaustible, uncontrolled harvested decimated their populations. Current legislation protects all marine turtles but threats to marine turtles still continue due to illegal take, loss of habitats caused by development activities, vessel collisions, stranding in gillnets, shark attacks, and climate change (National Turtle Report 2017).

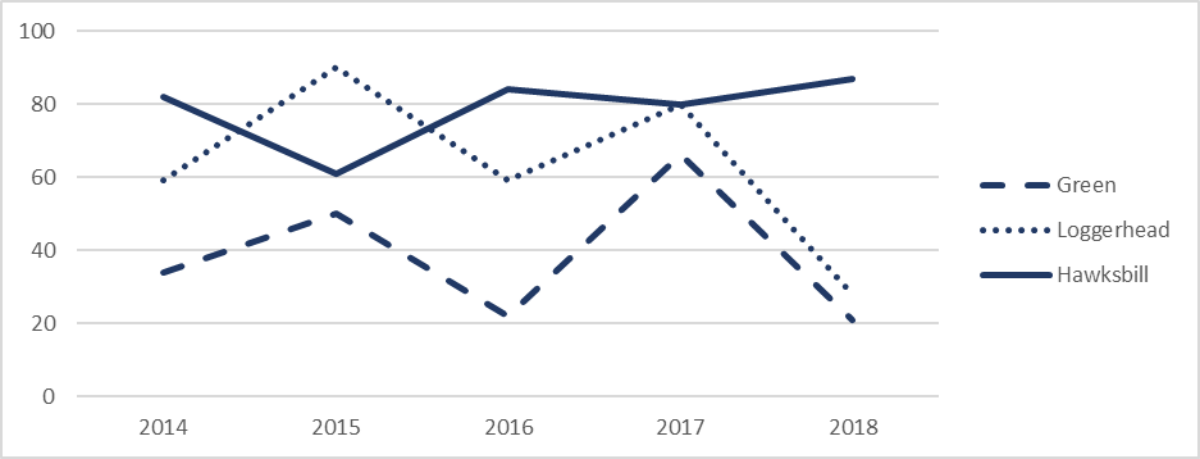
Poaching of turtles and eggs have been reduced due to effective conservation messages. Strandings have been documented from ghost nets, but data on bycatch from gillnets is limited. Increase in marine traffic mainly due to tourism activities, has resulted in turtle mortality due to direct hits or propeller damage. The loss of habitat is mainly due to the erection of seawalls to protect from beach erosion. In remote areas in northern Ambergris Caye, vehicular traffic on nesting sites has increased tremendously. The beach sand covering the nests is compacted making it difficult or impossible for hatchlings to emerge from the nests. Artificial lightning from hotels and private homes along the coast also disorients hatchlings and they may not find the direction to the sea. Heavy trash washed on the nesting beach may also make it impossible for the turtles to lay their eggs. Climate change has increased sea level eroding many nesting sites. Increase in temperature can cause turtle eggs to produce only females. This will disrupt the male to female ratio and reproduction viability and dynamics. There are also cases of known shark attacks of loggerhead turtles, albeit rare. Cases of *fibropapiloma* are extremely rare but have been documented in Belize since 1990s.

Monitoring the nesting zones

It is expensive to monitor turtle nesting, especially when turtles nest in remote areas. Many nests are lost to poaching but mostly to wildlife. Racoons are notorious for preying on the eggs. In the Manatee Bar nesting site, the monitoring team has to deploy heavy gauge wire mesh on the nests to minimize predation. Some nests need to be relocated when they are laid too close to the waterline.

Members of the BSTCN monitor nesting beaches throughout Belize to the best of their ability given the availability of resources and distances to nesting beaches. Figure 64 shows the number of nests by species for Belize for the years in review. Results show a fluctuation in numbers of nesting turtles which can be attributed to the lack of monitoring for half of the nesting season on northern Ambergris Caye, but also cyclical patterns of marine turtles as they nest every two to three years. The number of hawksbill turtle nests has maintained most stable between 60-80 nests. It is important to keep in mind that not all nesting beaches are regularly monitored in Belize and these results are not representative of all marine turtle nests laid in Belize. When additional resources are available, it is hoped more regular monitoring of all nesting beaches will take place and a more accurate number of turtle nests can be presented.

Figure 64 Total Yearly Nests for the Green, Loggerhead and Hawksbill Turtles 2014-2018



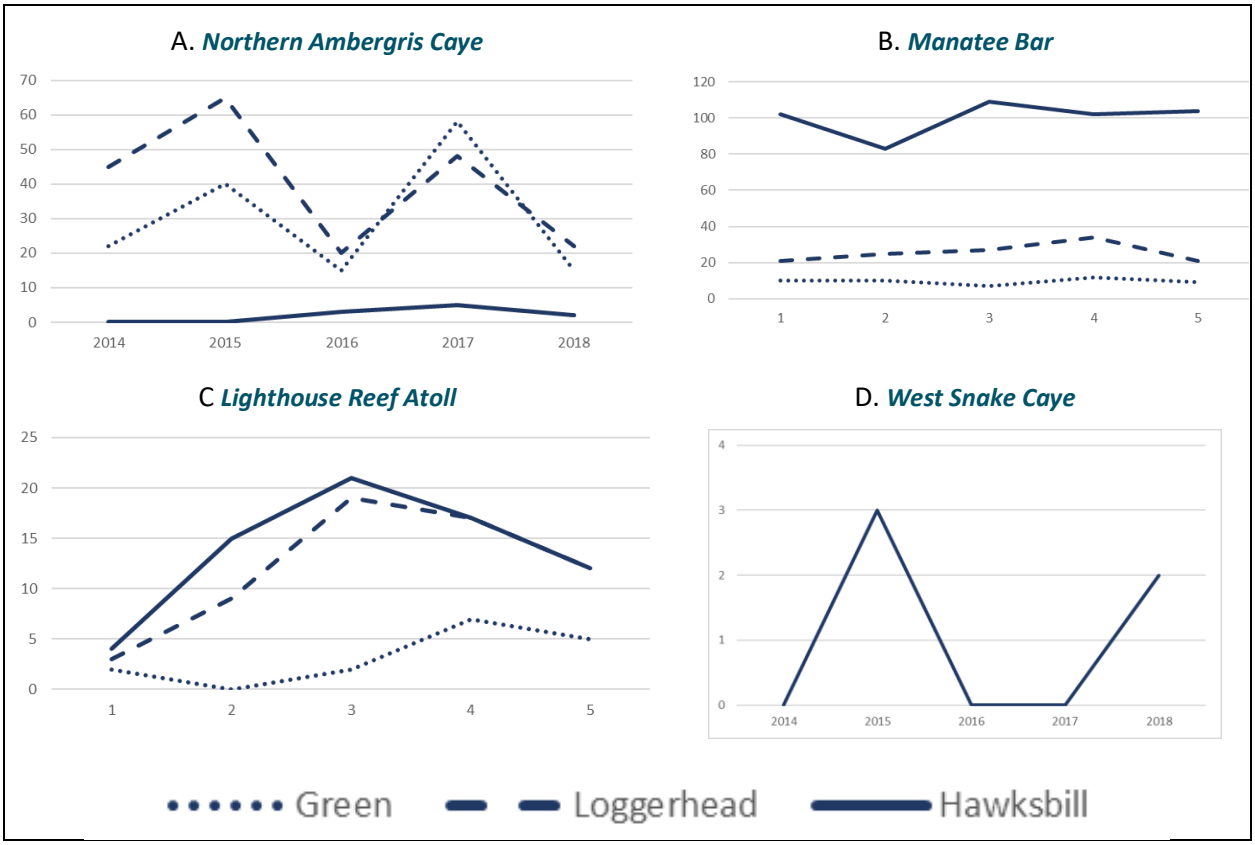
The turtle nesting areas on northern Ambergris Caye and Manatee Bar, Gales Point, are monitored more regularly than the other sites due to availability of financial resources. Staff from the Hol Chan and Bacalar Chico Marine Reserves collaborate and are dedicated to turtle monitoring on north Ambergris Caye while Kevin Andrewin, Gales Point Wildlife Sanctuary Management Committee (GPWSMC) and Dr Todd Rimkus, Marymount Univeristy monitor the nesting beach at Manatee Bar. The monitoring includes nest identification, protection, and data collection on the number of hatchings, to provide the percentage of successful hatchings per species. Turtle nests are marked using GPS and are monitored from nesting to hatching. The data from the different locations along northern Ambergris Caye is then entered into a database, analysed and reports are generated. Monitoring has been consistent for northern Ambergris Caye, Manatee Bar and Lighthouse Reef Atoll, (Figure 65). From this data, it is known that Loggerhead turtle nests are more predominant on northern Ambergris Caye and Lighthouse Reef Atoll while the hawksbill turtle nests are most abundant at Manatee Bar. Only hawksbill turtles have been reported to nest on West Snake Caye. Turtles may nest on other areas that were traditionally used but may not be reported so the data is not included in the national report.

Monitoring of foraging Areas

Monitoring the migration paths of sea turtles in Belize started in 2000 when the Belize Fisheries Department collaborated with NOAA to participate in the first Caribbean wide satellite tagging program. That year the Belize Fisheries Department tagged Gale, a hawksbill turtle that was found nesting at Gales Point. Earlier that same year, Belize Fisheries Department turtle biologist Isaias Majil participated in a training program in Costa Rica, and one of the turtles tagged migrated to an important foraging area that has been identified at Robinson Point. In 2011 Dr Todd Rimkus from the University of Marymount, launched a 10 year program to further our knowledge of the hawksbill turtle population at Gales Point, but has also made available satellite tags for other members of the BSTCN including ECOMAR, TIDE, BAS and Hol Chan Marine Reserve. In total there have been 30 satellite tags successfully applied to marine turtles, 22 of which were placed on hawksbill turtles, 6 were installed on loggerheads, and one green and one stranded olive ridley turtle were also tagged. Between 2014-2017 Wildlife Conservation Society tagged 6 hawksbill turtles and 1 green turtle at Glovers. Mar Alliance tagged 4 hawksbill turtles at

Lighthouse Reef in 2015. Other turtle conservation organizations in the region, specifically in Mexico, Costa Rica, Cuba, Jamaica and Honduras have also utilized satellite telemetry to monitor turtles and these migrations paths have led some marine turtles to Belize. The tagged turtles can be tracked between their nesting beach and foraging grounds. These tracks were published by Searle (2013) and shows critical foraging areas in Belize. Continued studies are planned to identify and evaluate the importance of these areas for marine turtles from throughout the Wider Caribbean.

Figure 65 Sea turtle nesting at four locations



Assessment summary

The following chart shows a summary of the state of the coastal zone based on the habitats and species populations of the coastal zone described above in the report (Figure 66). In each row of the chart a habitat or natural resource is assessed using a scale that ranges from *very good* to *very low*. In each case, a trend scale is used to indicate if the condition of the habitat or species population is deteriorating, getting better or there is no change (trend is not clear). This chart was constructed with individual responses from an online survey (which represent individual perceptions), then those responses were aggregated (to configure a collective perception) and were analysed and then validated in a national expert workshop (See Methodology section and Annex 1 and Annex 4). Finally, the chart indicates the grade of confidence that the national experts had on the assessment. The assessment ranges from *very*

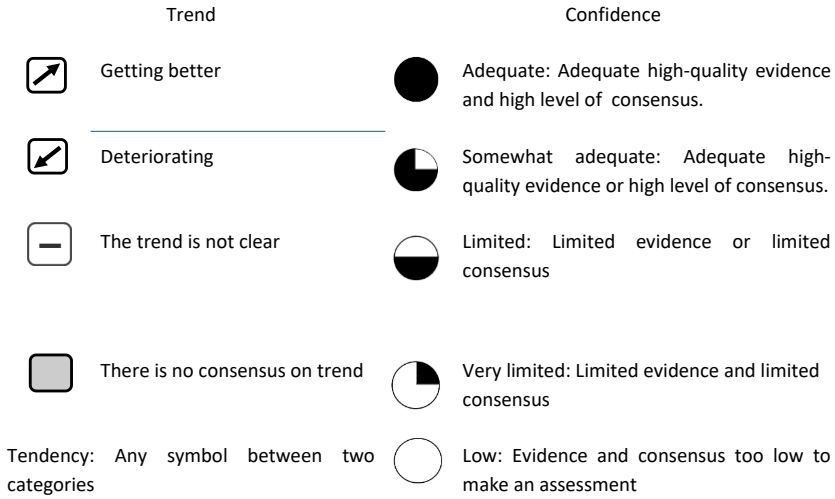
confident (because there is high quality of evidence and strong consensus in regard to the level of pressure) towards *low* which means that evidence and consensus are too low to make any assessment.

Figure 66 State of habitats and natural resources

Habitat or natural resource	Questions	No consensus	Very Poor	Poor	Good	Very good	Confidence on the state
Water Quality	What is the state of water quality due to nutrient contamination?		↙				◔
	What is the state of water quality due to coliform contamination?			↙			
Mangrove	What is the status of mangroves due to urban development?			↙			●
	What is the state of mangroves due tourism development?			↙			
	What is the status of mangroves due to the amount of garbage?			↙			
	What is the state of mangroves due to storms?				–		
Littoral forest	What is the state of the littoral forest due to urban development?			↙			◔
	What is the state of the littoral forest due to tourism development?			↙			
	What is the state of the littoral forest due to the amount of garbage?			↙			
	What is the state of the littoral forest due to storms?				■		
Coral reef	What is the status of the coral reef due to nutrient contamination?			↙			●
	What is the status of the coral reef due to coliform contamination?			↙			
	What is the status of the coral reef due to recreational activities?		↙				
	What is the status of the coral reef due to storm damage?				↙		
	What is the status of the coral reef due to increase in water temperature?			↙			
Seagrasses	What is the state of seagrasses due to nutrient contamination?	■					◒
	What is the status of seagrasses due to coliform contamination?			■			
	What is the state of seagrasses due to recreational activities?				↙		
	What is the state of seagrass for storm damage?				■		
	What is the state of seagrasses due to increase in water temperature?	■					
Protected areas	What is the status of protected areas due to economic activities?				■		◒
	What is the status of protected areas due to urban development?	↙					
	What is the status of protected areas due to pollution?				↙		
Species population	What is the status of species population due to economic activities?			↙			◒
	What is the status of species population due to urban development?			↙			
	What is the status of species population due to pollution?				↙		

Figure 66 State of habitats and natural resources (continuation)

Symbology



This chart shows at least three conditions: 1) very poor conditions in the case of the coral reef due recreational activities, 2) poor conditions for water quality, mangroves, littoral forest, and species population and 3) good conditions for habitat or natural resources which include protected areas and sea grasses. Considering the assessment confidence level, we observed two groups of habitats or natural resource assessment. The first group includes those assessments with adequate or somewhat adequate confidence levels which include coral reef, mangroves and water quality. The second group has those assessments with limited or very limited confidence levels which include species populations, protected areas, sea grasses and littoral forest.

Recommendations

In order to improve the conservation of coastal habitats and the species reviewed, the following milestones must be achieved:

1. 100% of the wastewater should receive at least primary treatment and at least 50% further secondary treatment.

2. Carrying capacity for tourism development and recreational activities are established and enforced in every tourism destination.

III. Effectiveness of Integrated Coastal Zone Management

Sixty-two per cent of the world's population lives on the coastal zone, therefore, making it inevitable to see drastic changes on both the marine and terrestrial environments over time as populations and migration from inland areas expand. Coastal zones throughout the world have historically been among the most heavily exploited areas because of their abundant resources (The World Bank, ESD Studies and Monographs Series No. 9). Increase in human population will also increase coastal resource utilization and conflicts; if there is no adequate environmental planning and management, resource utilization will lead to further environmental degradation. The Rio de Janeiro Earth Summit in 1992, recommended that Guidelines on Integrated Coastal Zone Management (ICZM) be drafted by all nations to minimise conflicts and to provide for optimal sustainable resource use.

In order to increase the economic benefits derived from the coastal zone, there is the need for coastal development especially for the tourism and agricultural industries. In order to erect the necessary infrastructure or plant monocultures, there is the need to clear the land from its existent vegetation, either being littoral or mangrove forests. Clearing of mangroves exposes the coastal land to erosion due to wave action and sea level rise. Clearing of littoral forests is alarming as these areas are found only along the coastal areas in patches. The mangroves and littoral forests are habitats, refuge, nursery and feeding areas for fauna especially bird species. These habitats also serve as biological corridors. There is also the loss of important seagrass beds due to dredging for filling materials (Figure 67A), piers and marinas. Dredging close to the shoreline creates heavy erosion along the beach and sedimentation if sediment curtains are not used (Figure 67B). Development also causes conflict of interest amongst user groups. Belize has excellent regulations for development and protection of the environment; however, they are not fully implemented.

Figure 67 Some pressuring process on the Belize coastal zone

A Dredging filling material after seawall construction

B. Sedimentation due to lack of sediment containment curtains

a. Governance and Management

ICZM is a process of governance consisting of the necessary legal and institutional frameworks to ensure that development and management plans are integrated with environmental goals with the full participation of stakeholders. ICZM maximises the benefits provided by the coastal zone and minimises the conflicts and harmful effects of activities on the environment and resources. In order to have sound ICZM, it is imperative to have research and monitoring to make decisions based on useful data. There is a need for the collection and analysis of data on the state of coastal resources and take mitigation actions to address environmental degradation.

In Belize, ICZM started under the Coastal Zone Management Unit of the Fisheries Department. The program was expanded under a Coastal Zone Management Project which was the precursor of the Coastal Zone Management Authority and Institute; the CZMAI was established under the Coastal Zone Management Act, Chapter 329 of the Laws of Belize, in April 1998.

The CZMAI has been active in the implementation of ICZM except for a brief period when it was operating on a skeleton staff due to lack of funding. The CZMAI presently has a full-fledged staff which has been very active in collecting environmental data and formulating various documents such as the *Coastal Zone Management Strategy*, *Belize Integrated Coastal Zone Management Plan 2016* (BICZMP) and *Coastal Zone Management Guidelines* (CZMG) for the various planning regions (Figure 1) and areas such as Caye Caulker and Goff's Caye. In order to have proper development and use of the coastal zone management resources, there is a need for full cooperation and collaboration amongst the government permitting agencies. The coastal advisory committees assisted the CZMAI in the formulation of development guidelines for the nine planning regions. The BICZMP is holistic and covers in detail the following:

a) Full description of the coastal zone including the barrier reef and associated habitats;
b) Description of the resources for fisheries, tourism etc.;
c) Coastal issues for national actions including urban expansion; and
d) Implementation of the plan describing the various stakeholders and legislative authorities; a vision for a sustainable coast including adaptation and mitigation for climate change.

The plan presents the state of the coastal and marine resources and what would be the scenario with development based on informed decisions. According to the BICZMP, research is increasing but it is still ill-defined and not centralised, so it requires an integrated approach at the national level to get the desired data for decision making. The National Environmental Appraisal Committee, under the Department of the Environment, composed of various government and non-government organisations, is an important instrument used for monitoring and advising on coastal and marine development in Belize. However, enforcement of development regulations is not fully enforced.

These documents guide and complement other development policies, rules and regulations for the coastal zone implemented by the other government agencies (Table 21).

Table 21 List of legislation that apply to development and resource extraction in the coastal zone.

Legislation	Focus Area	Implementing Agency
Coastal Zone Management Act	ICZM	CZMAI
Fisheries Act	Fisheries, marine reserves	Fisheries Department
Forest Act	Mangrove clearing	Forest Department
Village Councils Act	Urban Development	Village Councils
Belize Building Act	Building permits	Building Authority
Water Industry Act	Water supply	Belize Water Services Ltd.
National Integrated Water Resources Act	Water usage and conservation	Water Authority
Mines and Minerals Act	Dredging	Ministry of Natural Resources
Public Health Act	Water contamination	Public Health Department
Solid Waste Management Authority Act	Solid waste management	Solid Waste Management Authority
Environmental Protection Act	Control pollution of the environment	Department of Environment
Environmental Impact Assessment (Amendment Regulations, 2007)	Requirement of environmental impact assessment	Department of Environment
Environmental Protection Act "Chapter 238 Pollution Regulations"	Emission standards including dumping at sea	Department of Environment
Environmental Protection (effluent limitations) Regulations, 1995, and the Environmental Protection Act Chapter 328 Revised Edition 2003	Effluents standards	Department of Environment
Hazardous Waste Regulations 2009	Regulates hazardous waste	Department of Environment

i. Governance

The concept of "governance" is not new, but it can have different meanings depending on the level of governance we are talking about, the objectives to be achieved and the approach to be followed. In the case of coastal governance, the CCC (2019) defines it as the set of institutional processes and agreements through which decision-makers and stakeholders influence actions and impacts on the coast.

The amount and complexity of the different public problems that occur in the coastal zone often exceed the management capacities of the authority, so mechanisms have been established to include the population and other stakeholders in decision making and in conflict resolution, particularly at the local level, where government actions should have better results.

The collaboration of the population to reach agreements on the use of natural areas and resources in the coastal zone seeks to address that their interests are not affected by the lack of participation. This type of collaboration, not only in decision-making but also in the implementation of actions, is strengthened through the collaboration of key stakeholders such as non-governmental organisations whose work, in capacity building and technical assistance, benefits the communities and clarifies certain problems that can be complex for the local population.

On the other hand, promoting coastal zone governance as a matter of state is not a simple task, but the Belizean government has made efforts to include different areas of government to collaborate in reaching the objectives established in the BICZMP, which are: 1) focus management activities that are already being carried out, ensuring that they are integrated and 2) highlight additional activities and actions that could be taken to help meet the challenge of ensuring a sustainable future (CZMAI, 2016b).

The need to carry out collaborative actions with different areas is a common activity in the public administration of any country, but when permanent coordination actions are already established for the follow-up of a plan, the different areas of government or sectors are forced to 1) establish work agendas between two or more institutions and 2) solve problems related to the coastal zone (see Annex C, BICZMP). Although it is desirable to have formal mechanisms to carry out the previous work, the involvement and commitment of all parties are essential for the fulfilment of the specific objectives of the plan.

Another example of the coordination capabilities that Belize has in the area of integrated coastal zone management is the Advisory Council, which is a high-level group, composed of different areas of government, non-governmental organizations and private sector representatives that must address different issues related to the development and protection of the coastal zone, such as the preparation of policy projects, plans and programs related to the management of coastal areas (CZMA, 2000).

It is important to note that the relationships between different areas of government or sectors can be very complex. During the development of plans and programs, the capacity of the coordinating institution (in this case: CZMAI) and the maturity of the administrative system to establish points of agreement between areas whose policies, programs, strategies or investment projects may be completely contrary are tested, but with a common objective that is the sustainable development of the coastal zone.

The ability to integrate different areas of government, private sectors, non-governmental organizations and society in the implementation of the BICZMP will require a period of time and adaptation so that the plan is established as a new way of working within the government structure and whose consolidation will depend on factors such as effective governance, stability in the country's policy, financing capacity, adequate institutions, government evaluation systems, research on coastal or marine issues, trained personnel, public databases and adequate legislation.

The implementation of the BICZMP may present delays and non-compliance with the established objectives and goals due to the difficulties mentioned and other factors that affect the actions of the public administration and other actors, but with the passing of different administrations its

implementation will be strengthened, to reduce pressures in the coastal zone and maintain the flow of the provided benefits to society. Otherwise, the deterioration of habitats and their environmental services can generate difficult social and economic conflicts.

ii. Management

CZMAI has developed the regional coastal zone management guidelines (CZMG) for nine zones in order to support planned development and resource management along the coastline and in marine areas throughout the country (CZMAI, 2016a). These guidelines are the best example of how planning processes are implemented through concrete actions.

The CZMG for the different areas of the country are extensive documents, but it is important to emphasize two key elements that are the different maps where the zoning schemes for the activities and the implementation frameworks containing information on the area where they will be carried out are presented the activities, the characteristics of the area, the permitted uses, the restricted uses, the national support policies and the agencies that will verify that the permitted uses are respected, as well as a series of recommended actions for each activity.

The activities that are desired to be implemented by the private or public sector in the coastal and marine zone must comply with that established in the CZMG, with the results of the environmental impact assessment and with other requirements that the authorities request. In this way, the actions of different areas of government strengthen the management of the coastal zone and promote a culture of compliance with the legislation and plans that exist.

In terms of public policy, it is relevant to note that the BICZMP and the CZMG are very young instruments that will require time for the coordination of different actors, the implementation of plans and the evaluation of the results to know the impact they have had on the coastal zone management. These advances would not have been possible without the participation and collaboration of different actors (effective governance) and without a clear management structure to address the multiple public problems of the coastal zone.

b. Coastal Area Planning & Development

In the planning and development of a coastal area there are key elements such as 1) the number of natural resources that are likely to be used, including the scenic beauty of the landscape and habitats, 2) the amount of space that can be used to establish new infrastructure, 3) the number of sectors that can take advantage of the resources, habitats and spaces available to generate well-being for the population through its use and 4) protect the resources and habitats to maintain the environmental services derived from them. Planning processes should consider the above in order to offer solutions to the different problems that occur due to the development of the coastal zone.

The Belizean government began to better organize its coastal zone planning activities through the *Belize Integrated Coastal Zone Management Plan -2016* and the *Coastal Zone Management Guidelines* that

establish the permitted and restricted uses for different areas, which represents a significant advance for the management of the coastal zone.

The rest of the public or private sectors also have the task of planning and coordinating with other sectors in order to establish an harmonious development between the activities that are desired to be carried out in the coastal zone, as in the case of the tourism sector that through the *National Sustainable Tourism Master Plan 2030 National Destination Physical Plan* (NSTMP-NDPP) where it was proposed that the development of tourism activities be given from physical planning at different scales, to protect the natural and cultural heritage of potential impacts of tourism and new developments (MTCAC, 2011, p.10).

In section 8 of the NSTMP-NDPP, maps on development plans and recommendations are found. This document defines six categories of tourism development that can be carried out in the coastal zone (see: plan number 5 and 6). They also mention that when there is an overlap of new developments with some natural heritage, it must be ensured at least that the impacts are compatible with the environment and that any of the effects can be evaluated and mitigated (MTCAC, 2011, p. 10).

The examples of physical planning proposed by the Coastal Zone Management Authority and Institute - CZMAI - and the Ministry of Tourism, Civil Aviation and Culture – MTCAC - are a step towards more integrated processes. In them, it is proposed to regulate the development of new activities through physical planning and better coordination and aim to reduce the deficiencies of sectoral planning, through collaboration and coordination activities, where they are resolved from possible contradictions that may arise during the elaboration of plans and programs for the use of spaces and resources.

Establishing integrated mechanisms for planning and management of the coastal zone can generate enormous work within the different areas of government. For this reason, it is crucial to know the real capabilities available to coordinate different activities such as collaboration meetings, implementation of the plan, presentation of the results, evaluation of the results of the plan, make suggestions to improve monitoring or the indicators included in the plan, in addition to addressing the various issues that are presented day by day.

The necessary work to develop plans and programs consumes a great deal of time, human resources and budget of the institutions. Therefore, it is vital that these efforts are not unfinished or without application as in the case Revised Master Development Plan for Ambergris Caye (RMDPAC), which is a normative document whose purpose was to establish a comprehensive planning framework for the development of Ambergris Caye (Cardona and Cardona, 2009). Currently, Ambergris Caye has a CZMG (CZMAI, 2016), but the more in-depth analysis is necessary to know the reasons why the RMDPAC was not implemented and try to avoid similar situations that leave areas where they need to be regulated without plans urgently development activities.

Different sectors must develop plans with a spatial approach to know how their objectives and goals will be implemented in the coastal zone. Efforts of this nature must be accompanied by cartographic information and the appropriate scale, which allows locating the resources, habitats, as well as other characteristics of the territory that are necessary at the time of carrying out the physical planning work in the land and marine part. On the other hand, the different sectors require specific information according

to their activities or functions to perform the physical planning they need, but everyone must use a base mapping that allows locating with greater precision the points where conflicts can occur with other activities and avoid the use of cartography and different scales that make it difficult to compare the results of planning between sectors.

Currently, the Belizean government has already taken significant steps in physical planning for the integrated management of the coastal zone and the activities of the tourism sector. The experience acquired is very valuable and can be transmitted or adapted to the rest of the government areas or sectors, as a contribution to the physical planning processes of the country.

c. Beach & Shoreline Management

The tourist and recreational activities that take place along the continental coastline, on the islands and the keys, represent one of the most important economic activities for Belize. The value of the different environmental characteristics present, such as the barrier reef, the color of the water, the depth of the water, the type of coastal vegetation, the color of the sand, the texture of the sand, and the temperature of the water and the ambient temperature is a great attraction that favors the recreational potential of the coastal area. Under the Sustainable Tourism Project II, Ministry of Tourism, Civil Aviation and Culture, a Coastal Management Plan was developed for the Corozal Bay Area.

One of the essential natural resources for the development of tourist activities is sand. Visitors looking for sun, sea and sand touristic destinations consider features such as color and grain size to plan their vacations (see: Botero et al., 2013). The accumulation of sediment along the coastline forms beaches of different lengths and widths serves as a recreational area for visitors and protects the coastal infrastructure against storm events. These benefits derived from the presence of the beach may disappear unless the necessary measures are taken to care for these spaces.

i. Shoreline Management

According to Mangor et al. (2017), the management of the coastline is defined as the act of treating - in a planned way - the actual and potential coastal erosion and its relation to the development activities planned or existing on the coast. The loss of the coastline in a country like Belize can affect the infrastructure of various types, coastal vegetation, wild habitats, public or private property (CZMAI, ND) and can generate economic losses to different sectors, in case of erosion become chronic in certain segments of the waterfront.

Currently, there is evidence of the effects of erosion on the coastline of the cayes and islands (see: Ambergris Caye.com Forum, ND) and on the mainland (see: Karlsson (2015) and the results that are presented in the Erosion section of this report). However, it is necessary to make a diagnosis on the causes of erosion and the rate of retreat of the most affected beaches, to know the seriousness of the situation and to know if the actions for the stabilization of the coastline (see: CZMAI, 2016) are sufficient to solve the problem, or it is necessary to incorporate new actions into existing plans or develop a new plan for erosion control.

During the process of analyzing the existing information, the actions for the stabilization of the Belize coastline (CZMAI, 2016) were compared with the management tools that Williams et al. (2018) mentioned for erosion control and that include a baseline study and risk maps to locate the areas that are most sensitive to erosion. This information is necessary, but it implies an effort on the part of government institutions to generate the necessary data with a level of detail that allows for a proper diagnosis and hence the decision to incorporate new actions or develop a new plan, depending on the level of risk that exists for the loss of the natural capacity of recovery of some beaches.

ii. Beach Management

The beaches have a great variety of functions such as the defense of the coast, recreation and conservation. The different uses that beaches can have cause conflicts of interest (Williams and Micallef, 2009, p. 2) and make it necessary to establish control mechanisms, to rationally take advantage of the space, how activities or protection are carried out from the beach to keep the different species that use this space.

A specific control mechanism is beach management, which Williams and Micallef (2009) define as the management of people and how they interact with the beach environment, to avoid, remedy or to mitigate adverse interactions. The application of this control mechanism is carried out when the use of the beach (specific section of the coastline) is high or when there is a need to protect one or several species that use the beach during its life cycle.

In particular, the intensity of use of the beaches during times of great tourist influx requires the control of visitors and their activities in the emerged and submerged part of the beach. In order to minimize the impacts and improve the visitor's recreational experience and actions, it can be established from simple rules for depositing garbage in suitable containers, to beach certification schemes, which have been created or adopted in various parts of Latin America and the Caribbean (see: Zielinski and Botero, 2015).

Some government strategies designed to reduce the impact of recreational activities on the beaches of Mexico have shown that it is possible to implement sophisticated beach certification schemes, where the environmental protection part has a preponderant weight (see: DOF, 2006), although the costs of monitoring and actions to improve the environmental quality of the emerged and submerged part of the beach are high compared to other certification schemes.

Beach management may be appropriate for the control of activities on recreational beaches; however, the design and implementation of the strategy must be based on the need to control people and their activities more efficiently at certain times of the year. This strategy can be extended to those beaches of use is not recreational, but they also require some mechanism to maintain environmental services to the local population or that are a priority for the conservation of some species such as the turtle.

A new element that must be added to beach management is the presence of sargassum whose cleaning represents high costs for the private and public sector, in addition to generating losses for the tourism sector (see sargassum section in this report) because the sanitary, aesthetic and recreational quality of the beaches decreases, making them less attractive to local and foreign tourists. Sand is lost on a beach when the sargassum is removed as it clings to the seagrass.

The different tourist destinations that Belize offers on the coast and the authorities in charge of environmental protection should analyze the possibility of implementing particular beach management strategies, considering the plans that currently exist and the real needs of a particular strategy.

d. Research, Monitoring & Enforcement

As was indicated in the previous sections, large portions of the monitoring and research efforts are carried out by specialised working groups (on fish aggregation, coral reefs, manatees, sea turtles and so far). Despite restrictions on financial technical and human resources, this collaboration had generated updated information and have guiding fact-based decisions for several ICZM topics.

e. Fisheries Management

i. The impact of climate changes on coastal and marine fisheries

It is expected that climate change and variability will have vast impacts on coastal and marine fisheries in Belize. As carbon dioxide increases in the atmosphere, the oceans absorb more and as a result the water become more acidic. Coupled with increases in temperature, acidification has direct impacts on calcium carbonate which is used by marine organisms (shrimps, oysters, corals) to form their exoskeleton through the process of calcification. Zooplankton which forms the base of the marine food chain, will also be affected as their shells are harder to manufacture and become brittle. The entire marine food web will be altered resulting in changes in the distribution, productivity and species composition of global marine production. Migratory and pelagic fish stocks have unique spatial and temporal distribution patterns related to their bioclimatic niches. Climate changes with their associated shifts in primary and secondary production will therefore impact the distribution range, migratory habits and stock size of many marine species.

Since marine species live near their tolerance limits on a range of physical factors, increases in temperature and acidification may have deleterious effects in their populations. Coastal areas like Belize that experience fluctuations in fluvial patterns can experience lower dissolved oxygen and salinity levels. Some species will move away from shallow coastal waters and semi-enclosed areas into deeper cooler stable waters because of rapid and higher temperatures or freshwater intrusion increases. Anecdotal information from local fishers show that spiny lobster populations move from shallow waters with the barrier reef lagoon to deeper waters outside when temperatures and freshwater intrusions are too high. Less marine species to fish translates into lower income generation and food security.

Climate change will also alter current flows bring further shifts in the distribution of marine fisheries stocks. Scientist are closely monitoring shifts in fisheries stocks distributions and dynamics as well as recruitments. With changes in dynamics, certain geographical areas will benefit while other will lose stocks and revenue earnings. The impact of non- endemic species is also closely monitored in order to make informed management decisions.

ii. The impact of invasive species on coastal and marine fisheries

Marine invasive species can be found throughout the world. In the coastal and marine environment, they are found in rivers, bays, and along the coasts in lagoons, the continental shelves and down to thousands

of feet deep. The introduction of invasive species to new environments can be through vectors and pathways. Vectors are biological methods of transferring alien species such as an organism carrying a disease and transferring it directly to another. Pathways involve non-biological methods such as winds, hurricanes, ocean currents transportation via ballast water of cargo ships. Invasive species can destroy biodiversity, permanently alter habitats and lead to the extinction of endemic plants and animals through both direct and indirect impacts resulting in large economic loses.

Direct impacts are through predation and competition. Usually newly introduced invasive species have no natural predators and as a result can outcompete endemic species for food, prey and habitat. Indirect impacts are through the introduction of disease not found in the local environment. The most destructive species presently affecting Belize and the Caribbean is the Lionfish, *Pterois volitans* and *Pterois miles.*

f. Education, Awareness & Communication

In Latin America, environmental education appeared late in 1980 as part of a non-formal education scheme promoted by non-governmental organizations (González-Gaudiano, 2007); however, the approaches and results obtained from the environmental education programs in this region have been poorly documented (Briggs et al., 2018).

In the case of Belize, the Education and Public Awareness Programme established by the Coastal Zone Management Authority and Institute has produced several brochures, pamphlets, reports and audio-visual material for dissemination among the public, in order to promote awareness of the problems affecting the coastal area (CZMAI, N.D.).

Other environmental education practices conducted by the CZMAI include a Coastal Awareness Week, which consist of activities that take place over the course of a week including a trivia competition for primary schools as well as a race along the coast. The purpose of the commemoration of Coastal Awareness Week is to raise public awareness on the importance of Belize's coastline and marine resources (News 5, 2019).

Continuous information dissemination and development of events are expected to create a culture about caring for different coastal and marine habitats. However, parallel strategies involving schools (primary, secondary and tertiary levels) and non-governmental agencies (NGOs) are needed to strengthen knowledge on the state of the coastal zone and the pressures generated by productive activities.

Much of Belize's economy depends on the environmental goods and services provided by the coastal zone and the education system is of paramount importance to raise awareness of maintaining the environmental quality of the different habitats and species that exist in the coastal area. Efforts to integrate environmental education into the daily lessons in Belize's schools began with a joint project between Peace Corps Belize, the Ministry of Education and different stakeholders who developed new environmental education materials and workshops (Braus and Wood, 1993) thus increasing professional educators capacity as a basis for the improvement of both the individual and the region (Wesley, 2015, p:19).

Efforts to promote environmental education in the country are continuous and the educational programmes that currently exist at the primary and secondary levels could include topics that are considered important (e.g. marine pollution, sea level rise, beach erosion) to update its courses and strengthen the environmental culture of the coastal zone.

On the other hand, the participation of NGOs plays a fundamental role in Belize where the responsibilities of managing large natural areas has moved from the government to a network of organizations that promote the conservation of these areas (Medina, 2010) and in addition, actively participate in creating a culture of environmental protection. Those organizations whose work focuses on the coastal zone, have environmental education related activities and have supported schools to bring awareness on the state of the different habitats and species that exist in the coastal area.

One of the most important points for an efficient collaboration between education systems and NGOs is that the work agendas coincide with their objectives (Wesley, 2015, p:21) and teach topics that are appropriate to the needs of the country. These issues should also be agreed upon by the Coastal Zone Management Authority and appropriate communication channels should be established to agree on common work schedules.

In addition to primary and secondary education, it is important to have the support of local universities and researchers, but several situations have limited their participation in the development of academic programs, human resources capacity building (Young, 2008), provision of training courses, review of coastal zone management programmes and the preparation of a research agenda to support the resolution of problems in the coastal zone.

Making the necessary investment so that one or more institutions have some or all the capacities mentioned in the preceding paragraphs, is an issue that must be analysed by the Government of Belize in order to identify the possibilities and limitations that exist. Another idea behind this analysis would be to reduce dependence of foreign researchers and to let the local universities have their own specialists in coastal zone planning and management.

In 2015, the Department of Environment held a meeting with government agencies that had responsibilities for environmental and natural resource management, to discuss an awareness-raising program and build a partnership with the media, as part of a new communication strategy (News 5, 2015) because environmental issues receive very little media coverage unless it is a disaster where a species or habitat has been affected.

Although these efforts are not permanent, sensitization campaigns aim to raise awareness among society about environmental impacts and the rational use of natural resources through media such as radio and television. Currently these strategies already include social media networks that have become a more efficient way to reach sectors of the population that constantly use them in addition to their lower costs compared to radio or television.

Natural heritage awareness and preservation are important tasks for the Government of Belize and through collaboration with other stakeholders, it is possible to build outreach strategies that are in line with the objectives of sustainable development in the country.

Assessment summary

The following chart shows a summary of the effectiveness assessment of management topics outlined above in the report (Figure 68). In each row of the chart a management topic is assessed using a scale from *very effective* to *not very effective.* In each case, a trend scale is used to indicate if the management effectiveness is deteriorating, improving (getting better) or there is no change (trend is not clear). This chart was constructed with individual responses to an online survey (which represent individual perceptions), then those responses were aggregated (to configure a collective perception) and was analysed and validated in a national expert workshop (See Methodology section and Annex 1 and Annex 4). Finally, the chart indicates the grade of confidence levels that national experts had on the assessment which range from *very confident* (because there is high quality of evidence and strong consensus in regards to the level of effectiveness) towards *low confidence* which means that evidence and consensus are too low to make any assessment.

While the national experts agreed on the effectiveness status for most of the management topic, that was not the case for most of the trends on management effectiveness as there was no consensus. This is as a result that some management topics need more data in order to effectively be assessed. However, it is relevant to note that for those management effectiveness assessments where consensus was reached on the trends, they were mostly improving.

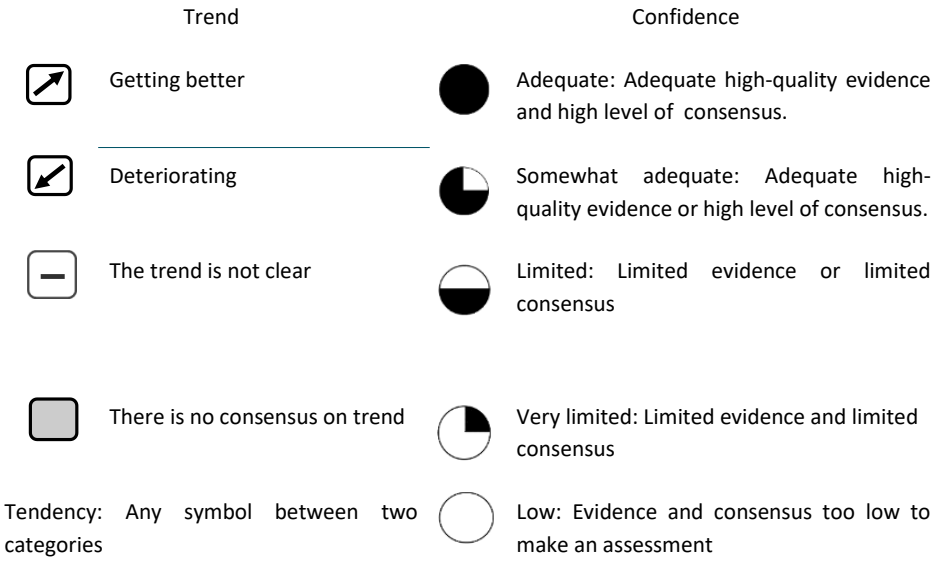
Based on the level of effectiveness we could observe two groups of management topics assessments: 1) assessments with not effective level which includes: coastal zone governance, research monitoring and enforcement and fisheries management, and 2) effective level assessments which included coastal management, certain components of coastal planning and development, as well certain components of education awareness and communications. It is also relevant to note that the assessments level for coastal zone governance, fisheries management and education awareness and communication are based on an adequate level of confidence because there is high quality of evidence. In contrast, more evidence is needed to better assess the topics of coastal zone planning, coastal planning and development, beach and shoreline management and research monitoring and enforcement

Figure 68 ICM effectiveness summary assessment (To be continued)

Topic	Questions	No consensus	Not Very effective	Not effective	Effective	Very effective	Confidence of the effectiveness
Coastal Zone Governance	What is the effectiveness of public participation mechanisms in the design and implementation of programs and plans for the coastal zone?		▢				
	What is the effectiveness government agencies responsible for implementing public participation mechanisms during the formulation and implementation of programs and plans for the coastal zone?		▢				●
	What is the effectiveness responsible government agencies in incorporating public comments and feedback in the design and implementation of programs and plans for the coastal zone?		▢				
Coastal Zone Management	What is the effectiveness of coastal zone plans and programs to reduce the negative impacts of development activities?				↗		
	Do government agencies have the capacity to monitor the coastal zone plans and programs to track progress?				↗		
	Are the coordination mechanisms to implement the coastal zone plans and programs adequate?				↗		◓
	What is the effectiveness of the mechanisms in the coastal zone plans and programs to address conflict resolution regarding the use of the coastal resources?		▢				
Coastal Planning and Development	What is the effectiveness of land use plans to conserve different types of coastal land habitats?				↗		
	What is the effectiveness of the environmental impact assessment to reduce the impacts of development projects?				↗		
	What is the effectiveness of urban planning in reducing impacts on the coastal zone?		↗				◔
	What is the effectiveness of plans to conserve coastal vegetation?		↙				
Beach and shoreline management	What is the effectiveness of management measures to prevent the deterioration of sandy beaches due to recreational activities?		▢				
	What is the effectiveness of management measures to prevent the deterioration of sandy beaches due to the presence of sargassum?		▢				◔
	What is the effectiveness of management measures to prevent shoreline erosion?	▢					
	What is the effectiveness of management measures to avoid shoreline erosion due to coastal protection infrastructures?	▢					
Research, Monitoring & Enforcement	What is the effectiveness of academic programs to improve the state of the coastal zone?		▢				
	What is the effectiveness of monitoring programs to improve the state of the coastal zone?		▢				
	What is the effectiveness of enforcing the pertinent legislations to improve the state of the coastal zone?		▢				
Fisheries Management	What is the effectiveness of management measures to maintain the sustainable extraction of commercial species?		▢				●
	What is the effectiveness of management measures to control the impacts of commercial fisheries in the marine area		▢				
Education, Awareness & Communi-cation	What is the effectiveness of education (primary, secondary and tertiary school programs) to improve the state of coastal				▢		
	What is the effectiveness of awareness (government campaigns) to improve the state of coastal zone?				▢		●
	What is the effectiveness of communication (media activities: newspapers, radio and television) to improve the state of coastal zone?		▢				

Figure 68 ICM effectiveness summary assessment (continuation)

Symbology



Recommendations

In order to increase management effectiveness, the following milestones must be achieved:

1. A set of indicators for effective public participation on coastal management is used on a regular basis.
2. A protocol is established, published and used to address conflict resolution regarding the use of coastal resources.
3. Progress reports on the implementation of the Belize City Master Plan are made available and lessons learned are incorporated into other planning process for coastal zone settlements.
4. Progress reports on the implementation of The Growth and Sustainable Development Strategy (GSDS), 2016-2019 are made available and lessons learned are incorporated in new national development plans.
5. Progress reports on the Shoreline Management Plan are made available.
6. A stakeholder engagement strategy is developed and implemented for coastal zone management.

IV. Resilience of the Coastal Zone

Added to the existing challenges related to development in the coastal zone are the impacts of variability and climate change, which are generating effects that are difficult to assess in the long term. In order to solve these problems, the international community has been forced to develop new solutions and strategies. However, the shift towards new planning and development paradigms is a gradual process. Particularly, developing nations need more time to implement the new proposals and make the necessary adjustments to their internal policy in such a way that they allow planning systems, such as integrated coastal zone management, to adopt methods for evaluating the impacts of climate variability and change, and thereby establish the necessary measures.

a. Socio-economic Adaptation Capacity

According to Brooks and Adger (2004), five components are considered in the design of adaptation policy, and in the first component, it is recommended to evaluate the capacity to adapt. In the case of the National Climate Change Policy, Strategy and Action Plan (NCCPSAP), it was defined as the ability to adjust to climate change to minimize potential damage; to take advantage of the opportunities, or to face the consequences (MFFSD, 2014) that affect the economic, social and environmental system.

In the design of adaptation policies, particular issues, regions or groups of a specific population that are at higher risk due to climate change and that belong to sectors particularly crucial for the national economy are considered (Brooks and Adger, 2004). The NCCPSAP identified in the coastal area three sectors (fisheries, aquaculture and tourism), two regions (marine and coastal) and a particular issue (human settlements) which will be affected by climate change (MFFSD, 2014) and whose effects will increase in greatly the complexity for planning and management of the coastal zone.

A relevant point of the NCCPSAP design is that it was aligned with the goals of economic development, poverty reduction and long-term sustainable development of the Growth and Sustainable Development Strategy 2014-2017. The adaptation strategies presented in the NCCPSAP consider part of the growth and sustainability goals for the fishing and aquaculture sector (see: Table 7.3, adaptation measures 1, 4, 7 and 16), marine and coastal resources (see: Table 7.4, adaptation measures 7 and 8), human settlements (see: Table 7.6, adaptation measure 7) and tourism (see: Table 7.7, adaptation measures 2, 3 and 4) (MFFSD, 2014).

It is essential to consider that, after the first cycle of implementation of adaptation measures and once the Government of Belize has advanced in the new institutional, legal and financing arrangements that are necessary to formally address the various issues related to adaptation to climate change, more issues that were not considered in the initial strategy should be included (see: MFFSD, 2014, p. 7).

In terms of integrated coastal zone management, one of the most important points mentioned in the NCCPSAP is the collaboration that must exist between the Climate Change Office and the Coastal Zone Management Authority and Institute (CZMAI). The collaboration and cooperation between the different areas involved in the coastal zone become more relevant with the incorporation of the climate change theme into the Belize national policy agenda. For this reason, it is necessary that the planning,

management and adaptation of the coastal zone, be carried out through mechanisms that optimize efforts in the elaboration of plans and strategies, to improve the effectiveness of government actions, to attend the most vulnerable groups, activities and habitats.

b. Prioritization of Ecosystem-based Adaptation

Ecosystem-Based Adaptation includes a wide range of ecosystem management activities aimed at increasing resilience and reducing the vulnerability of people and the environment to the impacts of climate change (Lhumeau and Cordero, 2012). Despite this, it is necessary to consider the limitations that exist for ecosystems to continue providing the environmental services they provide to the population in the face of 1) the impacts of climate variability, 2) development pressures in the short and medium-term and 3) for the impact of long-term climate change, in the coastal zone.

An example of this is the case of climatic variability associated with the increase in the number and intensity of hurricanes that reach the coast and produce erosion processes caused by storm waves that could reduce the width of some beaches. On the one hand, in terms of the impacts generated by human activities in the coastal zone, it is well-identified that the alterations produced by some protection structures generate erosion processes in adjacent areas. On the other hand, in terms of climate change, the gradual rise in sea level will also contribute in the long term to the loss of the coastline.

The effect produced by each of these phenomena on the beach or some other ecosystem, habitat or species found in the coastal zone varies depending on the area and the intensity of the impacts. For this reason, it is necessary to have an idea of the seriousness of each one, in such a way that they allow designing the most appropriate plans and strategies. Although the advantages of designing and implementing ecosystem-based adaptation measures to preserve the different elements of the coastal area have been strongly emphasised (see: Lhumeau and Cordero, 2012, p.15), the reality is that deterioration conditions where many ecosystems, habitats or species are found, are challenging to manage.

On the other hand, Mabey et al. (2011, p.52) considered that the impact of climate change requires adaptation policies and contingency plans that are capable of responding to the full range of possible higher risk scenarios. From this perspective, they refer to scenarios that result from the failure of mitigation plans and suggest that a prudent approach to risk management should (Mabey et al., 2011, p.11):

- Try to keep the heating below 2 ° C (3.6 ° F)
- Build and budget assuming 3-4 ° C (5.4-7.2 ° F) heating
- Establish a contingency plan for 5-7 ° C (9-12.6 ° F) heating

Although it is desirable to incorporate the three levels of risk in the process of developing a policy and its strategies against climate change, in practice, it is still a very complex task for public administrations in different countries due to the levels of uncertainty that exist, to the costs and to the technical and institutional capacities that are needed. However, the threat posed by the progressive increase in the temperature of the atmosphere and, consequently, in the water column (see: IPCC, 2019, p. 9), forces us to think about ecosystems, habitats and species will be affected and if it is possible to establish adaptation

measures that are efficient, effective and effective to deal with temperature ranges (see: Lhumeau and Cordero, 2012, p. 15) that in some cases could generate severe imbalances in the coastal area.

Efforts to reduce the impacts of climate change through ecosystem-based adaptation in the coastal zone is becoming a work of continuous learning, where the proposals made try to deal with the uncertainty that results from climate change scenarios and with the different pressures that derive from climate variability and development processes.

Currently, the Marine Climate Change Adaptation Project, under the Fisheries Department, has as its objective **"**to implement priority ecosystem-based marine conservation and climate adaptation measures to strengthen the climate resilience of the Belize Barrier Reef System.**"** Specifically, the Project has four components:

- Improving the protection regime of marine and coastal ecosystems;
- Promotion of viable alternative livelihoods for affected users of the reef in the areas impacted by project activities;
- Raising awareness and building capacity; and
- Project Management, Monitoring and Assessment.

Another project called "Smart Coast: Climate Smarting Marine Protected Areas and Coastal Management in the Mesoamerican Reef Region" is being carried out. This project aims to incorporate climate-smart principles in the management of marine protected areas and coastal development policies of the coastal countries of the Mesoamerican Reef, to improve the adaptive capacity of coastal communities in the region, use among other tools, ecosystem-based adaptation means (IKI-Alliance, ND).

To carry out this project, in Belize, three coastal planning regions were selected: the southern zone, the northern zone and Ambergris Caye. The selection was based on the high biodiversity contained and the vulnerability of the populations. The implementation of this project should consider the efforts that have been made regarding climate change in the reef barrier to strengthen the management of one of the marine ecosystems most vulnerable to the impact of climate change (see: GCA, 2019, p. 30) and only the evaluation of the results in the future will be able to say if the adaptation measures reduced the vulnerability of the communities and protected the reef area.

In the Belize Integrated Coastal Zone Management Plan (BICZMP), it was established that the Corozal district (northern coastal planning region) is vulnerable to natural hazards and the impacts of climate change (CZMAI, 2016, p. 140). With the Smart Coast project, aspects related to the vulnerability of the site will be more accurately identified.

c. Disaster Preparedness & Response

There are different natural hazards such as droughts, forest fires, floods caused by river overflows, storm surge or torrential rains, wind gusts caused by storms and landslides, which put the components of a community at risk (the population, economic activities or infrastructure) and can become a disaster when the intensity and duration of hazards dramatically increases the level of risk to one or more of the community components.

Due to the geographical location of Belize, the country is susceptible to the effect of various natural hazards caused by phenomena such as storms and hurricanes whose frequency, intensity and duration have forced the government to establish the agency called National Emergency Management Organization (NEMO). The NEMO has ten coordination district and three regional coordination through which natural disasters are managed. During the hurricane season, monitoring the condition of the marine climate is very important, and if a storm that goes to the coast exceeds a certain intensity and magnitude, the alert mechanism will be activated to prevent a disaster.

Disaster management focuses part of its efforts on extreme events that may generate short-term impacts, but another action to address these disasters in the medium and long term is to reduce exposure and risk, through plans (GCA, 2019, p. 17) that consider the main hazards that will arise along the coastline of the islands and the Belize mainland. The CZMAI will have a significant role in the following years, by working in collaboration with the NEMO and other authorities (see: CZMAI, 2016, p. 132), to improve the physical planning of the coastal zone incorporating measures that reduce exposure of the new infrastructure that is intended to be built in the coastal zone, against extreme events and the gradual rise in sea level.

The improvements made to the management plans and guides, which CZMAI is in charge of, will be part of the response to reduce the impacts of climate change in the coastal zone and, together with other actions established in the NCCPSAP, there will be the possibility to regulate development in the coastal zone better.

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Annexes

Annex 1. Pressure-State-Effectiveness Assessment System

As with any planning and management process, Integrated Coastal Zone Management (ICZM) should have the capacity to evaluate the environmental health of coastal and marine ecosystems through weighted quantitative or qualitative indicators on the impacts of activities in the coastal zone, the status of the resources and the effectiveness of governmental actions to control these activities.

The design for ICZM evaluation indicators has been widely described by Post and Lundin (1996), Olsen *et al.* (1999), UNESCO (2003) and UNESCO (2006), where main advances related to this field have been presented. Likewise, the environmental indicators that apply to the coastal zone have generally been developed between the Pressure-State-Response (PSR) or Driving Force-Pressure-State-Impact-Response (DPSIR) models that were proposed by the Organization for Economic Cooperation Development (OECD) (see: Belfiore, 2003).

The PSR model highlights these cause-effect relationships and helps decision makers and the public see environmental, economic, and other issues as interconnected. It thus provides a means of selecting and organising indicators (or state of the environment reports) in a way useful for decision-makers and the public and ensures that nothing important has been overlooked (OECD, N.D.).

The GRID-Arendal Norway Foundation has made available a website for the members of the Abidján Convention, where a tool is presented that allows evaluating the state of the marine and coastal environment in terms of its actual conditions, the pressures that influence these conditions, as well as the driving forces that create these pressures (GRIDA, 2019). Additionally, a variation on the precedent procedure was applied by independent experts (Jackson *et al.* 2016) in the "Australia State of the Environment, Coast" (2016) and "Australia State of the Environment, Marine" (2016) Reports. This modified version allows for grading of the pressure, state, and effective management of the measures.

For practical consulting purposes the Belizean Coastal Zone will be divided into the Land Coastal Zone and the Marine Coastal Zone. The established limits for the coastal zone in the Coastal Zone Management Act Chapter 329 are taken into account.

Pressures related to human activities on the Land Coastal Zone

The Land Coastal Zone as identified in the ICZM Plan (2016) covers an area of 3 Km of land from the high tide line and embraces the emergent part of the beach, bays, coastal lagoons, as well as mangrove forest and other vegetation.

Pressures on the land coastal zone arise from drivers of environmental change and the following list describes pressures from human activities exerted on the environment and natural resources:

1. Climate, weather and climate change
2. Coastal development and land use
3. Tourism and recreation

4. Energy generation
5. Resource extractions
6. Coastal lands and pollution
7. Sea level rise
8. Sediment transport
9. Erosion
10. Saline intrusion

Parameters and impacts (Land)

Table 22 presents a proposal of parameters and impacts that can be used for the qualitative evaluation of the pressure component on the land coastal zone for the 5-year referenced period.

Table 22 Parameters and summary of impacts on the Land Coastal Zone

Land Coastal Zone		
Pressures	**Parameters**	**Summary of impacts**
Climate, weather and climate change	Mangroves Littoral forest	What has been the impact of climate change on mangroves? What has been the impact of climate change on littoral forest?
Coastal development and land use	Mangroves Littoral forest	What has been the impact of urban development on mangroves? What has been the impact on the littoral forest due to new urban development?
Tourism	Mangrove Littoral forest Pollution from sewage or untreated sewage Garbage generation Coastline modification Pressure on wildlife species populations	What has been the impact of construction of new tourism development and recreational activities on mangroves? What has been the impact of construction of new tourism development and recreational activities on the littoral forest? What has been the impact of disposing untreated water in the mangrove areas? What is the impact of pollution generated by garbage in the mangrove areas? What is the impact of coastal infrastructure associated with tourism development and recreational activities on the beach? What is the impact on wildlife species populations as a result of tourism development and recreational activities?
Energy	Mangrove Littoral forest Bays Coastal lagoons Discharge of polluting substances on the ground	What has been the impact by the construction of new power plants in the mangrove areas? What has been the impact by the construction of new power plants on the littoral forest? What has been the impact by the operation of new power plants on the bays? What has been the impact by the operation of new power plants on the coastal lagoons? What have been the impacts by ground discharges of polluting substances used in the operation of power generation plants?

Resources extraction (sand and pebbles for the construction industry)	Mangrove Littoral forest Coastline modification Ground pollution caused by toxic substances	What has been the impact of mangrove by the extraction of resources? What has been the impact on the littoral forest by the extraction of resources? What has been the impact on the coastline caused by the extraction of resources? What has been the impact on the soil due to the spillage of toxic substances used in the extraction of resources?
Sea-level rise	Mangrove Littoral forest Tourist development	What has been the impact of mangroves due to sea-level rise? What has been the impact on the littoral forest due to sea-level rise? What has been the impact on tourist development due to sea-level rise?
Sediment transportation	Protection infrastructure Sediment input	What has been the impact on sediment extraction for the construction of coastal protection infrastructure? What has been the impact on sediment transport, due to the lack of sediment replenishment on the coast?
Erosion	Beach Coastal infrastructure Urban development Tourist development	What has been the impact of storm surge on the beach? What has been the impact of coastal protection infrastructure on the beach? What has been the impact of beach erosion on urban development? What has been the impact of beach erosion on the tourism development?
Saline Intrusion	Mangrove Littoral forest Water quality Aquaculture	What has been the impact of saline intrusion on the mangroves? What has been the impact of saline intrusion on the littoral forest? What has been the impact of saline intrusion on water quality for human consumption? What has been the impact of saline intrusion on aquaculture?
Aquaculture	Loss of mangroves Loss of other types of vegetation Pollution from pond discharges Coastline modification Wildlife populations health Escape of exotic species	What has been the impact on the mangroves due to the construction of new aquaculture ponds? What has been the impact on the mangroves and due to discharges caused by the cleaning of ponds? What has been the impact of aquaculture on the health of wildlife populations? What has been the impact on biodiversity as a result of the escape of exotic species associated with aquaculture?

Pressures related to human activities on the marine Coastal Zone

The marine coastal zone covers a strip from the highest tide line to the limit of the exclusive economic zone, where the submerged part of the beach, bays, coastal lagoons, seagrasses, Cayes, atolls and the coral reefs are located.

Pressures on the marine coastal zone arise from drivers of environmental change and the following list describes pressures from human activities exerted on the environment and natural resources:

1. Marine Pollution
2. Pollution by nutrients
3. Dredging
4. Invasive species
5. Sargassum
6. Tourism and recreation
7. Fisheries
8. Shipping
9. Mariculture
10. Sport fishing

Parameter and impacts (marine)

Table 23 presents a proposal of parameters and impacts that can be used for the qualitative evaluation of the pressure component on the marine coastal zone for the 5-year referenced period.

Table 23 Parameters and summary of impacts on the marine portion of the coastal zone

Marine Coastal Zone		
Pressures	**Parameters**	**Summary of impacts**
Marine Pollution	Water quality	What has been the impact on water quality due to marine pollution?
	Seagrasses	What has been the impact on seagrasses due to marine pollution?
	Reefs	What has been the impact on reefs due to marine pollution?
	Fisheries	What has been the impact on the various fisheries due to marine pollution?
Pollution by nutrients	Water quality	What has been the impact on water quality due to nutrient pollution?
	Seagrasses	What has been the impact on seagrasses due to nutrient pollution?
	Reefs	What has been the impact on reefs due to nutrient pollution?
	Fisheries	What has been the impact on the various fisheries due to nutrient pollution?
Dredging	Mangroves	What has been the impact on the mangroves by dredging activities?
	Coastal lagoons	What has been the impact on coastal lagoons by dredging activities?
	Reefs	What has been the impact on the reefs by dredging activities?
	Seagrasses	What has been the impact on seagrasses by dredging activities?
	Fisheries	What has been the impact on the various fisheries by dredging activities?
Invasive species	Reefs	What has been the impact of invasive species on the reefs?
	Seagrasses	What has been the impact of invasive species on seagrass?
	Fisheries	What has been the impact of invasive species on the various fisheries?
Sargassum	Reefs	What has been the impact of sargassum on coral reefs?
	Seagrasses	What has been the impact of sargassum on seagrasses?
	Fisheries	What has been the impact of sargassum on the various fishery?
	Tourism activities	What has been the impact of sargassum on tourism activities?
Tourism	Reefs	What has been the impact of tourism on coral reefs?
	Seagrasses	What has been the impact of tourism on seagrass?
	Fisheries	What has been the impact of tourism on the various fisheries?

	Beaches Water quality Biodiversity	What has been the impact of tourism on sandy beaches? What has been the impact of tourism on water quality in the marine environment? What has been the impact of tourism on biodiversity e.g. manatees, dolphins etc.
Lobster fishery	Reefs Seagrasses Species	What has been the impact of the lobster fishery on coral reefs? What has been the impact of the lobster fishery on seagrass? What has been the impact of the lobster fishery on other species?
Marine transport	Manatees Cetaceans	What has been the impact of sea transport noise pollution on manatees? What has been the impact of maritime transport noise pollution on cetaceans?
Mariculture	On the seabed On water quality	What has been the impact of mariculture on the seabed? What has been the impact of mariculture on water quality in the marine environment?
Sport fishing	Bonefish Tarpon Permit	What is the status of the Bonefish, Tarpon and Permit populations due to sportfishing? What is the status of these sportfishing species due to fish nets? What is the status of the these sportfishing species populations due to coastal development?

Pressure Assessment System

The assessment grade levels are based on the State of the Environment (2016) grading systems (Clark and Johnston, 2017). For pressure there is Table 24 that measures the 4 impacts grade levels (very low impact, low impact, high impact, very high impact), and 4 grades on trends (getting better, deteriorating, stable, the trend is not clear)

Table 24 Pressure assessment system

Degrees	Trend
Very low impact: imposes negligible pressure on the state of habitats; species/groups of taxa; or physical, biogeochemical, biological or ecological processes. **Low impact:** imposes low pressure on the state of habitats; species/groups of taxa; or physical, biogeochemical, biological or ecological processes. **High impact:** imposes moderate pressure on the state of habitats; species/groups of taxa; or physical, biogeochemical, biological or ecological processes. **Very high impact:** imposes strong pressure on the state of habitats; species/groups of taxa; or physical, biogeochemical, biological or ecological processes.	Getting better Deteriorating Stable The trend is not clear

SOURCE: CLARK G.F. AND E. L. JOHNSTON (2017). AUSTRALIA STATE OF THE ENVIRONMENT 2016: COASTS, INDEPENDENT REPORT TO THE AUSTRALIAN GOVERNMENT MINISTER FOR ENVIRONMENT AND ENERGY, AUSTRALIAN GOVERNMENT DEPARTMENT OF THE ENVIRONMENT AND ENERGY. CANBERRA. BASED ON THE LIKERT SCALE

Habitat quality parameters and trends

Status and trend for habitat quality are defined as the current condition of important environmental components relevant to the theme and recent trends (State of the Environment, 2016) taking into consideration the environmental conditions in Table 25 relating to the quality of the environment and the quality and quantity of natural resources (OECD, N.D.).

Table 25 Parameters and status summary on the Land and Marine Coastal Zone

Land and Marine Coastal Zone		
Habitat or element status	**Parameters**	**Status Summary**
Water Quality	Nutrients Coliforms	What is the state of water quality due to nutrient contamination? What is the state of water quality due to coliform contamination?
Mangrove	Urban development Tourism development Solid waste Storms	What is the status of mangroves due to urban development? What is the state of mangroves due tourism development? What is the status of mangroves due to the amount of garbage? What is the state of mangroves due to storms?
Littoral forest	Urban development Tourist development Solid waste Storms	What is the state of the littoral forest due to urban development? What is the state of the littoral forest due to tourism development? What is the state of the littoral forest due to the amount of garbage? What is the state of the littoral forest due to storms?
Coral reef	Nutrient pollution Coliform contamination Damage caused by recreational activities Damage caused by storms Water temperature damage	What is the status of the coral reef due to nutrient contamination? What is the status of the coral reef due to coliform contamination? What is the status of the coral reef due to recreational activities? What is the status of the coral reef due to storm damage? What is the status of the coral reef due to increase in water temperature?
Seagrasses	Nutrient pollution Coliform contamination Damage caused by recreational activities Damage caused by storms Water temperature damage	What is the state of seagrasses due to nutrient contamination? What is the status of seagrasses due to coliform contamination? What is the state of seagrasses due to recreational activities? What is the state of seagrass for storm damage? What is the state of seagrasses due to increase in water temperature?
Protected areas	Economic activities Urban development Pollution	What is the status of protected areas due to economic activities? What is the status of protected areas due to urban development? What is the status of protected areas due to pollution?
Species population	Economic activities Coastal development Pollution	What is the status of species population due to economic activities? What is the status of species population due to coastal development? What is the status of species population due to pollution?

Status and Trend Assessment System

The assessment grade levels are based on the State of the Environment (2016) grading systems (Clark and Johnston, 2017). For status there is Table 26 that measure the 4 impact grade levels (very poor, poor, good, very good) and 4 trend grades (getting better, deteriorating, stable, the trend is not clear).

Table 26 State and trend assessment system

Degrees	Trend
Very Good: Human activities or the decline in environmental conditions have had minor impacts on habitats; species/taxa groups; or in physical, biogeochemical, biological or ecological processes. **Good:** Human activities or the decline in environmental conditions have had some significant impacts on habitats; species/taxa groups; or in physical, biogeochemical, biological or ecological processes, but the effects are not persistent or substantial in general habitats, groups or processes of species/taxa. **Poor:** Human activities or the decline in environmental conditions have caused substantial changes in habitats; species/taxa groups; or in physical, biogeochemical, biological or ecological processes, which result in substantial and persistent effects on habitats, species/taxa groups or processes. **Very poor:** Human activities or the decline in environmental conditions have caused widespread changes in habitats, species/groups or processes, resulting in loss of habitat, species/taxon groups, and ecosystem.	Getting better Deteriorating Stable The trend is not clear

SOURCE: CLARK G.F. AND E. L. JOHNSTON (2017). AUSTRALIA STATE OF THE ENVIRONMENT 2016: COASTS, INDEPENDENT REPORT TO THE AUSTRALIAN GOVERNMENT MINISTER FOR ENVIRONMENT AND ENERGY, AUSTRALIAN GOVERNMENT DEPARTMENT OF THE ENVIRONMENT AND ENERGY. CANBERRA. BASED ON THE LIKERT SCALE

Topics and Parameters for asses the effectiveness in Coastal Zone Integrated Management

Management effectiveness is the management responses to each of the pressures identified in this report and refers to the collective actions and reactions in Table 27, intended to: mitigate, adapt to or prevent human-induced negative effects on the environment; halt or reverse environmental damage already inflicted and preserve and conserve nature and natural resources (OECD, N. D.).

Table 27 Topics and parameters for Coastal Zone Management Effectiveness

Land and Marine Coastal Zone		
Topic	**Parameters**	**Effectiveness Summary**
Coastal Zone Governance	Coastal population Plans and programs Responsible agency	What is the effectiveness of public participation mechanisms in the design and implementation of programs and plans for the coastal zone? What is the effectiveness of government agencies responsible for implementing public participation mechanisms during the formulation and implementation of programs and plans for the coastal zone?

		What is the effectiveness of the responsible government agencies in incorporating public comments and feedback in the design and implementation of programs and plans for the coastal zone?
Coastal Zone Management	Plans and programs Government capacities Coordination mechanisms Stakeholders	What is the effectiveness of coastal zone plans and programs to reduce the negative impacts of development activities? Do government agencies have the capacity to monitor the coastal zone plans and programs to track progress? Are the coordination mechanisms to implement the coastal zone plans and programs adequate? What is the effectiveness of the mechanisms in the coastal zone plans and programs to address conflict resolution regarding the use of the coastal resources?
Coastal Planning and Development	Land use Environmental Impact Assessment Urban planning Coastal vegetation	What is the effectiveness of land use plans to conserve different types of coastal land habitats? What is the effectiveness of the environmental impact assessment to reduce the impacts of development projects? What is the effectiveness of urban planning in reducing impacts on the coastal zone? What is the effectiveness of plans to conserve coastal vegetation?
Beach and shoreline management	Recreational activities Sargassum Shoreline erosion	What is the effectiveness of management measures to prevent the deterioration of sandy beaches due to recreational activities? What is the effectiveness of management measures to prevent the deterioration of sandy beaches due to the presence of sargassum? What is the effectiveness of management measures to prevent shoreline erosion? What is the effectiveness of management measures to avoid shoreline erosion due to coastal protection infrastructures?
Research, Monitoring & Enforcement	Academic programs Monitoring programs Legislation	What is the effectiveness of academic programs to improve the state of the coastal zone? What is the effectiveness of monitoring programs to improve the state of the coastal zone? What is the effectiveness of enforcing the pertinent legislations to improve the state of the coastal zone?
Fisheries Management	Sustainable exploitation Commercial fisheries impact	What is the effectiveness of management measures to maintain the sustainable extraction of commercial species? What is the effectiveness of management measures to control the impacts of commercial fisheries in the marine area?
Education, Awareness & Communication	Education levels government campaigns media activities	What is the effectiveness of education (primary, secondary and tertiary school programs) to improve the state of coastal zone? What is the effectiveness of awareness (government campaigns) to improve the state of coastal zone? What is the effectiveness of communication (media activities: newspapers, radio and television) to improve the state of coastal zone?

Management Effectiveness Assessment System

Assessment grade levels proposed by Biosfera Desarrollos team.

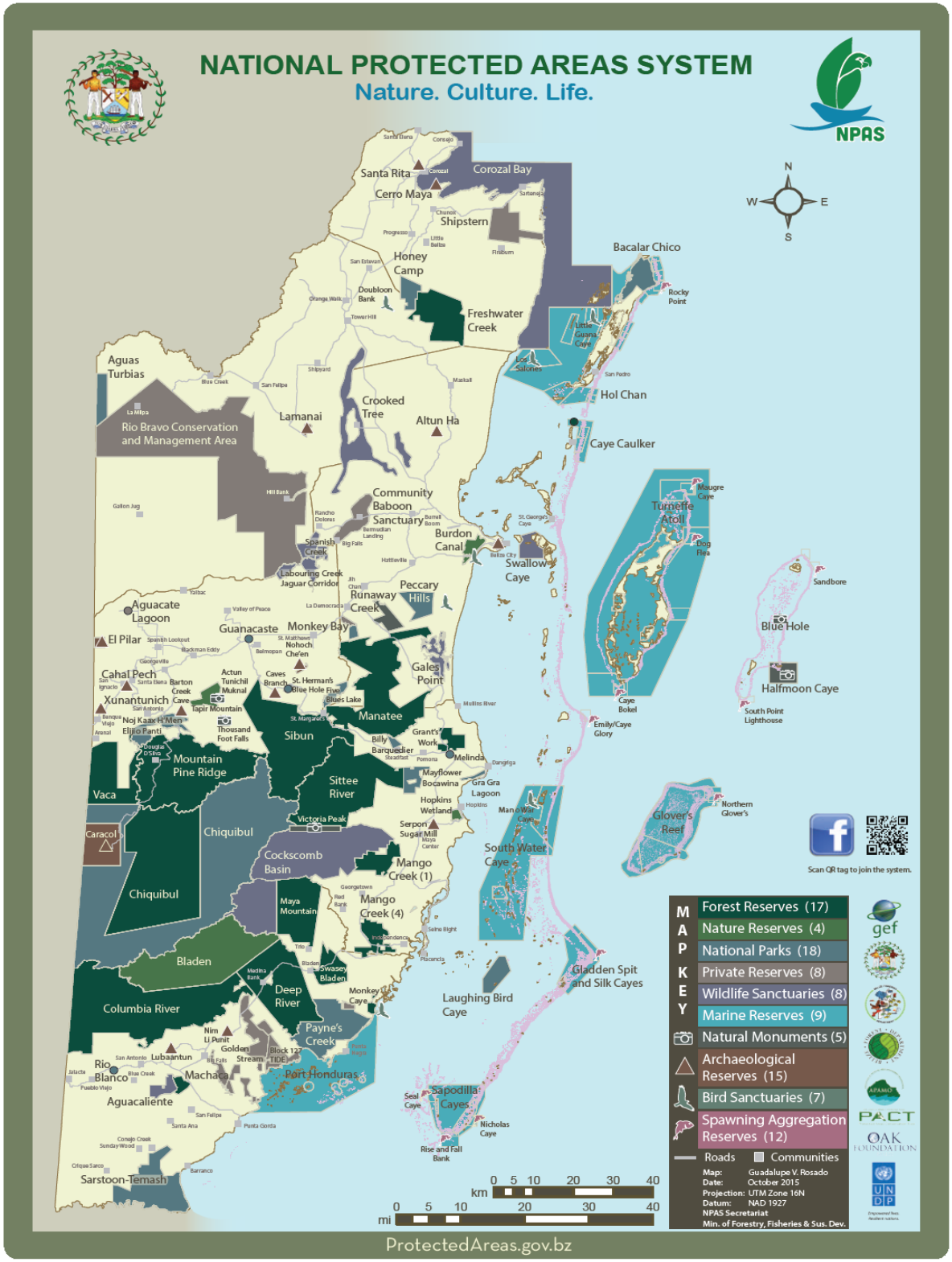
For effectiveness there are (Table 28): 4 impact grade levels (inefficient, non-efficient, not very efficient, efficient), and 4 trend grades (getting better, deteriorating, stable, the trend is not clear).

Table 28 Management effectiveness assessment system

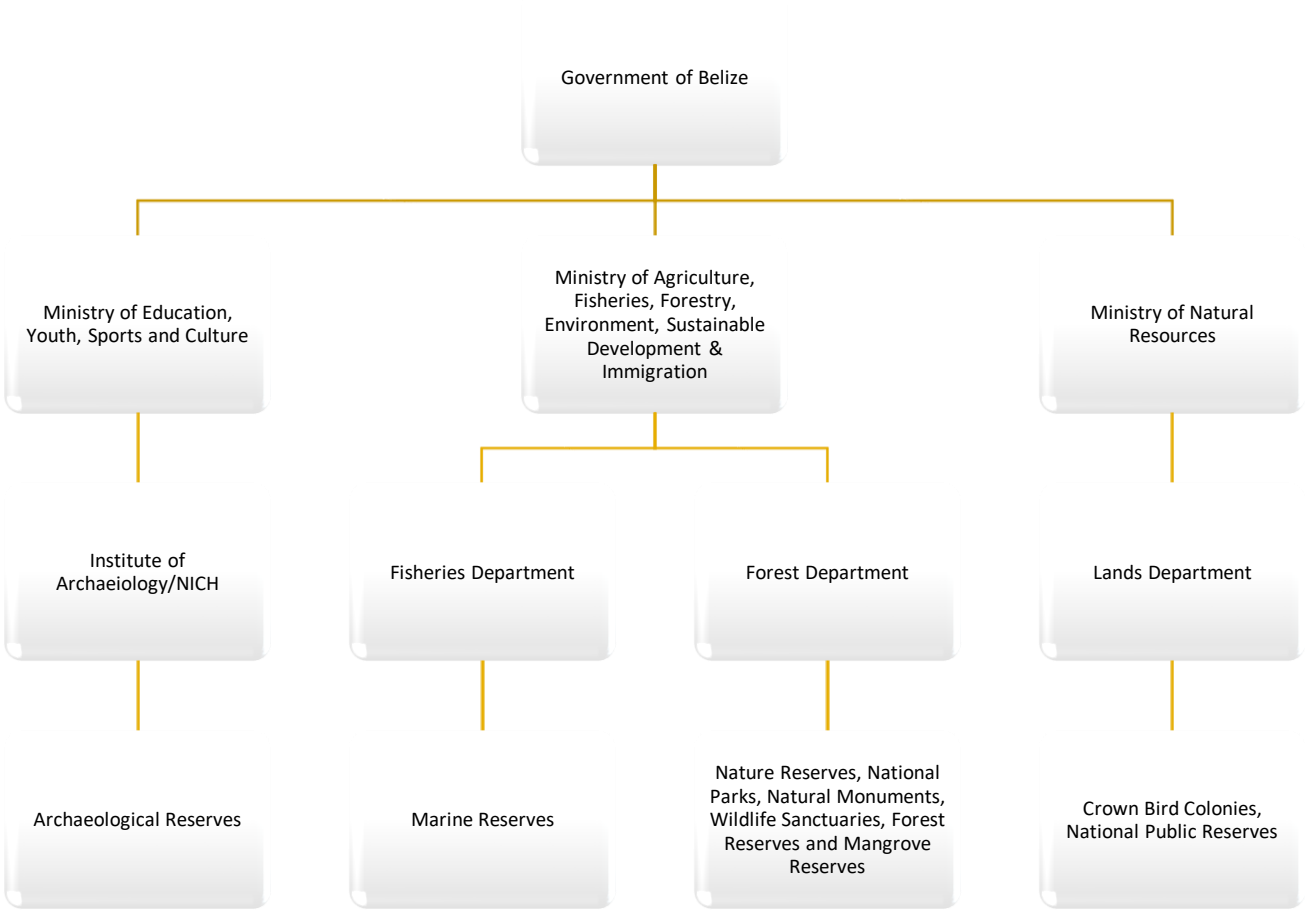
Degrees	Trend
Efficient: Human activities have been properly managed through specific management and coordination instruments between government agencies. Environmental conditions have had minor impacts on habitats; species/taxa groups; or in physical, biogeochemical, biological or ecological processes. **Not very efficient:** Human activities have been controlled partially correctly by deficiencies in management instruments or by the absence of better coordination between government agencies. Environmental conditions have had some significant impacts on habitats; species/taxa groups; or in physical, biogeochemical, biological or ecological processes, but the effects are not persistent or substantial in general habitats, groups or processes of species/taxa. **Non-efficient:** Human activities have not been adequately controlled due to deficiencies in management instruments and the lack of coordination between government agencies. Environmental conditions present substantial changes in habitats; species/taxa groups; or in physical, biogeochemical, biological or ecological processes, which result in substantial and persistent effects on habitats, species/taxa groups or processes. **Inefficient:** Human activities cannot be controlled because there are no management tools or coordination between government agencies. Environmental conditions present widespread changes in habitats, species/groups or processes, resulting in loss of habitat, species/taxa groups, and ecosystem.	Getting better Deteriorating Stable The trend is not clear

SOURCE: SELF-MADE. BASED ON THE LIKERT SCALE

Annex 2. Protected areas in Belize



Annex 3. Legislative framework



Annex 4. Agenda and participation for the national expert's validation workshop

Invitation to participate in the

Validation workshop for the State of the Belize Coastal Zone Report 2014-2018

Venue: Meeting Room – Meeting Room at the Coastal Zone Management Authority and Institute

Coastal Zone Multi-Complex Building, Princess Margaret Drive. Belize City

Date: 24- January 2020

Presentation:

Different planning efforts have been undertaken in Belize towards Coastal Zone Integrated Management. Recently under an adaptive management approach, the ***Belize Integrated Coastal Zone Management Plan*** was approved and published which provides a comprehensive value of the coastal zone, an in-depth review of the critical issues on the coastal zone and sets forth a future vision for the coast based on an informed management scenario; the plan establishes strategic actions and finally, coordinates the implementation of those actions by a wide set of governmental and non-governmental organisations. Therefore, two complementary aspects are of notable significance: What changes in the coastal zone have happened since the last report? Moreover, how effective have the management actions included in the CZIM Plan been? By following the Coastal Zone Management Authority and Institute (CZMAI as follows) commitment to inform the government and the people of Belize about the state of the coast as a way to create awareness on the relevance of the coastal zone for its survival as well as quality of life in Belize, a new report of the State of the Coastal Zone is under preparation This Report encompasses statistics from 2014-2018 and adopts the approach of the Pressures-State-Effectiveness evaluation system. To increase the national expert's perspectives into this report, the CZMAI is pleased to invite you to participate in a national validation workshop for this report.

Goals

Facilitate a consensus building process with national experts in regards to the Pressure – State – Management system for the Belize´s Coastal Zone.

At the end of this workshop participants will be able to:

- Review the draft of the State of the Belize Coastal Zone Report 2014-2018
- Provide feedback on the content of the Draft report
- Update information that must to be included into the report

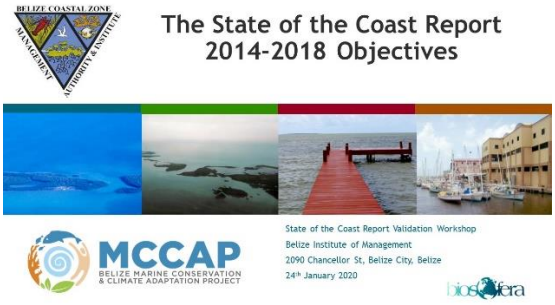
- Analyze the Pressure – State – Management system and the initial assessment obtained by an online survey
- Build a consensus on the main topics for the Pressure – State – Management system for the Belize's Coast.

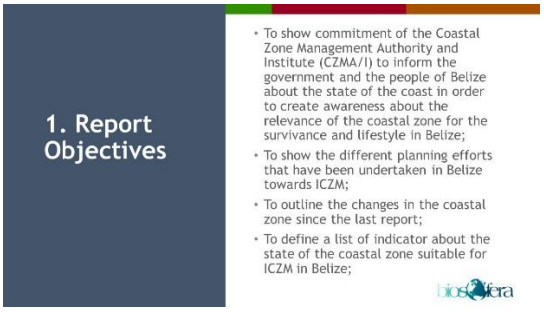
Agenda:

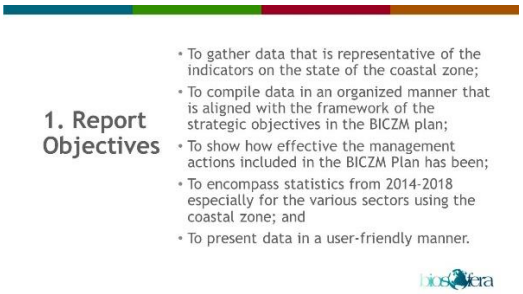
Time	Activity	Responsible
8:00-8:30	Participant registration	All
8:30 -9:00	Opening session Welcome and CZIMA expectation Review the agenda Key agreements for the dynamics of the workshop	 Ms. Arlene Young Fernando García James Azueta
9:00-9:30	The State of the Belize Coastal Zone Report 2014-2019 Report objectives The Pressure -State – Management approach Methodology (SoME Method)	James Azueta Gilberto Enriquez
9:30 – 10:00	The Draft of the State of the Belize Coastal Zone Report at a glance Presentation	James Azueta – Gilberto Enriquez
10:00-11:00	Feedback on the Draft report State of the Belize Coastal Zone Report 2014-2018	Working groups and plenary
11:00-11:30	Presentation of the results of the Online Survey	Gilberto Enriquez
11:30-12-30	Rounds of Review the initial Assessment for: Pressures (Land and Marine) Habitats Management effectiveness	Fernando García facilitates Four teams 15 minutes each.
12:30 -13:30	Lunch	
13:45-14:30	Presentations of the results of the feedback	
14:40 -15:30	Rounds of feedback: (Carrousel) (Confidence – Compatibility) Pressures (Land and Marine) Habitats Management effectiveness	Fernando García facilitates Four teams 15 minutes each.
15:30 -16:00	Facilitated discussion about the relevance of the results	Fernando García

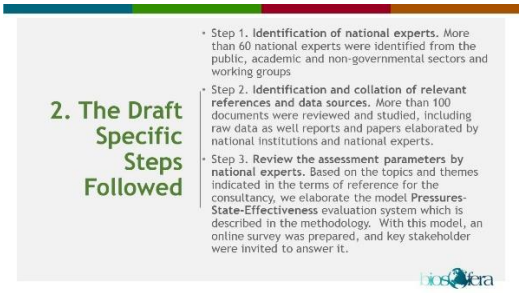
16:00-16:00	Closing remarks and next step	Ms. Arlene Young

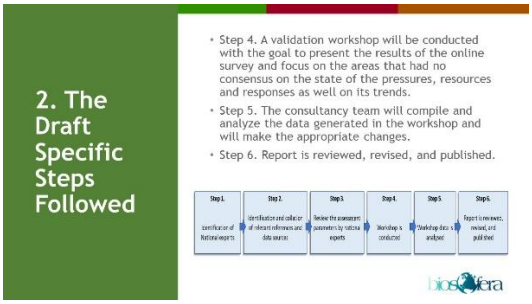
Workshop Presentation

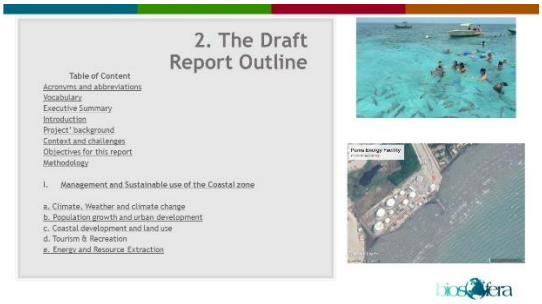












2. The Draft Report Outline

Table of Content

g. Land-Water Interface
- i. Sea-level rise
- ii. Sediment Transport
- iii. Erosion
- iv. Saline Intrusion

h. Coastal Waters
- i. Nutrient Pollution
- ii. Marine Pollution
- iii. Dredging
- iv. Fishing
- v. Shipping
- vi. Aquaculture & Mariculture
- vii. Invasive Species
- viii. Sargassum
- viv. Sportfishing

II. State of the Coastal Zone

a. Water quality
b. Coastal Habitats
i. Mangrove
i. Littoral Forest
iii. Coral Reefs
iv. Seagrass
c. Protected Areas
d. Species Population

III. Effectiveness of Integrated Coastal Zone Management
a. Governance and Management
b. Coastal Area Planning & Development
c. Beach & Shoreline Management
d. Research, Monitoring & Enforcement
e. Fisheries Management
f. Education, Awareness & Communication

IV. Resilience of the Coastal Zone

a. Socio-economic Adaptation Capacity
b. Prioritization of Ecosystem-based Adaptation
c. Disaster Preparedness & Response

Annexes

KEY COMMENT
The report has 166 pages and it does not include the report for the results of the online survey.

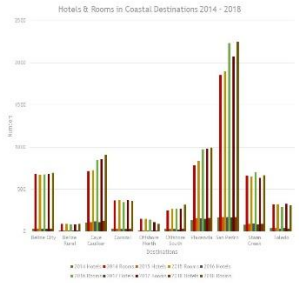
Link: https://we.tl/t-1YXY45RdNp

Management and Sustainable use of the Coastal Zone

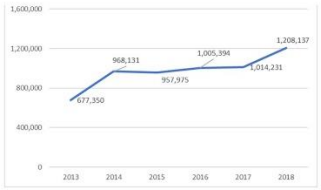
2. The Draft Some Data

Tourism visitation (overnight) continues to grow

	Belize (a)		Guatemala (b)		Mexico (Quintana Roo)(c)	
Year	Tourist (Thousand)	Difererence	Tourist (Thousand)	Difererence	Tourist (Millions)	Difererence
2012	277,135		1,188,906		9.416	
2013	294,177	6.15%	1,213,100	2.03%	10.869	15%
2014	321,220	9.19%	1,359,855	12.10%	12.257	13%
2015	341,161	6.21%	1,473,458	8.35%	13.265	8%
2016	385,583	13.02%	1,584,727	7.55%	15.205	15%
2017	427,076	10.76%	1,659,597	4.72%	15.926	5%
2018	489,261	14.56%	1,780,775	7.30%	16.675	5%

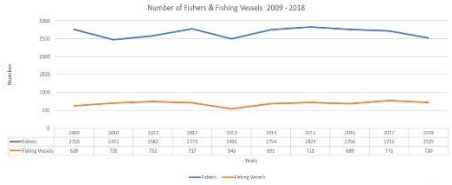


Number of hotels and rooms (Over $400 million tourism industry; 11.5% of GDP)

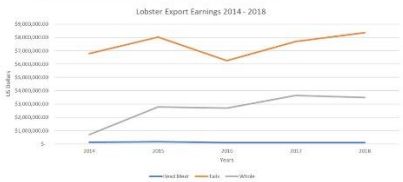


Cruise tourism visitation (2013-2018)

Fisheries employ about 2,700 fishers; generates about 3.6 % of GDP



Fisheries
Lobster is the highest export commodity



State of the Coastal Zone

2. The Draft
Some Information

Coastal Development

The state of littoral forest

The state of the mangrove

2. The Draft
Some information

Effectiveness of Integrated Coastal Zone Management

- The Coastal Zone Management Authority and Institute (CZMAI), has designed the Belize Integrated Coastal Zone Management Plan -2016 (BICZMP) and Coastal Zone Management Guidelines (CZMG) for the different planning regions with the intent to solve particular public problems on the coastal zone through effective governance and management.
- The ability to integrate the different government legislative authorities, private sectors, non-governmental organizations and society in the implementation of the BICZMP will require a period of time.
- Consolidation of the plan will depend on effective governance, policy stability, financing capacity, human resources, evaluation systems, research on coastal and marine issues, trained personnel, public databases and adequate legislation.

2. The Draft
Some information

- A shift towards new planning and development paradigms is a gradual process.
- The National Climate Change Policy, Strategy and Action Plan (NCCPSAP), defined resilience as the ability to adjust to climate change to minimize potential damage.
- There is the need for collaboration between the climate change policy and the BICZMP.
- Prioritization of ecosystem-based adaptation: a good example is to leave coastal mangroves to protect the shoreline in the event of increasing hydrometeorological phenomena due to increase in global temperatures.

2. The Draft
Some information

- Coordination and collaboration among different agencies is one of the most important challenges for coastal zone management actions

Legislation	Focus Area	Implementing Agency
Coastal Zone Management Act	ICZM	CZMA/I
Fisheries Act	Fisheries, marine reserves	Fisheries Department
Forest Act	Mangrove clearing	Forest Department
Village Councils Act	Urban Development	Village Councils
Belize Building Act	Building permits	Building Authority
Water Industry Act	Water supply	Belize Water Services Ltd.
National Integrated Water Resources Act	Water usage and conservation	Water Authority
Mines and Minerals Act	Dredging	Ministry of Natural Resources
Public Health Act	Water contamination	Public Health Department
Solid Waste Management Authority Act	Solid waste management	Solid Waste Management Authority
Environmental Protection Act	Control pollution of the environment	Department of Environment

Resilience of the Coastal Zone

2. The Draft
Some information

- Need to have a good disaster preparedness and response plan. Due to the geographical location of Belize, the country is susceptible to the effect of various natural hazards caused by phenomena such as storms and hurricanes whose frequency, intensity and duration has increased.

Final Comments

2. The Draft
Some information

- The report covers all the thematic areas as outlined in the terms of reference;
- The report is written in a user-friendly manner for the general public;
- The report explores some aspects between climate change and coastal zone management which was absent from previous reports;
- It was difficult to gather all the needed relevant data for the years in review;
- When data was available it was not always consistent;
- In regard to the online survey, it was very difficult to engage stakeholders for the usual reason of work staff overload;
- There is the potential for successful coastal zone management in Belize if there is the political will.

Key Agreements for the Dynamics of the Workshop

MCCAP
BELIZE MARINE CONSERVATION & CLIMATE ADAPTATION PROJECT

State of the Coast Report Validation Workshop
Belize Institute of Management
2090 Chancellor
St, Belize City, Belize
24th January 2020

3. The workshop

Workshop Objectives

- To provide a brief overview of the Draft State of the Coast Report 2014-2018
- To get feedback on the content of the Draft Report
- To identify information that must to be included into the report
- To present the findings of the online survey: Pressure - State - Management
- Build consensus on the main topics for the Pressure - State - Management system for the Coastal Zone in Belize that had no consensus in the questionnaire

3. Online Questionnaire

- Three sections (pressure, state and effectiveness)
- Specific topics for each section
- Specific questions and trends for topics

- The questions addressed:
- Pressures on the land coastal zone (36 questions) plus trends
- Pressures on the marine coastal zone (36 questions) plus trends
- The state of the resources (26 questions) plus trends
- The management effectiveness (23 questions) plus trends

3. The workshop

Workshop Objectives

To split into groups to address the main topics for the Pressure - State - Management Survey that had no consensus if necessary

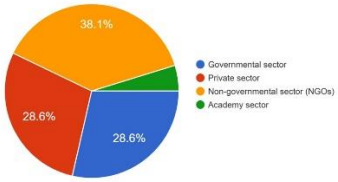
To record the feedback from the participants to make the necessary changes in the State of the Coast Report and findings from the online survey

Online Questionnaire Results

State of the Coast Report Validation Workshop
Belize Institute of Management
2090 Chancellor
St. Belize City, Belize
24th January 2020

3. Online Questionnaire

The sectors



3. Online Questionnaire

- The assessment grade levels are based on the State of the Environment (2016) grading systems (Clark and Johnston, 2017).

EXAMPLE

For pressure there are 4 impact grade levels
1. Very low impact
2. Low impact
3. High impact
4. Very high impact

4 trend grades
1. Getting better
2. Deteriorating
3. Stable
4. The trend is not clear

3. Online Questionnaire

Decision rules:

- When a question had 10 or more similar answers and the rest of the answers were distributed in the other categories, it was considered that there was consensus in the answer.
- When the majority of responses to a question concentrated on two categories (e.g., high and very high pressure or low and very low pressure) it is considered that there was a trend. In these types of responses, it was considered that there was also consensus.
- When a question did not have at least 10 or more similar responses, nor a trend, it was considered that there was no consensus

Example:

Pressure on land coastal zone
Total:36
- 22 consensus
- 9 no consensus
- 5 tendencies

Trend of the land pressures
Total: 36
- 26 consensus
- 10 no consensus

Example of marine pressure

3. Online Questionnaire

Pressures	Questions	N-C	Very high impact	High impact	Low impact	Very low impact
Marine Pollution	On water quality?			☑		
	On seagrasses?			☑		
	On reefs?			☑		
	On the various fisheries ?			☑		

Example of Land pressure

Pressures	Questions	N-C	Very high impact	High impact	Low impact	Very low impact
Climate, weather and climate change	What has been the impact of climate change on mangroves? mangroves?				☑	
	What has been the impact of climate change on littoral forest?				☑	

Task

1. Read the relationships
2. Focus on those relationships that do not reach consensus yet
   1. At what position it must to be? What trend it really has?
3. Is there another relationship that has to be analysed? Please add
4. Chose 2-3 topic
   1. Write down a summary for the topic

How Confident are you in regards of the condition of the topic

- **Adequate:** Adequate high-quality evidence and high level of consensus
- **Somewhat adequate:** Adequate high-quality evidence or high level of consensus
- **Limited:** Limited evidence or limited consensus
- Very limited: Limited evidence and limited consensus
- Not adequate: Evidence and consensus too low to make an assessment

Workshop activities

Presentations

Participant feedback